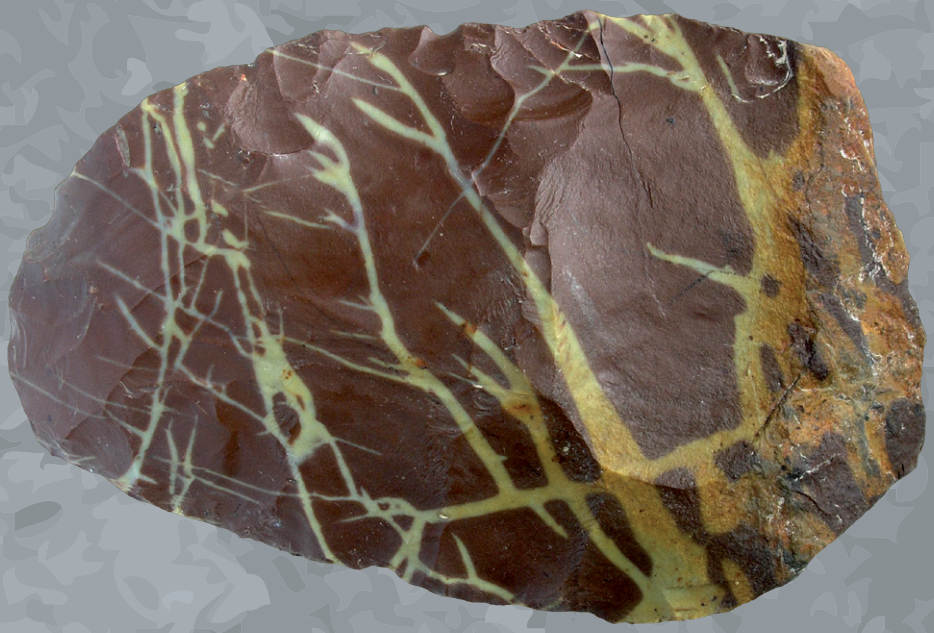
LITHIC RAW MATERIALS IN PREHISTORIC TIMES

OF EASTERN CENTRAL EUROPE

Antonín Přichystal



Masaryk University
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Reviewers of the original Czech text:
Prof. RNDr. Dušan Hovorka, DrSc., Bratislava
Dr. hab. Jerzy Kopacz, Kraków

Reviewers of the chapter II.2.6.
Dr. Jaroslaw Bronowicki, Wrocław;
Prof. Dr. hab. Andrzej Pelisiak, Rzeszów
Reviewer of the chapter II.2.8.
Dr. Katalin T. Biró, Budapest
Reviewer of the chapter II.2.4
Prof. G. Trnka, Wien

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I.
INTRODUCTION

I.1. Context of prehistoric lithic research in Central Europe

When did humans begin using stone as a raw material? The exact answer is unknown. Anthropologists have been pushing the date of the earliest humans ever farther back in time, as they follow the first signs of the use of stone tools, considered a defining feature that distinguishes humans from other species in the animal kingdom. By all accounts Australopiths, the oldest known predecessors of homo (the taxonomic genus of modern and ancient humans), lived in East Africa as early as the late Tertiary, three to four million years ago. Australopiths are thought to have used stone tools though researchers debate whether this was intentional and systematic. Anthropologists consider the making of stone tools to be the decisive third milestone in hominid evolution, after descent from the trees, and walking on hind legs. It was for the making of stone tools in Africa 2–1.4 million years ago that the oldest representative of the Homo genus was given the name Homo habilis (Latin "Handy-man"). Homo habilis is also credited with the oldest stone building – possibly a shelter against wind and bad weather. In the traditional Three-Age classification system, the Stone, Bronze and Iron Ages are each defined by the primary raw material used for tool making. The Stone Age in Central Europe ended roughly around 2000 BC. Nearly 99.9 % of the long period of human evolution and social development occurred within this period. Afterward stone retained its critical place as an indispensable natural resource use and remains a valued raw material.

Stone processed into tools or other objects are an irreplaceable and the definitive source of data from which are deduced ethnicity, range of human activity, and interregional contact. Data obtained from stone tools contribute to the clarification of broader social and archaeological questions. Archaeologists were aware of the importance of this data as early as the second half of the 19th century, driving their early cooperation with petrographers around that time. Petrography gradually developed new methods and instrumentation, such as the polarising microscope, physical and chemical methods, electron probe microanalyser, and cathode luminescence microscope. These, along with the development of comparative databases of natural rock outcrops, have made possible to reliably classify tool stone and determine their sources.

Cooperation between archaeologists and petrographers in Europe through the 19th and 20th centuries has been extensively examined by J. Štelcl and J. Malina. They describe three periods of the lithic studies from 1863–1905, 1905–1936 and 1936–1970, examined in detail in their monographs (Štelcl & Malina 1970, 1975). The author deals only with critical developments, and some key finds in Central Europe, during these periods. Developments since the last third of the 20th century, a period of significant accumulation of new knowledge about stone tool raw material, extraction and distribution, are examined below in greater detail.

Although cooperation between archaeologists and petrographers began as early as the second half of the 19th century in Central Europe, and an immense volume of significant data gradually acquired, the vast majority of publications have been written in Czech, Slovak or Polish. Some of them have German or English summaries and remain inaccessible to professionals internationally. One of the objectives of this monograph is to draw international attention to this important body of older research.

I.1.1. Second half of the 19th and the first two thirds of the 20th century

From a Central European perspective, Moravian researchers K. J. Maška and J. Palliardi kept pace with the top European specialists in the early years of petrography in the late 19th century. They played a significant role in European discussions concerning the jadeitite and nephrite polished industries (see the chapter on these raw materials below). The remarkable volcanic glass, obsidian, was of particular interest amongst chipped stone tools as researchers were able to distinguish it from other chipped tool stone through simple macroscopic examination. With outcrops found along the coasts of the Baltic and English Channel flint was thought the most prominent raw material. A key discussion took place between K. J. Maška and J. Woldřich on the origin of the flint found at the already famous Palaeolithic research site at Přerov-Předmostí (Fig. 1). Maška (1886) correctly drew attention to the importance of erratic flint, transported by continental glaciers as far south as the Moravian Gateway 35 km northeast of Přerov-Předmostí, which eliminated the need for explanations revolving around the transport of this tool stone from the distant Baltic coast. However, the provenance of flint cropped up again (e.g. Štorch 1907, 29) with speculations that flint at Palaeolithic sites around Prague arrived by trade from Belgium via Germany along

Fig. 1. In 1886, the famous Palaeolithic site at Přerov-Předmostí interfered in an important dispute concerning provenance of used flint raw material in Moravia. In seventieth of the 20th century, it had been signed in the former Chromeček's garden only by the commemorative plaque on the outcrop of Devonian limestone. Skeletons of more Palaeolithic individuals were found in loess above it. Photo by the author, 1974.

Fig. 2. K. Žebera (1911-1986), the discoverer of prehistoric marble quarries at the Bílý kámen Hill near Sázava in 1937. Archives of S. Vencl.

the Elbe. In the late 19th and early 20th centuries the first comprehensive reviews of prehistoric stone raw material used in Bohemia (Matiegka 1894, Niederle 1894), Hungary (Ortway 1887), and south-eastern Germany (Luedecke 1902) were published.

The second period of lithic analysis occurred between the turn of the century and World War II. An outstanding work was conducted by Deecke (1933) with his synthesis of the Central European silicite chipped industry, and the summary of prehistoric using of obsidian from the Zemplín Mountains (Janšák 1935). Raw material research of important Palaeolithic localities included Rosický & Zapletal's (1935) work at Otaslavice near Prostějov in Moravia, and Leitmeier's (1934) research at Willendorf in Lower Austria. In Central Europe, prehistoric tool stone extraction sites were discovered and studied for the first time; including, banded silicite (flint) from Krzemionki in Poland (Samsonowicz 1923), radiolarite from Vienna-Mauer between 1929 and 1930 (J. Bayer), and limnic silicite from the Avas Mount near Miskolc, Hungary between 1928 and 1930 (J. Hillebrand). Other tool stone extraction sites were found, such as the Bílý Kámen Hill marble quarries near Sázava, Czechoslovakia (Fig. 2; Žebera 1937).

In the third period, after World War II until the 1970's, there was enormous development of tool stone research, particularly of the polished industry in England, France, and Switzerland. In the Central Europe cooperation between archaeologists, petrographers and geologists continued as in the pre-war period, through the occasional evaluation of select localities. In Czechoslovakia, Žebera (1955) summarised his long experience in identifying prehistoric raw materials, though based largely on knowledge of the regional geology and macroscopic examination. In Austria, Zirkl (1956–1959) continued petrographic studies of stone raw materials used at the famous Palaeolithic site at Willendorf. In East Germany important research included the Jahn (1960) summaries of the oldest known extraction of the stone raw materials and their distribution in Europe, investigation of stone raw materials of the Mesolithic and Neolithic industries (Herrmann & Schüller 1952), and research into the lithics of the Linear Band Pottery and Corded Ware cultures from two sites in Thuringia (Scholz 1968).

I.1.2. Late 20th and early 21st centuries

The latest stage of lithic studies started in the early 1970s. In Brno, Czechoslovakia, Štelcl & Malina (1970) defined petroarchaeology (the use of petrography in archaeology) and wrote the textbook "Principles of petroarchaeology". In a number of published studies they identified the sources of stone raw materials used in the chipped and polished industry in Moravia. The 1st Petroarchaeological Seminar was held in Brno, Czechoslovakia, between April 21st and 23rd, 1975 (proceedings; Štelcl & Malina, eds. 1975) and attended by Czech and Slovak researchers with colleagues from Poland, Bulgaria, Hungary, and the Soviet Union. The seminar was very useful and led to the recognition of Polish important stone raw materials for the chipped industry. The 2nd Petroarchaeological Seminar held under the auspices of Prof A. Majerowicz in Wrocław and Sobótka, Poland, from October 2nd to 4th, 1980 (proceedings; Kulczycka-Leciejewiczowa, ed. 1980), included participants from Austria and the German Democratic Republic as well. The 3rd seminar (Fig. 3) was held in Plovdiv, Bulgaria, between August 27th and 30th, 1984 (proceedings; Kunchev, Nachev & Cholakov, eds. 1984). After a lengthy hiatus, the author organised a petroarchaeological workshop "Lithic raw materials in prehistoric times and in the Middle Ages of Czechoslovakia" held in Brno from January 29th to 30th, 1991 (proceedings; Přichystal, ed. 1992). Thanks to initiative of Prof B. Gediga, the 4th Petroarchaeological Symposium took place in Wrocław, Poland, from October, 11th – 13th, 2007 (proceedings; Přichystal, Krmíček & Halavínová, eds. 2008). These meetings have gradually become truly international events with participation growing to include researchers from across Central and Eastern Europe and the USA.

In western Europe the Flint Symposia were initiated in 1969 to discuss prehistoric tool stone extraction, production technology, and how to distinguish and classify silicites ("flints") on the basis of their chemical composition, trace elements, rare earth elements, and microfossils. The first three Symposia took place in Maastricht, Holland,

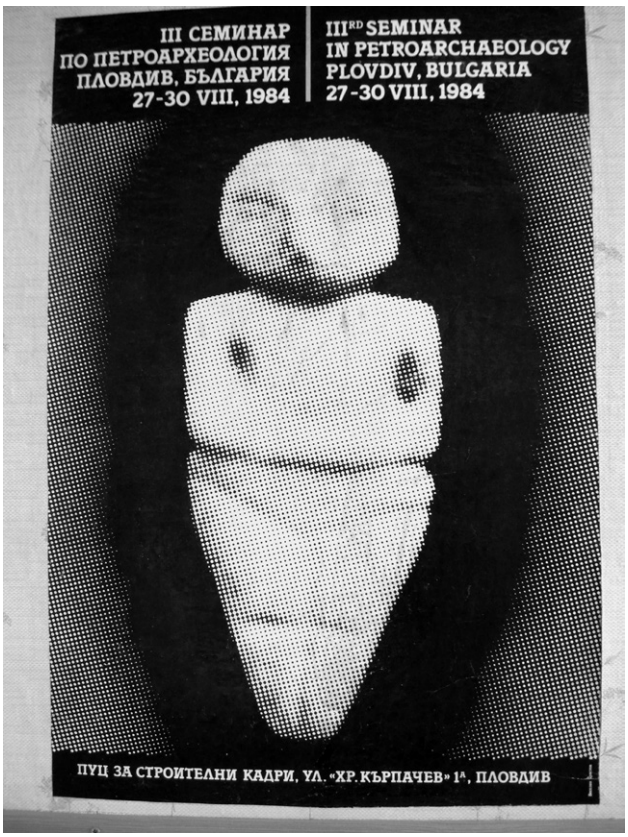

Fig. 3. Poster with annoncement on the 3rd Petroarchaeological Seminar in Bulgarian Plovdiv in 1984.

in 1969, 1975, 1979 (Roos et al. 1971; Engelen, ed. 1975, 1979). The fourth was held in 1983 in Brighton, England; the fifth in Bordeaux, France in 1987; the sixth in Granada, Spain in 1991; and the 7th Symposium in Warsaw-Ostrowiec Świętokrzyski in Poland (proceedings, Schild & Sulgostowska eds. 1997). The 8th and latest Symposium was held in Bochum, Germany, in 1999 (proccedings; Körlin & Weisgerber, eds. 2006). In 1980 the Bergbau Mining Museum in Bochum issued a catalogue of prehistoric European mines for raw materials of the chipped industry. The catalogue has been continuously updated and the latest 3rd issue now lists over 250 sites (Weisgerber, Slotta & Weiner, eds. 1999). A special amendment appeared on the occasion of the 7th Flint Symposium held in Warsaw in 1995 (Kobyliński & Lech, eds. 1995).

In the latter half of the 1980s the Hungarian National Museum initiated its Lithotheca, a collection of stone raw materials and related data (Biró & Dobosi 1991; Biró, Dobosi & Schléder 2000). Similar collections have been established in other Central European countries, such as those at the Institut für Ur- und Frühgeschichte at the University of Vienna, under Prof. G. Trnka (partially web accessible); at the Institute of Geological Sciences, Faculty of Natural Sciences at Masaryk University of Brno, under the author; at the Institute of Archaeology, Polish Academy of Sciences in Kraków (J. K. Kozlowski, K. Sobczyk) and at the University of Mining and Metallurgy in Kraków under M. Pawlikowski. The latter also wrote Petroarchaeology, a Polish language textbook (Pawlikowski 1992), though this work has been criticised (see for example Kwiatkowski 1993–1994). Thanks to the initiative of R. Elburg and P. van der Kroft, a group of German researchers developed a virtual "lithotheca" of Central European stone raw materials which can be accessed at www.FlintSource.NET.

Led by Prof D. Hovorka from Bratislava, Central European geologists and archaeologists requested and were granted funds for a lithic research project conducted between 1999 and 2002. Under an IGCP/UNESCO grant (No.442) the project "Raw Materials of the Neolithic/Aeneolithic polished stone artefacts: their migration paths in Europe" (Fig. 4) supported investigation of the raw materials used for polished stone tools. Five meetings were held over the course of the project. The initial meeting took place in Bratislava, Slovakia (June 21–23, 1999, abstracts prepared by Hovorka, ed. 2000). The second workshop was combined with the "Lengyel '99" conference held in Veszprém, Hungary (October 11–13, 1999) focused on stone raw materials used by people of the Lengyel culture (abstract book 1999; proceedings Regenye, ed. 2001). In successive years the third meeting, organised by Prof G. Trnka, took place in Eggenburg, Austria (September 27–29, 2000, proceedings Hovorka, ed. 2000a); and the fourth workshop, prepared by Prof C. D`Amico, was held in Udine and Genova, Italy (September 24–28, 2001, book of abstracts by Méres & Dubíková, eds. 2001; proceedings by Hovorka & Méres, eds. 2001). A final meeting took place in Bratislava, Slovakia, and Šlapanice near Brno, Czech Republic (guidebook of excursions – Přichystal 2002; proceedings – Hovorka & Méres, eds. 2004). The project significantly advanced the identification of rocks used

Fig. 4. Logo of the IGCP/UNESCO Project Nr. 442 that was concentrated on raw materials of lithic polished artefacts in 1999–2002.

for polished tools, particularly in Central Europe. Along with the above mentioned proceedings, project outcomes were published in several monographs. D. Hovorka and L. Illášová summarized their research findings in Slovakia in the joint monograph (Hovorka & Illášová 2002).

In Bohemia the start of the 3rd millennium witnessed the discovery of the presumed and long-sought after primary extraction centre of the most prevalent rock of the Neolithic polished industry: thermally metamorphosed metabasite. In 2002 large-scale prehistoric extraction sites were discovered where the Železný Brod Crystalline Unit (phyllites with intercalations of metabasite) was thermally influenced by the granite intrusion of the Krkonoše-Jizera Massif; at Jistebsko, 5 km south-east of Jablonec na Nisou (Šrein et al. 2002), and at Velké Hamry, 2 km south of Tanvald (Přichystal 2002a). The significance of these sites undoubtedly extends beyond the Czech Republic, and future research is likely to identify a vast distribution network inclusive of Bohemia, Moravia, Czech and Polish Silesia, west into Germany, and south-east into Austria and Hungary. It has been possible to reconstruct even more extensive distribution networks as those we know for important Polish raw materials (banded and spotted silicites, silicites of the Cracow-Częstochowa Jurassic) used for the chipped axes. All this, together with surprisingly large-scale chert extraction throughout the Bronze Age, Hallstatt and La Tène periods in the Krumlovský les Highland, south-western Moravia (see for example Oliva, Neruda & Přichystal 1999), raises new questions about the role of extraction and distribution of stone raw material in prehistoric communities.

The increasingly important cooperation between natural scientists and archaeologists has resulted in the annual Natural Science Methods in Archaeology conferences. Alternating between the Czech Republic and Slovakia the conference addresses many issues including the raw materials used for stone tools. Seven conference proceedings have been published as "In Service to Archaeology" (Brno 1998, 2001a, 2001b, 2003; Brno – Nitra 2004, 2005, 2006) and later from 2007 to 2008 in a journal of the same name.

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I.2. Defining the research area

The term “Central Europe” has not been clearly and unambiguously defined even in the geographical literature. It is usually applied to the countries that lie between the Baltic Sea and the Alps, bordered to the east by the former Soviet Union and in the west by France. The east/west political division of Europe in the second half of the 20th century cut right through the centre of the continent. Its overwhelming import led to increased use of this socio-politically defined geographical divide. Geography atlases usually designate 8 countries as being within Central Europe: to the east are the so called “Visegrád Four” comprised of the Czech Republic, Slovakia, Poland, and Hungary; to the SW the Alpine countries of Germany, Austria, Slovenia and Switzerland. For a detailed analysis of regional prehistoric stone raw material a territory defined in these terms is far too extensive. In addition, our current understand of raw material resources from the area of the present-day Switzerland or Rhineland does not suggest any marked effect in the area of prehistoric eastern Central Europe.

The geomorphological division of Europe which include the Hercynian Central Europe and Alps-Carpathian region, and which is based on geomorphological difference between these ancient orogens, is of a greater interest. From the point of view of prehistoric distribution

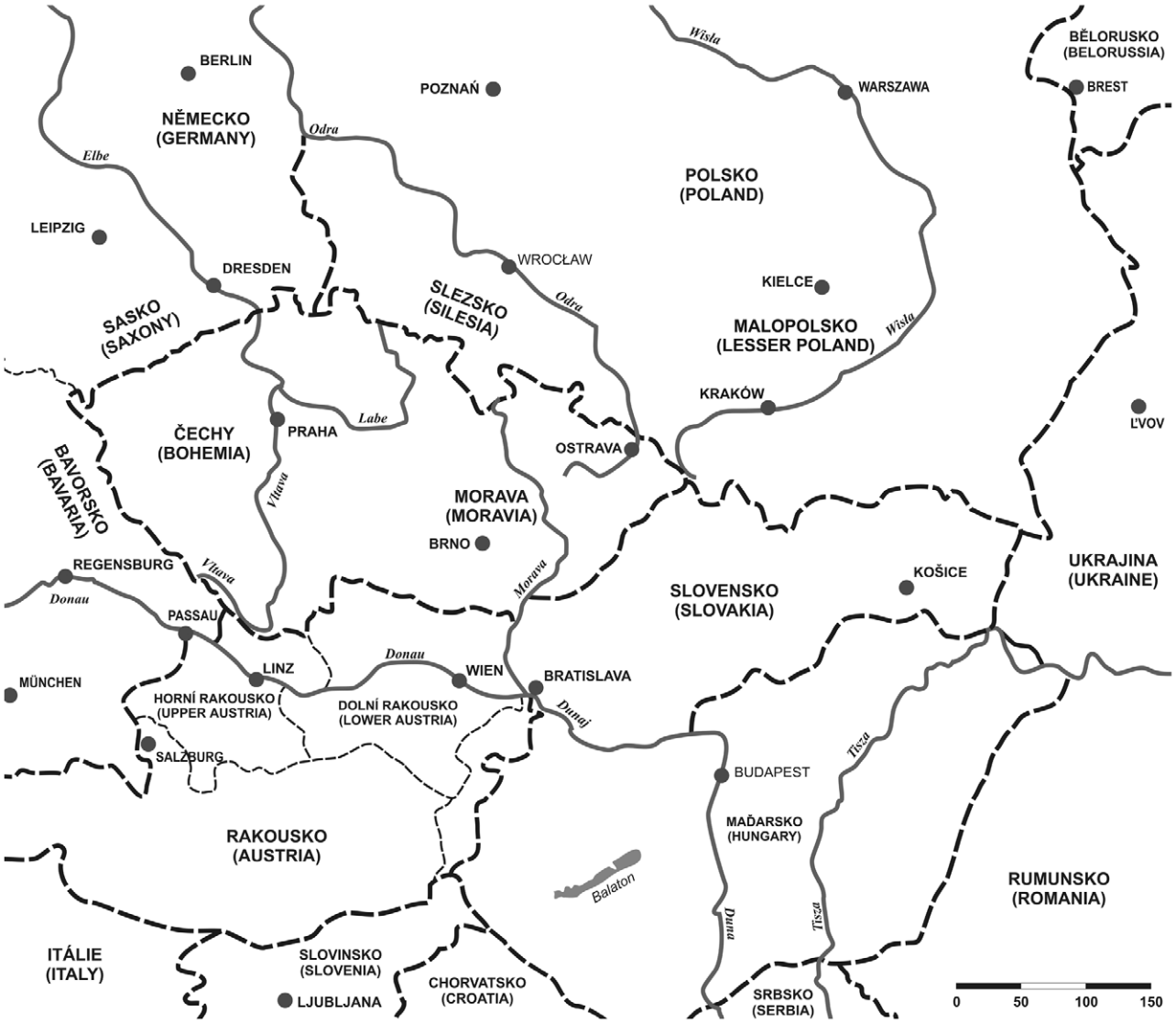

Fig. 5. Studied part of eastern Central Europe with individual republics and countries.

of the stone raw material it is clearly of a greater importance. The border between these two regions, the backbone of Central Europe, is comprised of a complex of depressions: the Moravian Gateway, the Lower Moravian Graben, the Upper Moravian Graben, the Dyje (Thaya)-Svratka Graben. These form natural corridors in the landscape that connect the Polish lowlands in the northern part of Central Europe with the archaeologically rich area of the Danube basin to the south in Austria and Hungary.

The author focuses primarily on the area with which he is thoroughly familiar (i.e. on the Czech Republic and Slovakia), with consideration of adjacent areas within Germany (Bavaria and Saxony), Austria (Lower, Upper and Burgenland), Poland (Silesia and Lesser Poland), Hungary and western Ukraine (Fig. 5). Stone raw material sources in the eastern Austrian Alps are often referenced, but their complete treatment would require a separate work in its own right. This region is the eastern part of Central Europe, or what is sometimes called eastern Central Europe. This book systematically examines the lithics of this region including stone raw materials used in the chipped industry (Chapter II) and polished industry (Chapter III). Other tool stone sources identified in eastern Central Europe or imports from other parts of Europe are also examined in detail (e.g., jadeitite from northern Italy and flint from Scandinavia). For comparative purposes data on some unique raw materials, such as, tektites, jadeitites, and nephrites of non-European origin are shortly discussed as well.

I.3. Geomorphological characterization

When examining the sources of raw materials used in prehistoric lithic industries, also known as tool stones, it is necessary to routinely use various geomorphological terms. As this terminology has undergone considerable development and, moreover, is severely impacted by multi-lingual labelling, a number of ambiguities may be met in the archaeological literature. This happens, for example, when various authors designate one geomorphological unit with a variety of names, which leaves the reader with the impression that a raw material originates from multiple sources. We proceed on the principle that current physical geography terms should be used, and follow the recommendation to use the place names in the official languages of the individual states. Where necessary, the use of Czech exonyms (Czech names for foreign places) are cited in brackets. The synoptic geomorphological characteristics of the research area, eastern Central Europe, are derived from "The Physical Geography of Europe" (Král 2001). Geomorphological descriptions for specific countries are derived as follows: Czech Republic (Demek & Mackovčin eds. 2006; Mackovčin et al. 2009), Slovakia (Mazúr & Lukniš 1980), and Poland (Kondracki 1988). Hungarian geographical names in English have been used according to the recommendation of Gercsák (2002).

Geomorphologically, eastern Central Europe includes three important units:

Hercynian Central Europe,
Alps-Carpathian area,
and East European Plain.

The unit of Hercynian Central Europe shows by its name that the Hercynian (the term Variscan is preferred in the geological literature nowadays) folding in the late Palaeozoic Era played the key role in its formation. It can be followed ca 1,600 km from west to east, stretching from Calais, France to Lviv, Ukraine. Within the research area it is a 400 to 600 km wide belt. The border between Hercynian Central Europe and the Alps-Carpathian area runs from the Burgundy Gateway (La Porte de Bourgogne) at the southern foot of the Vosges Mts. to the upper course of the Danube at the town of Krems in Lower Austria where it turns to the north-east and continues through the Moravian depressions and the Moravian Gateway to the upper course of the Vistula River. It follows the river to its junction with the San River. A component part of the Lesser Poland Highland – Roztocze, Roztochchia in Ukrainian, forms a narrow extremity south-east to Lviv. To the north of Lviv the Hercynian Central Europe blends into the East European Lowland without any significant morphological change. Polish geographers (e.g. Kondracki 1988) draw the contact between these two units along the east slopes of the Wyżyna Lubelska Highland, proceeding north to Brest in the Bug River valley, north-west towards the eastern edge of Gdańsk Bay through the outskirts of the cities of Łomża and Olsztyn.

Hercynian Central Europe includes two basic units: the Central European Highland and the Central European Lowland. Within the research area, the Central European Highland includes the Czech Highland (Česká vysočina, Böhmische Masse, Masyw Czeski), and the Lesser Poland Highland (Wyżyna Małopolska). The Czech Highland is not only the key source of raw materials for polished tools but it is also the source for a number of unique raw materials used for chipped artefacts. From the geomorphological point of view the Czech Highland and Western Carpathians within the Czech Republic are detailed in the lexicon of Demek & Mackovčin eds. (2006). On the other hand, in the Lesser Poland Highland, which comprises the sub-units of the Wyżyna Krakowsko-Częstochowska Highland and the Wyżyna Kielecko-Sandomierska Highland (Kondracki 1988), there are extensive occurrences of high-quality silicites (flints according to Polish archaeologists). The Góry Świętokrzyskie Mountains are the highest range in the Lesser Poland Highland. The Central European Lowland spreads to the north of the Central European Highland and covers vast areas of Poland and northern Germany up to the Baltic Sea. Its flat relief is the result of processes related to the advances, withdrawals and melting of the Scandinavian continental glacier throughout the Pleistocene (Fig. 6). Apart from the Baltic Sea coast, where there are outcrops of Cretaceous chalk with flint, the only source of stone raw material across the entire extent of the Central European Lowland, with young moraines to the north and old moraines to the south, are erratic rocks (Latin *erraticus*, from *erro* = to wander, i.e. rocks transported by the glacier).

The Alps-Carpathian unit found within the research areas includes the Western Carpathians, and the westernmost portion of the Eastern Carpathians. The border between the Western and Eastern Carpathians is usually located at the Przełęcz Łupkowska Pass at the source of the Laborec River. In regard to physical geography, the Western Carpathians are divided into the Outer Carpathian depressions, and the Outer and Inner Western Carpathians.

The Outer Carpathian depressions stretch along the outward Carpathian bow. In the west they show the character of morphologically marked, narrow depressions between the Outer Western Carpathians and the Czech Highland. They are the most important passage from the plains to the north of the Carpathian Mountains through to the Danube. This corridor was used as early as in the Palaeolithic by hunters tracking herds of mammoth and other animals migrating along this north-south direction. Through this passage outstanding silicites originating in southern and central Poland were distributed southward in the Neolithic and Eneolithic, and it was the route of the Amber Trail throughout the Roman Period. The Outer Carpathian depressions begin at the Weinviertler Highland in Lower Austria and extend through the Dyje-Svratka Graben in southern Moravia, the Vyškov Gateway, the Upper Moravian Graben, the Moravian Gateway, and the Ostrava Basin (Kotlina Ostrawska) to Poland. There they connect with the Kotlina

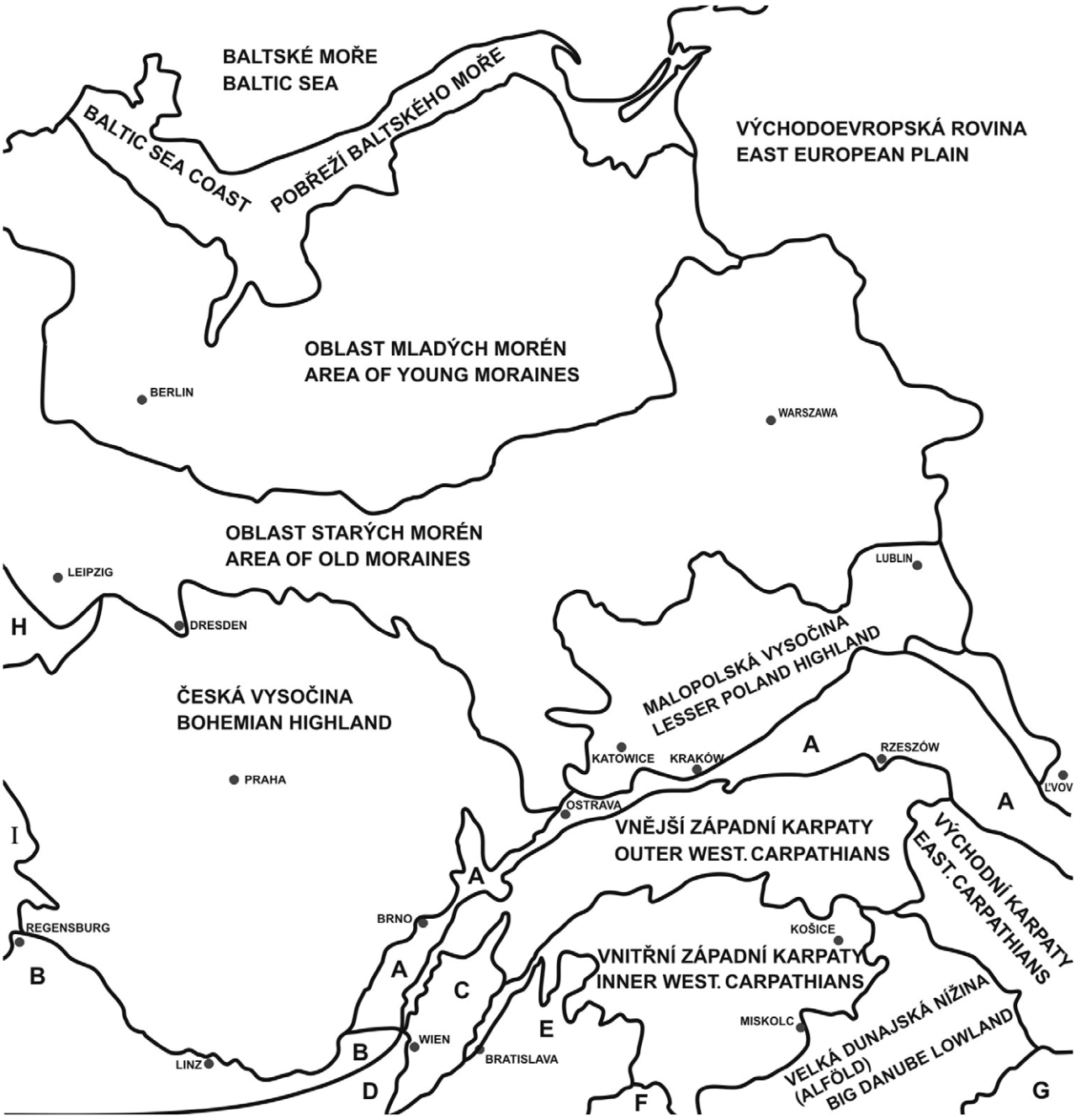

Fig. 6. Principal geomorphological units in eastern Central Europe. Compiled using maps after Král (2001). A - Outer Carpathian depressions (Północne Podkarpacie), B – Outer Alpian platforms and hilly-lands (Alpenvorland), C – Vienna Basin (Wiener Becken), D – Eastern Alps, E – Little Danube Lowland (Kisalföld), F – Back-Danube Hilly-lands (Dunántuli dombságok), G – Transilvanya Basin (Podişul Transilvaniei), H – Central German hilly-lands and basins, I – Fränkische Alb, Oberpfälzer Hügelland and Bodenwöhrer Bucht.

Oświęcimska Basin to become significantly narrower in the area of the Brama Krakowska Gateway and, conversely, reach their maximum width farther to the east by the Kotlina Sandomierska Basin. This basin spreads as far as the western outskirts of Lviv, Ukraine, where it is known as the Sans'ko-Dnistrovs'ka rivnyna Plain and is connected with the Verchn'odnistrovs'ka rivnyna Plain. In regard to stone raw material, the Outer Carpathian depressions in Moravia are of interest because they contain gravels with chert and radiolarite pebbles transferred to the area by the predecessor of the Danube, from the area of the rising Alps over the course of the Tertiary.

The Outer Western Carpathians consist of highlands, hilly lands, and mountain regions (for more details, see Král 2001, 170–171) that again begin in Lower Austria by the Niederösterreichische Inselbergschwelle Unit. This continues into southern Moravia as the Mikulov Highland with the morphologically distinct and archaeologically

renowned Pavlovské vrchy Highland at its highest part. The chain of the Outer Western Carpathians continues through south-eastern Moravia and western Slovakia to the Moravskoslezské Beskydy Mts. (Beskid Śląski Mts. on the Polish side) and, through further geomorphological units in southern Poland, it continues as far as the Pogórze Dynowskie Mts., Pogórze Przemyskie Mts., and Beskid Niski Mts. in south-eastern Poland (Laborec Highland on the Slovak side).

The East European Plain appears only marginally in the area under observation from the east, at the units of the Volhyno – Podolian Highland and the Dnieper Highland. The former unit adjoins the Outer Carpathian basins; the latter extends farther to the east, approximately between the rivers Yuzhnyi Bug in the west and Dnieper in the east.

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I.4. Overview of geology considering potential sources of lithic raw materials

Six basic geological units crop out in the mentioned part of eastern Central Europe: the Bohemian Massif, Lesser Poland Highland (Massif), Western Carpathians, Eastern Alps, Pannonian Basin System and Fenosarmatian (East European) Platform (Fig. 7; Supplement/Photo 1). These units are described especially from the viewpoint of potential raw materials used in prehistoric times. Because it represents many pieces of knowledge formulated as an overview, in the following text there are citations of the most important handbooks and emphasis is layed especially on geological maps of individual regions because using them the reader can obtain more detailed information.

I.4.1. Bohemian Massif (Český masiv, Böhmische Masse, Masyw czeski)

It is a horst structure prevalently built of Pre-Mesozoic metamorphic and igneous rocks cropping out from younger Cenozoic sediments of Central Europe. The Bohemian Massif is a part of the eastern branch of the Variscan (Hercynian) orogenic belt that started to be individual during the Cenozoic. It has rhomboidal shape with a spur elongation towards the Thüringer Wald Mts. and forms basement not only for the Czech Republic but exceeds under Poland, Germany and Austria as well. In Lower and Upper Austria it reaches the Danube, in eastern part even over the Danube (Dunkelsteinerwald). Its limitation follows a system of Franconian (Danubian) faults in the south-west; the Odra fault represents its NE margin. Towards NW is buried under the Mesozoic to Quaternary sediments in Germany, in the east is bordered towards the Outer Carpathian depressions by the eastern margin of the Bohemian Highland, it means approximately the line Ostrava – Přerov – Šlapanice near Brno – Krhovice near Znojmo – St. Pölten in Lower Austria.

The whole area of the Czech Republic is covered by published geological maps of the scale 1: 50 000, some areas even by geological maps 1: 25 000. The numbers of individual map sheets is possible to find at the server of the Czech Geological Survey in Prague (http://www.geology.cz). The Geological Survey of Austria in Vienna (Geologische Bundesanstalt) issued also geological maps 1: 50 000 of the Bohemian Massif in the territory of Austria (http://www.geologie.ac.at), there exists a general geological map of Lower Austria in the scale 1: 100 000 (Schnabel, ed. et al. 2002). Polish geologist L. Sawicki (Sawicki 1995) prepared a general map of Lower Silesia with the exceeded Bohemian Massif to Poland (scale 1: 100 000).

Similar relics of the Variscan orogenic belt in the forms of individual horst structures can be followed towards the west up to the Atlantic coast: the Harz, Rheinische Schiefergebirge and Schwarzwald Mts. in Germany, the Ardennes Mts. in Belgium, the Vosges, Massif Armorician and Massif Central in France, the Iberian Massif in Spain, the Cornwall and South-Irish Massifs in the British Isles.

From the vertical point of view, the Bohemian Massif can be divided in three stages: the pre-platform basement (the crystalline and Lower Paleozoic affected by the Variscan orogeny) and platform cover (the rocks of Triassic to Quaternary age). The limnic Permian and Upper Carboniferous has special position because it has genetic relations to the Variscan orogeny on the one hand but especially the Upper Permian has already signs of the platform cover on the other hand. According to the Working Group for Regional Geological Classification of the Bohemian Massif (Chlupáč & Vrána, eds. 1994) in which about 30 Czech geologists participated, a basic division of the pre-platform basement is into six regions (Fig. 8):

Moldanubian Region (Moldanubicum);
Kutná Hora – Svratka Region;
Central Bohemian Region (Bohemicum);
Saxothuringian Region (Saxothuringicum);
Lusatian Region (Lugicum);

Fig. 7. Basic geological units in the eastern part of Central Europe. MPV – central part of the Lesser Poland Highland.

Moravo-Silesian Region (Moravosilesicum).

Another division of the pre-platform basement of the Bohemian Massif has been proposed by J. Cháb (in Cháb et al. 2010). This division is much more interpretative from the standpoint of plate tectonics and it is a question of time what proposals will be generally accepted. That is why the division of Working Group (Chlupáč & Vrána, eds. 1994) is preferred in this book.

I.4.1.1. Moldanubian Region (Moldanubicum)

The designation was introduced by the Austrian geologist F. E. Suess (Donau-Moldaugebiet) at the beginning of the 20th century according to German name of the Vltava (Moldau) and Latin name of the Danube (Danubius) for the most metamorphosed core of the Bohemian Massif. There are such its characteristic features:

A high degree of metamorphosis with gneisses as prevalent rocks;

Large areas of granitoide plutons connected with the Variscan orogeny;

Intensive migmatitization in the surroundings of granitoide plutons;

Occurrence of specific metamorphic rocks (granulites, eclogites, spinel and garnet serpentinites);

Exceptional presence of the platform cover (only in the South Bohemian Basins).

The Moldanubicum is an extensive region enlarged in the territory of the Czech Republic, Austria and Germany and from this reason is divided in a few parts (from the west to the east):

a) Moldanubicum of the Oberpfälzer Wald and Bayerische Wald in Germany;

b) Moldanubicum of the Český les, Šumava Mts. and Bohemian Moldanubicum in Bohemia;

c) Moldanubicum of Mühlviertel and Waldviertel in Austria;

d) Moravian and Strážek Moldanubicum in Moravia.

Reliable fossils have not been found in the high-grade metamorphosed rocks till recent time, that is why the age of the original volcano-sedimentary rock complex is still a matter of discussion and the principal division of the Moldanubicum is based on litostratigraphy in two fundamental groups: the Monotonous Group (prevalent) and the Varied Group (it forms a few belts). The Monotonous Group (Ostrong Unit according to Austrian geologists) is larger one from the viewpoint of area distribution and is built by sillimanite-biotite and biotite paragneisses, substantially less are presented biotite-muscovite paragneisses or micaschists, in places there are small inercalations of erlans or quartzites. Before the metamorphosis it was a complex of clastic sediments (graywackes, shales) with occassional small lenses of calcareous sediments or quartz sandstones. In the surroundings of the Variscan granitoide plutons the rocks of the Monotous Group are migmatitized or thermally metamorphosed. From the viewpoint of area distribution, the Monotonous Group

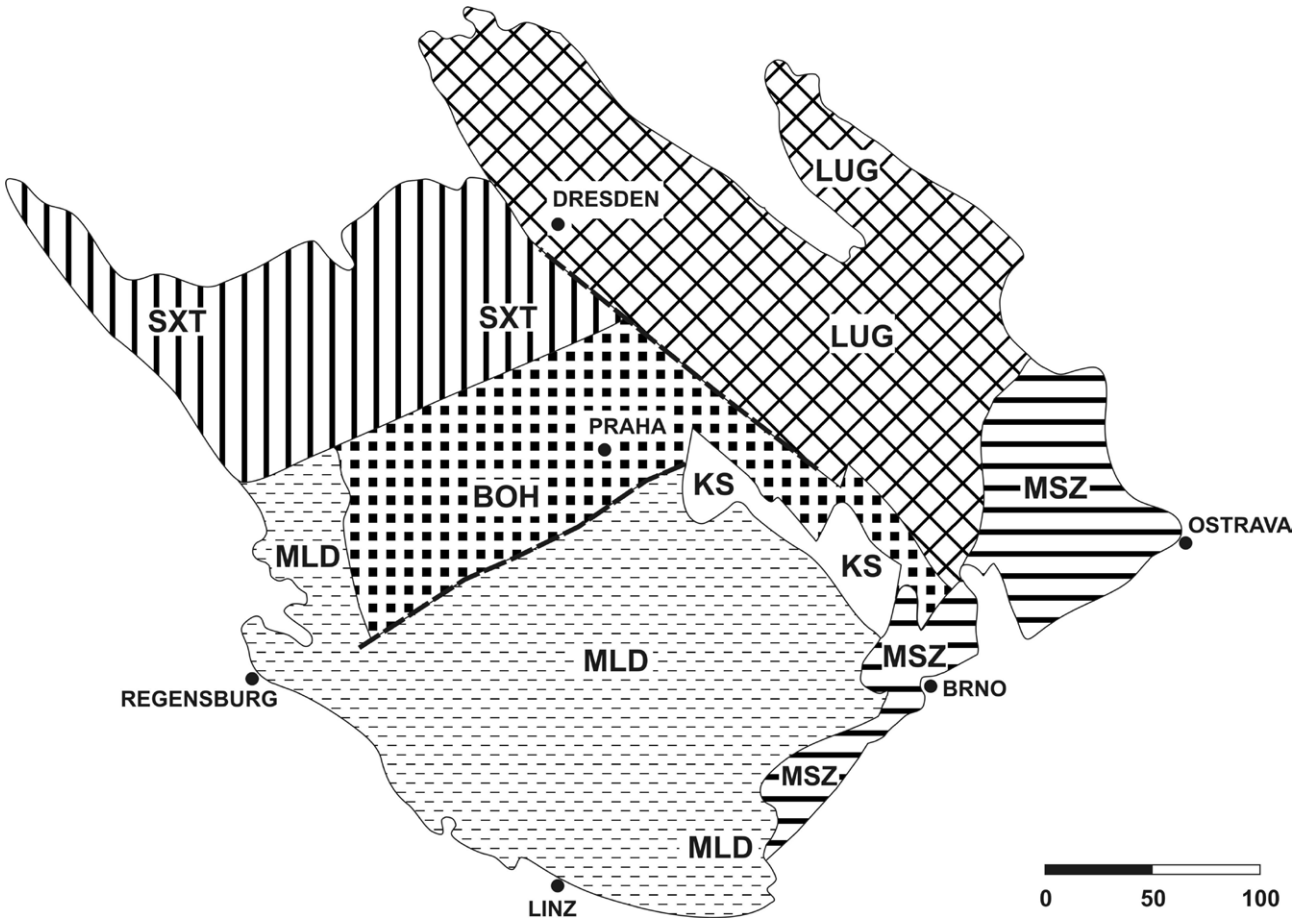

Fig. 8. Schematic picture of regional-geological division of the Bohemian Massif into six basic regions. Compiled using pictures after Mísař et al. (1983) and Zoubek (1985). MLD – Moldanubicum (the Moldau-Danube Region), KS – the Kutná Hora-Svratka Region, BOH – Bohemicum (the Central Bohemian Region), SXT – Saxothuringicum (the Saxony-Thüringen Region), LUG – Lugicum (the Lusatian Region), MSZ – Moravosilesicum (the Moravo-Silesian Region).

builds the Český les and Šumava Mts., central part of the Bohemian Moldanubicum and western and eastern surroundings of the Moldanubian (South Bohemian) Pluton.

The Varied Group (Drosendorf Unit) represented originally a volcano-sedimentary complex by its metamorphosis originated besides similar gneisses as those in the Monotonous Group also a lot of other rocks: amphibolites, calcite and dolomite marbles, erlans, pyroxene gneisses, quartzites, graphite gneisses and smaller bodies of orthogneisses. It is believed to be younger than the Monotonous Group. Its distribution in the Moldanubicum can be summarized as a few belts trending NE – SW to N – S. Using the schematic map of Fiala, Fuchs & Wendt (1995, 419), we can see from W to E the Klatovy, Sušice, České Budějovice-Votice and Chýnov belts in the Bohemian Moldanubicum, the western part of the Moravian Moldanubicum and a belt within the Strážek Moldanubicum. In the older Czech geological textbooks (e.g. Mísař et al. 1983) the Varied Group incorporated rocks of the next Gföhl Unit as well.

Especially Austrian geologists have separated the third Gföhl Unit (Group). The occurrence of granulites, serpentinized peridotites, eclogites, Gföhl gneiss and leukocratic migmatites (leptynites) is typical for it. The Gföhl Unit crops out in southern Bohemia: granulite massif of the Kleť Mt. (Fig. 9), the Prachatice and Křišťanovice granulite massifs together with serpentinites and amphibolites as a narrow belt border the Monotonous Group in the central part of the Bohemian Moldanubicum. It also forms the western and SE margin of the Strážek Moldanubicum (the Bory granulite and serpentinite massifs) and prevalent part of the Moravian Moldanubicum, especially in the east: the Náměšť-Krumlov granulite massif and a large body of Gföhl orthogneiss with many smaller serpentinite occurrences between Jevišovice and Koněšín SW of Náměšť nad Oslavou.

The age of original sedimentary and igneous rocks of the Moldanubian metamorphic complexes probably varies from Lower Proterozoic to Lower Palaeozoic (Chlupáč et al. 2011, 48; Cháb et al. 2010, 70). Older metamorphic events have been superimposed by the last intensive thermal metamorphosis connected with intrusion of huge granitoide plutons during the Carboniferous. This metamorphosis resulted to the origin of minerals such as sillimanite, K-feldspar and cordierite. Undoubtedly there

Fig. 9. Moldanubicum of southern Bohemia, Český Krumlov Varied Group. A view from the top of Kleť Hill (1084 m, granulites) towards the north to the villages of Křemže and Chlum, the village of Bohouškovice in the background. Serpentinite bodies around the villages are morphologically absolutely inconspicuous, their presence is marked usually only by occurrences of siliceous weathering products in the soil. Postcard, 1932.

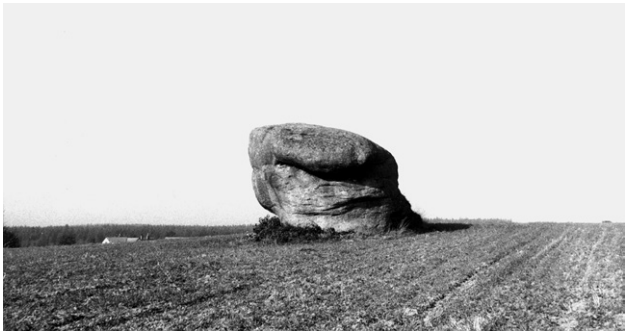

Fig. 10. Moldanubian (South Bohemian) Pluton, Waldviertel, Austria. A tor exhumated along parallel vertical joints. Coarse-grained granite of the Eisgarn type. Türnau, 5 km NE of Litschau. Photo by the autor, 1993.

was also a high-pressure Variscan metamorphic event that influenced especially rocks of the Gföhl Unit.

An overview of Moldanubian rocks in Bavaria is to be found for example in a chapter of Blümel (1995). Original paragneiss is often migmatized; non-migmatized gneiss can contain lenses of fibrolite sillimanite with quartz (Oberpfälzer Wald). Amphibole gneiss and silicified marble are also present. Higher metamorphic rocks including garnet-cordierite-biotite diatexite have been described from the area between Cham and Regen. The most interesting rocks crop out in the eastern part of Oberpfälz region – polymetamorphic low pressure gneiss with interbeds of eclogite amphibolite, spinel metaharzburgite and kyanite granulite, all of which are assembled in the Winklarner Serie.

The already mentioned large granitoide bodies (Fig. 10) are an important part of the Moldanubicum. The Moldanubian Pluton (or South Bohemian Batholith) with estimated area of about 6 000 km^2 is built of two parts called "central massif" and "Šumava branch". In the Czech part of the "central massif" the Eisgarn two-mica granite totally prevails and it is possible to distinguish three varieties in the framework of it: the Mrákotín, Číměř and Landštejn varieties according to their granularity and phenocrysts. The Šumava branch is less denudated and is formed by a few isolated smaller massifs in which crops out either the Eisgarn granite (Fig. 11) or the Weinsberg granite (porphyritic coarse-grained biotite granite). This granite is the most extensive type in the Austrian part of the Moldanubian Pluton (in Austrian geological papers is usually named the „Südböhmische Batholith"). Dark igneous rocks with specific position between granite and syenite composition are designated as durbachites and form a few massifs. Famous pegmatite dykes occur in their surroundings in the area of Třebíč and Písek.

The Central Bohemian Plutonic Complex (Batholith) is much more complicated comparing the Moldanubian Pluton in spite of its roughly half-extended area. The origin is connected with an important tectonic line at the boundary of the Moldanubicum with Bohemicum. Between Říčany and Blatná it encloses thermally metamorphosed rocks of the Proterozoic and Palaeozoic age, so called "Islet Zone". More to the west lies the Jílové Zone (according to the town of Jílové near Prague) – another belt of enclosed Proterozoic volcanic and magmatic rocks. The Pluton is prevalently built from various granodiorites and tonalites; granites (the Říčany type) occur substantially less. There are numerous lamprophyre dikes. Aplites represent the light dyke rocks. Zircon isotope ages of the granitoids vary between 333–354 My, it means they correspond to the Lower Carboniferous.

Sources of Raw Materials in Prehistory: From the viewpoint of potential raw materials for chipped artefacts it is necessary to underline that in strongly metamorphosed rocks of the Moldanubicum cannot occur sedimentary silicites. That is why in the area there were used other local raw materials represented especially by minerals SiO_2 such is rock crystal, smoky quartz, citrine and rose

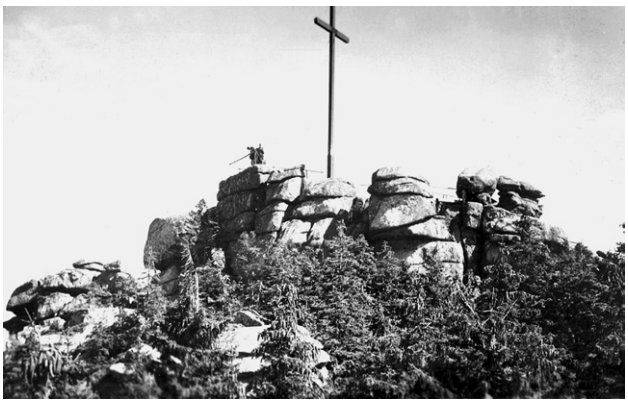

Fig. 11. Moldanubian (South Bohemian) Pluton, Šumava Mts. (Böhmerwald), Bavaria. The top of Hochstein Mt., (1339 m) is built of two-mica granite of the Eisgarn type. The conspicuous rock outcrops attracted attention of prehistoric man in high altitudes also as is evidenced by a find of chipped artefact between the tops of Hochstein and Plechý (Fröhlich 1997). Postcard, around 1930.

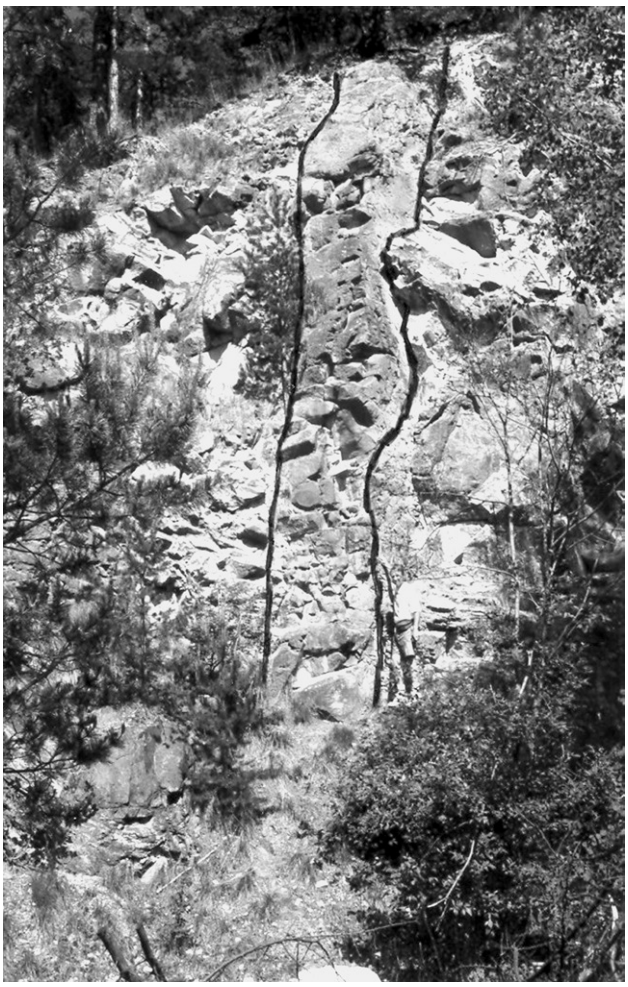

Fig. 12. Moldanubicum, Jemnice „Na Jemničkách“, 1998. A vertical dyke of younger lamprophyre breaks through marbles and amphibolites of the Varied Group. Archives of the author, photo in 1998.

quartz connected with pegmatite bodies in the surroundings of Lipno Dam reservoir, in the area of Písek, near Brtnice in the area of Jihlava and in the wider surroundings of Žďár nad Sázavou. Siliceous weathering products of serpentinites or other metamorphic rocks respectively represented also important sources of unusual raw materials for chipping. We know them at almost all serpentinite bodies in western Moravia, in southern Bohemia around the small town of Křemže, in Lower Austria e.g. near the village of Japons and they can be supposed in the Bavarian part of the Moldanubicum at silicified marbles or ultrabasic rocks. Permian acid subvolcanics of the Lásenice type were use for chipped artefacts in southern Bohemia and SW Moravia.

In the other way, a lot of metamorphic and igneous Moldanubian rocks fulfilled requirements for polished artefact raw materials. From metamorphic rocks there were used especially fine-grained amphibolites in Lower Austria, probably some serpentinites in western Moravia, marbles of the Moravian Varied Group are supposed to be polished for bracelets and pearls in the Neolithic, in places there were rarely used granulites and orthogneisses. It is necessary to mention production of small Eneolithic axes from quartz-sillimanite lenses occurring in widely spread biotite-sillimanite paragneisses not only in western Moravia but also in southern Bohemia and Bavaria. As is igneous rocks concerned, especially younger dykes of lamprophyres (Fig. 12) appear among the raw materials for polished artefacts. Granites of the both largest batholiths and durbachites of the Třebíč Massif were used in the Middle Ages for millstones and very probably they served for this purpose already in prehistoric times (querns). Dark mica from weathered and disintegrated durbachites of the Třebíč Massif was used as a temper for prehistoric pottery.

I.4.1.2. Kutná Hora – Svratka Region

Independant position of the region is sometimes debatable because some geologists believe to be a part of the Moldanubicum; in any case its part is possible to compare with the Gföhl Group of the Moldanubicum. In general, it differs from the Moldanubicum by lower metamorphosis (the boundary against the Moldanubicum is usually put on the muscovite isograde, it means the southernmost occurrences of muscovite in the Kutná Hora – Svratka Region), by rock composition of the metamorphic complexes (prevalence of two-mica paragneisse and micaschist) and by the absence of Variscan granitoide massifs. The region has the west – east elongation, i.e. it runs from central Bohemia to western Moravia, geologically it bordes the Moldanubian Region in the north. It is possible to distinguish within it three parts: the Kutná Hora, Oheb (or Čáslav) and Svratka Crystalline Units (Mísař et al. 1983; Chlupáč & Vrána, eds 1994). As a consequence of strong frost weathering in the Pleistocene morphologically conspicuous frost cliffs or rock walls have originated (Fig. 13) especially in the Svratka Crystalline Unit.

Sources of Raw Materials in Prehistory: As is raw materials for prehistoric polished artefacts concerned, marbles and amphibolites of the Šternberk-Čáslav Group in the Kutná Hora Crystalline Unit were the most important. The marbles were quarried already in the Neolithic at

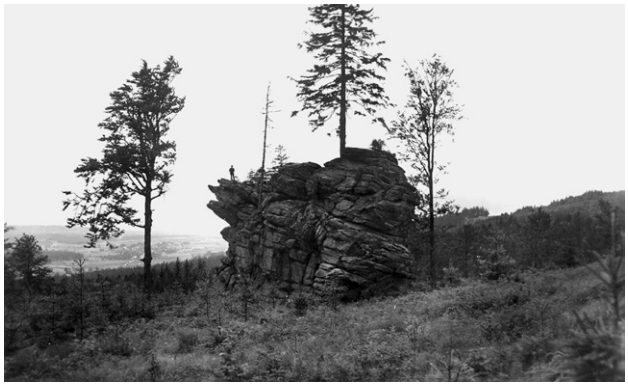

Fig. 13. Svratka Crystalline Unit, Cikháj near Žďár nad Sázavou. Migmatitized two-mica gneiss forms often frost cliffs to walls. Postcard, 1947.

Fig. 14. Stone stele from the Celtic sanctuary at Libenice (district of Kolín), 2 m hight and weighting about 1.4 ton. It is composed of two-mica migmatite to orthogneiss from the Kutná Hora Crystalline Unit. To the place of finding was transported at a distance minimally 1.5 km. At present it is situated in the courtyard of the Archaeological Institute of AS CR in Prague. Photo by the autor, 2006.

the Bílý kámen Hill near the town of Sázava, in addition to it we can suppose making of polished artefacts from fine-grained amphibolites cropping out e. g. at Markovice near Čáslav and for this purpose we can not exclude using of serpentinites and eclogites from small bodies in the surroundings of Kutná Hora. Raw material for chipped artefacts could be siliceous weathering products of serpentinite near Bořetice where Kratochvíl (1947, 494) has introduced up to 10 x 7 cm big fragments of dark brown opal, in places with green-grey stripes. Extraordinary find of 1,4 ton weighting artificially pointed monolith made of migmatite to orthogneiss from the Kutná Hora Crystalline Unit (Fig. 14) has been described by Rybová & Soudský (1962) from the Celtic sanctuary place at Libenice near Kolín (eastern Bohemia). It was transported at the distance of 1.5 km minimally.

1.4.1.3. Central Bohemian Region (Bohemicum)

A vast area elongated in the east-west direction lines the Moldanubicum and the Kutná Hora-Svratka Region from western Bohemia as far as western Moravia. However its eastern elongation through to the Letovice Crystalline Unit (Mísař et al. 1983, Chlupáč & Štorch et al. 1992) most probably is not correct and it should very likely be ended up at the Hlinsko Zone. This is because of lithological similarity of the Polička Crystalline Unit with the classic units of the Lugicum, i.e. the Zábřeh and Staré Město Crystalline Units.

Contrary to the previous two regions, in the Bohemicum the levels of Upper Proterozoic and Lower Palaeozoic may be reliably corroborated due to finds of fossils. This characteristic feature may be observed both in the Barrandian and in the area of the Železné hory Mts. and the Hlinsko Zone. The Domažlice and Teplá (possibly also Tachov) Crystalline Units in western Bohemia are usually considered to be more strongly metamorphosed equivalents of the Proterozoic of the Barrandian.

Proterozoic of the Barrandian

It forms an area in the shape of an elongated triangle with a vertex near Brandýs nad Labem and a foot roughly between Klatovy and Vlčí hora to the west of Stříbro. The central part (Křivoklát area) is available to the public on a 1: 50 000 geological map (Mašek, ed. et al. 1997). It is a complex of only slightly metamorphosed sedimentary and volcanic rocks with an overall thickness estimated at over 10 000 m, which is divided into two groups: the older Kralupy-Zbraslav and the younger Štěchovice Group. In the Kralupy-Zbraslav Group dark siliciclastic rocks (greywacke, siltstone, and shale) prevail; in the NE – SW direction five stripes of volcanics of the so-called spilite and quartz keratophyre association are placed out in them. Occurrences of our oldest silicites (phthanites), the lenticular bodies of which due to their endurance often form conspicuous little rocks visible in the landscape (Fig. 15), are probably related with this submarine volcanism. We are aware of our oldest microfossils (Algae, Cyanophyta) from phthanites or sporadic small bodies of limestones. Occurrences of the so-called alum shales (black shales rich in pyrite) from which alum and sulphuric acid were produced in the past are of interest from the economic viewpoint. On the grounds of the chemical composition of this volcanism and its likely development in the space and time it is assessed as island arc volcanism. The younger Štěchovice Group may be interpreted as Cadomian flysch (a rhythmic alternation of

Fig. 15. Barrandian. The oldest Bohemian silicites – Proterozoic phthanites – crop out also in the territory of Prague in the valley of Divoká Šárka where they form e. g. rock outcrop Dívčí skok (background right). Postcard, 1940.

Fig. 16. Barrandian, the castles of Žebrák and Točník. The bed of quartzites at the base of Ordovician sediments was well visible before forestification of the both castle hills. The quartzites had been used for lower part of querns in the Neolithic. Postcard, condition in 19th century.

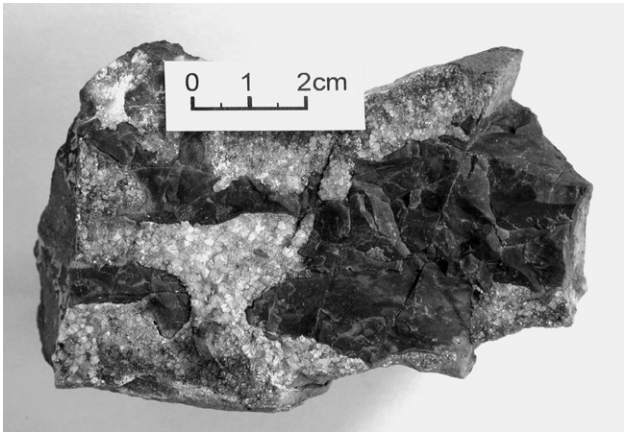

Fig. 17. Barrandian, Prague. Black chert concretions (about 8 cm) in the Devonian Zlíchov limestone from the Barrande Rock. Photo by the author.

clayey shales, siltstones, and greywackes); conglomerates are also significantly represented. The Štěchovice Group stretches in the SE part of the Barrandian between Úvaly and Příbram.

Domažlice and Teplá Crystalline Units

To the west of the Proterozoic of the Barrandian proper roughly through to the Bohemian Quartz Lode (i.e. to the boundary with the Moldanubicum) a quick increase in metamorphism occurs, and from the emergence of biotite (biotite isograde) the rocks in the territory between Domažlice and Bor near Tachov are classified as the Domažlice Crystalline Unit. Lithologically this is a transition from phyllites through mica schists to gneisses at a relatively small distance. A similar situation is found to the north-west of the Proterozoic of the Barrandian, where metamorphites to the north-west of the biotite isograde through to the Litoměřice deep fault are a part of the Teplá Crystalline Unit. A vast occurrence of metamorphosed basic and ultrabasic igneous rocks is found within the Mariánské Lázně metabasite complex.

Barrandian Lower Palaeozoic

The Barrandian is a territory of a worldwide fame, with the presence of sediments from Early Cambrian to Middle Devonian. Cambrian sediments (conglomerates, sandstones, and silty shales with trilobites), which may be considered the molasse of the Cadomian orogen in this area, are spread in two basins: the Příbram-Jince (Brdy) Basin, and the substantially smaller Skryje-Týřovice Basin. They are also present within the so-called Rožmitál Palaeozoic. Our oldest macrofossils (arthropod *Kodymirus vagans* in the Paseky shales) are known from the Early Cambrian sediments, which evolved mainly in fluvial and lacustrine, but in places also lagoon brackish environment. Ordovician sediments were deposited after the hiatus; they form a basal formation of the Prague Basin and are often deposited directly on the folded Proterozoic. These are firstly quartzites and conglomerates (Fig. 16), greywackes and sandstones, with silicites (spongolites) upwards, but a prevailing part of the Ordovician sediments is represented by alternation of quartzites, siltstones, and shales. Basic volcanic rocks, their tuffs, tuffites, hyaloclastites with often accompanying iron ores are present as well. The Ordovician sediments (the Letná Formation) have a marked share in the morphology of Prague, as they form the Hradčany Mound, the Vyšehrad Rock, or Vítkov Hill. Bigger clasts of exotic rocks that apparently fell off from thawing blocks of ice floating on the Ordovician sea (so called "dropstones") are described from the youngest Kosov Formation. A synoptic geological map of Prague and its surroundings at the 1:100 000 scale was compiled by Kovanda (1995); geology and the most interesting sites in the surroundings of Prague were elaborated in detail by Chlupáč (1999).

The Lower Silurian is characterised by sedimentation of black graptolite shales, and an intense submarine basaltic activity manifests itself again. Organogenic limestones, or in places tuffaceous calcareous shales emerged on volcanic elevations or in their vicinity. The Upper Silurian is mainly represented by limestones the best known of which are cephalopod ("orthoceras") limestones that were largely utilised as a decorative stone. The Silurian/Devonian boundary is excellently documented in the Barrandian; for this reason both international stratotype and parastratotype of this boundary are located in this area (Klonk near Suchomasty, the Budňanská skála Rock near Karlštejn). The sediments of Lower and early Middle Devonian are represented by various types of limestones, often with nodules of cherts (Fig. 17); it was only towards the end of Devonian when flysch-like alternations of siltstones, sandstones, and to a lesser degree also clayey shales (the Srbsko Formation) were deposited.

Crystalline units of the Železné hory Mts. and the Chrudim Palaeozoic

In the area of the Železné hory Mts. we are aware of analogical units to the Barrandian: the Železné hory (the Chvaletice-Sovolusky) Proterozoic, its probably more strongly metamorphosed equivalent is the Podhořany Crystalline Unit, and an analogy of the Barrandian Palaeozoic is the Chrudim Palaeozoic. In the latter unit sedimentation is considered from Middle Cambrian to Lower Devonian, and occurrences of Silurian to probably Lower Devonian limestones are known from the area between Prachovice and Vápenný Podol. A comprehensive work on the geology of the Železné hory Mountains is the publication by Vodička (1997).

Hlinsko Zone

As against the other units of the Bohemicum, this has an unusual north-southern routing between the Železné hory Pluton in the west and the Svratka Crystalline Unit in the east. The southern half (from Křižová to Hlinsko) is considered a volcano-sedimentary complex of Upper Proterozoic age. Phyllitic slates and greywackes NE of Hlinsko are either Upper Proterozoic, or already Lower Palaeozoic. Superposed quartzites are considered Ordovician as there are paleontologically evidenced Silurian graptolite shales above them. Judging by microfossils, the northernmost part of the Hlinsko Palaeozoic is most probably Middle Devonian, however Lower Carboniferous cannot be excluded either.

Polička Crystalline Unit

It is located to the north of the Svratka Crystalline Unit; the critical objections to its classification within the Central Bohemian Region were already mentioned. It is a monotonous complex of fine-grained biotite and two-mica gneisses with attitudes of marbles and amphibolites in the lower part. Bodies of quartz diorites elongated in parallel with foliation and forming contact zones of varying thickness around them are its characteristic part. Moreover, bodies of two-mica granites are found at the boundary with the Hlinsko Zone, and those of gabbros and diorites in the surroundings of Polička.

Letovice Crystalline Unit

Likewise with this unit neither its regional and geological classification nor its dating is quite clear but according to the hitherto valid regional geological division (Chlupáč & Vrána, eds. 1994) it is named within the Central Bohemian Region. To the north it stretches through to the faults near Moravská Třebová or is covered by the Cretaceous sediments, in the east it is overlaid by the Permian of Boskovice Furrow. Mísař et al. (1983) divide the unit into Monotonous and Ophiolite Groups. The first group consists of two-mica gneisses and mica schists with attitudes of quartzites, metaphthanites, metacarbonates, and graphitic rocks; the second group contains an array of cumulate ultrabasic rocks and metagabbros in the north-east, and ultrabasic rocks and metavolcanites in the south-western part.

Sources of Raw Materials in Prehistory: The Central Bohemian Region, namely the Palaeozoic of the Barrandian and the Chrudim Palaeozoic, offers a number of cherts of Ordovician, Silurian, and especially Devonian age, and these were indeed more or less used, mainly for chipped tools. Also the oldest silicites in the Bohemian Massif – the Proterozoic phthanites – were in the centre of attention of primeval humans especially in the Palaeolithic. Contrariwise, spilite volcanoclastics of the Barrandian Proterozoic served for the manufacture of axes in the Eneolithic; also acid and intermediate Cambrian volcanites (palaeorhyolites and palaeoandesites) of the Křivoklát-Rokycany Belt were used for polished industry. Future research will show whether gabbros and ultrabasic rocks of the Ransko Massif or the Letovice Crystalline Unit were utilised for these purposes, and what was the role played by the serpentinites of the Mariánské Lázně Complex.

1.4.1.4. Saxothuringian Region (Saxothuringicum)

The largest unit of this region within the Czech territory is the Krušné hory (Erzgebirge) Crystalline Unit, which builds the entire borderline zone between Jáchymov in the SW and the Tisá Pass near Děčín in the NE. In the south it is restrained by the distinct Krušné hory Fault. The geological map of the western part of the region at the 1: 50 000 scale was compiled by Škvor & Sattran, eds. et al. (1974). The oldest unit – the Freiberg Group (lower grey gneisses) outcrops in the NE, the main central part consists of the Krušné hory Group – top grey gneisses, red gneisses, and migmatites (Fig. 18), and finally in the SW it is the youngest Jáchymov Group (two-mica gneisses and mica schists, carbonate schists, metabasites). On the western side of the Cheb Basin the Smrčiny (Fichtelgebirge) Crystalline Unit protrudes. Its partial units are usually compared with the individual groups of the Krušné hory Crystalline Unit (Mísař et al. 1983): there does not appear to be an equivalent of the Freiberg Group, only the rocks in the surroundings of Aš correspond with the Krušné

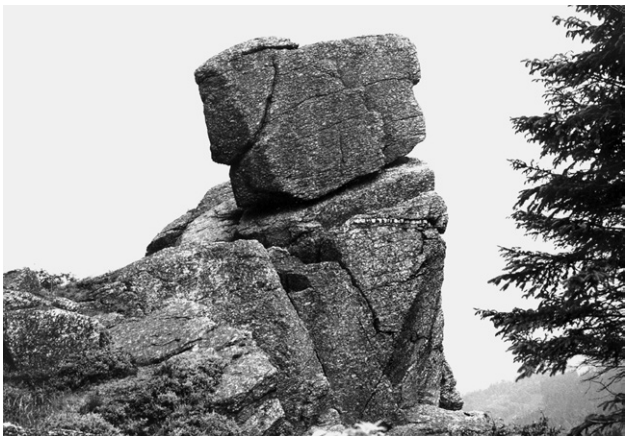

Fig. 18. Krušné hory Crystalline Unit, flaser-gneiss, rocky formation called Sphinx. Activities of prehistoric man are proved or supposed around some conspicuous rocks in the summit parts of the Krušné hory Mts. (Koutecký 1985, Marek 1999). Postcard, 1968.

hory Group; nevertheless a complex of rocks corresponding with the Jáchymov (possibly also the Arzberg) Group would be significantly represented. The Variscan Smrčiny Pluton protrudes in the core of the crystalline unit. In the western part of Cheb and to the southwest of the Cheb Basin not very extensive the Cheb-Dyleň Crystalline Unit crops out (phyllites, quartzites, two-mica to biotite mica schists). Contrariwise, to the east of the Cheb Basin there is another unit of this region – the Svatava Crystalline Unit (mica schists, phyllites, and quartzites of unspecified age). The Vogtland-Saxony Palaeozoic only slightly steps into the Czech territory.

In the area of the Krušné hory Mountains, the Variscan granitoids are again significantly represented in the Karlovy Vary-Nejdek Pluton. Two main types are divided in it: the so-called mountain granites, i.e. older porphyritic biotite granites and granodiorites, and younger Krušné hory (autometamorphosed) granites with characteristic alterations, accompanied in places by greisenization and tin mineralization.

Sources of Raw Materials in Prehistory: If the Kukla's (1970) research of raw materials for polished artefacts of the Corded Ware culture in the well known cemetery of Vikletice was correct, a relatively extensive utilization of the Krušné hory Crystalline Unit rocks, erlans according to him, follows from it. The body of Permian ignimbrites near Teplice (formerly the Teplice quartz porphyry) yielded rocks suitable for crushers, querns and millstones. So far we do not know whether siliceous weathering products of local ultrabasic rocks from Ahníkov and Černovice could be used for chipped artefacts.

1.4.1.5. Lusatian Region (Lugicum)

The Lusatian Region is divided by the Intra-Sudetic Basin into two different parts. The Western Sudetenland part consists of the Elbtalschiefergebirge in Saxony (with only a small equivalent in the Elbe valley to the north of Děčín in northern Bohemia) and several granitic rock massifs, the Lusatian Pluton with a crystalline mantle, and in the Czech territory the largest Krkonoše-Jizera Crystalline Unit. The Eastern Sudetenland part is built by the Orlice-Sněžník Crystalline Unit, to which the Nové Město Crystalline Unit adjoins in the west, the Zábřeh Crystalline Unit in the south, and the Staré Město Crystalline Unit in the east.

Elbtalschiefergebirge

It emerges to the south of Dresden, and is elongated in the NW – SE direction. The oldest rocks are phyllites with quartzites and quartzose slates on the base, higher up with attitudes of chloritic gneisses, marbls, and amphibole-chlorite schists. According to the map explanations by Gotte & Hirschmann, eds. (1972), from the viewpoint of age these rocks are classed within the Cambrian and Ordovician. They are most probably followed by the Upper Ordovician shales and quartz sandstones with paleontologically evidenced Silurian quartzose shales with lydites above them. Lower and Middle Devonian rocks are missing; the Upper Devonian is represented by basalte ("diabase") volcanism with abundant tuffs, intercalations of limestones, and with cherts in the highest part. There are conglomerates with pebbles of quartz shales and cherts on the base of Lower Carboniferour followed by shales and greywackes higher on. A relatively large syenite-diorite massif (amphibole syenodiorite, biotite granodiorite and other igneous rocks) crops out in the surroundings of Meissen.

Lusatian Pluton

The largest magmatic body is the Lusatian Pluton that emerges primarily to the west of Polish and German border as far as the Elbe valley, with the smaller part on the Polish side between Zgorzelec and Zawidów; it steps into the Czech territory in the Varnsdorf projection and the western part of the Frýdlant projection. Petrographically it is biotite granodiorite, two-mica granodiorite and biotite granite connected with the Cadomian orogenesis.

Krkonoše-Jizera Crystalline Unit

This part of the Lusatian region is elaborated in detail in the monograph by Chaloupský et al. (1989) and in the 1:100 000 geological map (Chaloupský, ed. 1989). It is divided into several further units. From the west it is firstly the Jizera Crystalline Unit formed primarily by Jizera orthogneisses (interpreted as strongly deformed granites of the Lusatian Pluton). The Krkonoše Crystalline Unit also constitutes the Proterozoic level (with orthogneisses in its southern part and mica schists and phyllites in the northern part, which are in addition partly thermally metamorphosed by the Krkonoše-Jizera Pluton). The Lower Palaeozoic level is represented by the Ještěd, Železný Brod, and Rýchory Crystalline Units. The largest area is that of Železný Brod Crystalline Unit (Ordovician – Devonian) consisting mainly of phyllites, rarely of dolomites, and a mighty volcanic complex metamorphosed to greenschists. Finds of blueschists considered to be a proof of Devonian subduction on the northern margin of the Bohemian Massif are of great importance. Until quite recently the geological situation in the Ještěd Crystalline

Fig. 19. Lugicum, the Železný Brod Crystalline Unit. A view from Návarov towards the north to the valley of Kamenice River. On the western slope of Jírův kopec Hill (746 m, in the background to the right of the valley) the author found in 2002 prehistoric quarries of thermally metamorphosed metabasites for polished artefacts. The Černá Studnice ridge is at the same level to the left of the valley. Postcard, 1932.

Unit was considered an evidence of the Caledonian orogenesis manifestation but this was not corroborated by the research of the recent years. The rocks at the northern margin of the Železný Brod Crystalline Unit were thermally metamorphosed by the younger Krkonoše-Jizera Pluton; this enhanced the properties of local greenschist or metabasite intercalations to such a degree that they became the most sought raw material for the Neolithic shoe-last adzes and flat axes in this part of Central Europe (Fig. 19).

Orlice-Sněžník Crystalline Unit

Forming a core of the Eastern Sudetenland region, this crystalline unit geographically covers especially the Orlické hory Mts. the geological map of which was compiled by Opletal & Domečka, eds. (1983), and the Králický Sněžník (geological map by Gawlikowska & Opletal et al. 1997). The division is again based on lithostratigraphy. The presumably Proterozoic Sněžník Group (gneisses, orthogneisses, and migmatites) is alternated with the markedly more variegated Stronie Group (gneisses, micaschists, marbls, amphibolites, quartzites, metalydites, and graphitic rocks). Its age could even be Lower Palaeozoic.

Nové Město, Zábřeh, and Staré Město Crystalline Units

These crystalline units line the Orlice-Sněžník Crystalline Unit on the south-west, south, and east. The Nové Město Crystalline Unit in the west is built in its lower part mainly by phyllites, in the upper part by metagreywackes and metapelites. Basic volcanism metamorphosed to amphibolites and greenschists is significantly represented in both parts. The original sedimentary rocks of the Zábřeh Crystalline Unit were altogether more coarse-grained (greywackes). These were metamorphosed to mica schists to gneisses, but amphibolites, greenschists, marbles, and small serpentinite occurrences are present as well. The horizon of metaconglomerate near Hoštejn is significant; it divides the crystalline unit into two parts. The southern part is of Lower Palaeozoic age, the northern one is composed most probably from Proterozoic rocks. Bodies of amphibole quartz diorites (tonalites) of Variscan age form a part of the Zábřeh Crystalline Unit. The Staré Město Crystalline Unit is located to the east of the Orlice-Sněžník Crystalline Unit, and represents the easternmost unit of the Lugicum. It is usually divided into the more westerly Hraničná Group (biotite and two-mica gneisses with interbeds of marble, erlan, graphitic shale, and quartzite) and the Ophiolite Group (amphibolites with lenses of ultrabasic rocks and metagabbros). The age of the Ophiolite Group is recently stated as Cambrian. Again, bodies of Variscan quartz diorites (tonalites) are present, around which thermal metamorphosis has occurred.

Sources of Raw Materials in Prehistory: The most important rocks are thermally metamorphosed metabasites at the contact of the Železný Brod Crystalline Unit and the Krkonoše-Jizera Pluton in the territory between Jablonec nad Nisou and Tanvald, which were extensively quarried especially in the Neolithic as a very high quality raw material of shoe-last adzes and flat axes. Other territory of resource is represented by the serpentinite massifs in the surroundings of the Góry Sowie Mountains block in Poland. Extraction of serpentinites for battle axes of the Corded Ware culture is evidenced in the Gogolów-Jordanów Massif; apparently siliceous weathering products of serpentinites were also used for the manufacture of chipped tools. It is very much likely that some types of gabbros from the Ślęża Mountain slopes were polished; utilization of the local granites for prehistoric sculptures, rotary querns and millstones was described as well. Devonian radiolarites from the Bardo Palaeozoic Unit were chipped in the Mesolithic. Processing of gabbros and ultrabasic rocks from the Staré Město Crystalline Unit for polished implements was not corroborated so far.

I.4.1.6. Moravo-Silesian Region (Moravosilesicum)

It is in a crosswise contact with all the previously mentioned regions except for the Saxothuringicum. The lower level of the region consists of an old block consolidated during the Cadomian orogenesis and called the Brunovistulicum; this is overlain by rocks of various degree of folding and metamorphosis and being of Cambrian to Permian age. The western boundary of the region is represented by the Moravo-Silesian Fault Zone; the eastern one is a margin of surface outcrops roughly on the Znojmo – Brno – Přerov – Ostrava line. However the Brunovistulicum continues in the basement of the Carpathian Foredeep and flysch nappes to the east, at least to the Klippen Zone of the Western Carpathian. It crops out in the form of the Brno Batholith and Olomouc Massif, further on it forms parts in the structures of Moravicum: the Dyje (Thaya) Massif with its envilope in the Thaya Dome, the Deblín Group in the Svratka Dome and the Kladky Crystalline Unit in the Nectava Structure. Detailed geology of a great part of the Moravo-Silesian region is assessed in the proceedings Geology of Moravia and Silesia (Přichystal, Obstová & Suk, eds. 1993).

The Brno Batholith is of a triangular shape with points roughly near Boskovice, Miroslav, and Brno. In geological maps it is distinguished by a conspicuous three-part structure: the western granitoide part, the metabasite zone, and

Fig. 20. Brno Batholith. Quarry for metabasites at Želešice south of Brno. Photo by the author, 1998.

Fig. 21. Vrbno Group of the Silesicum. Bradlo Hill (600 m) near Šumperk. Deformed quartz conglomerate of Devonian age. In the Neolithic, it was used as lower parts of querns. Photo by the author, 1987.

the eastern granitoide part. On the grounds of mapping there are usually three types of granodiorites differentiated in the eastern part, with six or more granite – granodiorite types in the western part that is generally more granitic (Štelcl & Weiss et al. 1986). Granodiorites are either biotite or amphibole-biotite ones. The metabasite zone is divided into more westerly metadiorite part consisting of amphibole metadiorites with lenses of serpentinites, uralitized ultrabasic rocks and hornblendites that underwent several alterations, and nowadays have the character of greenschists or amphibolites (Fig. 20). Apart from the prevailing, strongly deformed metabasalts and their volcanoclastics the more easterly metabasalt subzone also contains small layers of acid volcanites. Newly published radiometric data provide evidence that this is the oldest volcanism in the Czech Republic. The Brno Batholith also contains both light and dark dyke rocks, the light aplites and simple pegmatites are of the Cadomian age, the dark porphyritic microdiorites and lamprophyres are Variscan. The prevailing part of the Brno Batholith is captured in the Geological map of Brno and surroundings at the 1: 50 000 scale (Hanžl et al. 1999), the geology of this territory is characterized in the publication by Müller & Novák et al. (2000).

The Olomouc Massif is represented by outcrops of granitoids among Olomouc, Prostějov, and Přerov. The outcrops are small-sized; in spite of it they are important from the geological viewpoint. They crop out in the cadastral areas of Krčmaň, Dub nad Moravou, Hněvotín, Třebčín, Čelechovice na Hané and are represented by pegmatite, muscovite and two-mica granite, biotite quartz diorite, and biotite to two-mica granodiorite.

Moravicum

At the beginning of the 20th century F. E. Suess designated two tectonic half windows (the Dyje and Svratka Domes) emerging in the basement of the overthrusted Moldanubicum. The third comparable Nectava Structure is represented by three minor crystalline units cropping out in the Culmian rocks of the Zábřeh Highland (the Kladky, Nectava and Svinov-Vranová Crystalline Units). The individual Moravian structures consist of an autochthonous or possibly paraautochthonous parts corresponding to the Brunovistulicum and the Moravian nappe.

The autochthonous part in the Svratka Dome is formed by so called the Deblín Group of Proterozoic age (mylonitized granitoids with their crystalline mantle) and the Devonian clastic rocks and limestones lying over it. From the bottom the Moravian nappe consists of the Bílý potok Group (prevailingly phyllites), the Býteš Group (prevailingly orthogneiss), and the Olešnice Group (mica schist, marble, amphibolite, garnet paragneiss, and phyllites).

The autochthonous part in the Dyje Dome is built of the Dyje Massif with the lower part of the former Lukov Group (in the sense of Austrian geologists it is the Therasburg Group). On the surface the Devonian sediments are only

Fig. 22. Brno-Hády. Folded Hády – Říčka limestones with bedding cherts, above them platform Jurassic limestones with chert concretions. Photo by the author, 2007.

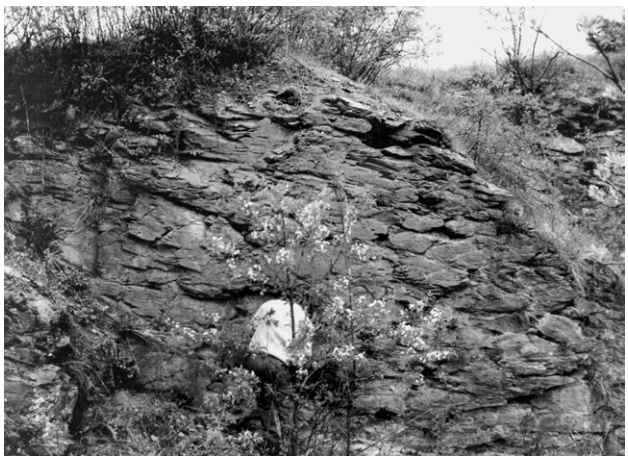

Fig. 23. Pillow lavas of the Devonian spilites near Šternberk, central Moravia. Devonian volcanic rocks (dolerites, spilites and spilite porphyrites) were probably sometimes worked for polished artefacts in prehistoric times. Photo by J. Otava, 1978.

represented by basal clastic rocks, limestones were drilled under a Tertiary sedimentary cover. The local Moravian nappe has an analogical structure to the Svratka Dome: from the bottom the upper part of the Lukov Group (according to Austrian geologists it is the Pernegg Group, the Bíteš Group, and the Vranov Group). The 1: 25 000 geological map of the Podyjí National Park, which comprises a substantial part of the Dyje Dome in the Czech territory, was compiled by Batík (1992).

Silesicum

It builds the geological foundation of the Hrubý Jeseník Mts., a great part of the Hanušovice and Zlaté Hory Highlands (see the geological map of Jeseníky prepared by Aichler & Koverdynský et al. 1987). In the west the Lugicum is thrusted over the Silesicum alongside the Nýznerov and the Ramzová thrusts. The first western Silesicum unit is wedged between these thrusts in the northern part; it is the Velké Vrbno Group of largely variegated lithology. Its age corresponds very probably to the Lower Palaeozoic. Further to the east is located the Branná Group the upper part of which (graphite phyllites with marbles) is Lower Palaeozoic, most likely Devonian. The Keprník Group rocks are heterogeneous – in the central part the group is built by orthogneisse and migmatite (the tops of Keprník and Šerák), the margins are considerably more variegated (paragneisse, mica schist, phylite, quartzite, and marbles). The rocks of the Červená hora Pass Group are of Devonian age, and create a link between the Sobotín and the Jeseník amphibolite massifs. The area of the highest Moravian mountain Praděd and another one to the north (Orlík Mt.) is formed by the Desná Group (dynamically metamorphosed paragneisses to phyllonites, and orthogneisses of Orlík). The easternmost part of the Silesicum is called the Vrbno Group reliably classified as Devonian. Lithologically it consists mainly of phyllites, quartzites, metaconglomerates (Fig. 21), metabasites and metaquartzkeratophyres, the Lahn-Dill type iron ores, rarely also marbles.

Moravo-Silesian Palaeozoic

It comprises non-metamorphosed or only slightly metamorphosed rocks in the range from the Lower Cambrian to Upper Carboniferous (the limnic Permian and Upper Carboniferous rocks are characterized in the next chapter). Cambrian sediments were evidenced only recently, and for the time being we only know them from drill holes. Sediments of the Ordovician age from the Moravian-Silesian region are not corroborated. Silurian black graptolite shales form a point occurrence near the village of Stínava in the Drahany Highland probably within a tectonic slice of predominantly Devonian rocks. A vast area of extension only relates to rocks of the Devonian age, which are usually divided into two basic developments: the Moravian Karst or platform development and the Drahany or basinal development. The Moravian Karst development is characterised by a total dominance of limestones after sedimentation of basal clastic rocks. The lower Macocha Formation, which consists of the Josefov, Lažánky, and Vilémovice limestones, is followed by the Líšeň Formation with the Hády-Říčka (Fig. 22), Křtiny, and Hněvotín limestones. A detailed, 1: 25 000–scaled geological map of the Moravian Karst was published by Dvořák (1993) in the form of atlas. The basinal development is characterized by clayey and silty shales with small lenses of impure limestones (the Stínava-Chabičov Formation), and especially by submarine spilite-quartz keratophyre volcanism (Fig. 23). The Jesenec limestone originated near the volcanic elevations; the highest part of this development is formed by shales with radiolarites (the Ponikev Formation).

The Lower Carboniferous (Culm) rocks are especially spread in the Drahany and Nízký Jeseník Highlands. After the sedimentation of the Březina shales with trilobites there are three formations in the Drahany Highland differentiated from west to east: the Protivanov Formation (flysch character), the Rozstání Formation (prevalence of shales), and the Myslejovice Formation (with the dominance of conglomerates). In the Nízký Jeseník Highland the Culmian sedimentation begins with the Andělská hora Formation (shales, siltstones, and greywacke), in the east it borders on the Horní Benešov Formation (predominantly greywacke), followed by the Moravice Formation (flysch with prevalence of shales and siltstones), and finally the Hradec-Kyjovice Formation (greywackes with lenses of conglomerates below, and siltstones and clayey shales with lenses of greywackes higher on). The last formation verges into the Upper Carboniferous.

The Upper Carboniferous (Namurian to Westphalian) is mainly represented in the Upper Silesian Basin (Variscan Foredeep), although its great part is hidden under Neogene and Quaternary sediments there. Both of the main Ostrava and Karviná Formations feature a characteristic cyclic structure: basal sandstones or conglomerates, siltstones, coal beds, and claystones.

Sources of Raw Materials in Prehistory: With only the Devonian to Lower Carboniferous radiolarites of the Ponikev Formation and the cherts of the Hády-Říčky limestones emerging the crystalline units and the slightly metamorphosed Palaeozoic of the Moravo-Silesian region is lean in materials suitable for chipped artefacts. So far chipping of the radiolarites was not described; the other raw material mentioned was recorded in a small quantity among the chipped artefacts of the Magdalenian in the Pekárna Cave situated in the southern part of the Moravian Karst. On the other hand the Moravo-Silesian region yielded a wide spectrum of high-quality raw materials for polished tools. In the first place it is necessary to mention the metabasites of the Brno Batholith, out of them primarily those from Želešice to the south of Brno, furthermore the non-deformed diorites from the surroundings of the Brno Dam, and porphyritic microdiorites that emerge in the form of veins in many places in the wider surroundings of Brno. In central Moravia and in Silesia we are aware of a wide utilisation of Culm siltstones and fine-grained greywackes for drilled polished tools towards the end of Neolithic and in the course of Eneolithic. People with the Moravian Painted Ware in

Mokrá near Brno also used the poor quality, disintegrating Březina shales of the Lower Carboniferous age for small polished axes.

Granodiorites of the Brno Batholith, possibly also mylonized biotite granites of the Dyje Massif served as the saddle querns at the Neolithic sites of Vedrovice or Těšetice near Znojmo; especially vein aplitic granites in the Krumlovský les type granodiorite were favoured for this purpose. Violet rocks of basal Devonian clastics (quartz conglomerates, feldspathic sandstones) may be often observed also as raw materials for saddle querns (e.g. in the Funnel Beaker workshop at Stránská skála). Throughout Moravia and Silesia, in the area of the Drahany, Zábřeh and Nízký Jeseník Highlands we come across abundant crushers made of Culm greywackes to fine-grained conglomerates.

I.4.1.7. Limnic Upper Carboniferous and Permian

They lie discordantly on individual units of all the mentioned regions; their sediments have the largest spread in the Central Bohemian and Lusatian Regions. The thickness may even exceed 3 000 m (the Intra-Sudetic Basin, the Boskovice Furrow). The exclusively continental (lacustrine, lacustrine-deltaic, alluvial, proluvial) sedimentation is accompanied by so called melaphyre or quartz porphyry volcanism (Fig. 24), although chemically these are basaltic andesites, with acid rhyolites and ignimbrites also present, e.g. in the Vraní and Javoří Mountains. Sediments are usually represented by conspicuously red-brown conglomerates, arcoses, shales, interesting are horizons of diverse-coloured tuffitic rocks with limnic silicites, abundant plant remains, and finds of stegocephalians (the earlest amphibia colonized the dry land of the Bohemian Massif). A complex elaboration of the limnic Upper Carboniferous and Permian in the Czech territory is in the work by Pešek et al. (1998).

As far as spreading of the limnic Upper Carboniferous and Permian in the individual regions is concerned, they are only slightly represented in the Saxothuringian Region near Brandov and Mikulov. Vast occurrences are found in the Central Bohemian Region (from west to east it is the Manětín, Plzeň, Žihle, Rakovník, Kladno, Roudnice, Česká Kamenice, and Mšeno Basins). Classic territories are the Upper Carboniferous and Permian basins in the Lusatian Region (Krkonoše Piedmont, Lower Silesian, and Mnichovo Hradiště Basins). In the area of the Moldanubicum it is the Blanice Furrow, only partly preserved, and the practically totaly denuded Jihlava Furrow the continuation of which presumably represents the occurrence of the Permian in the Železné hory Mts. near Seč and Kraskov. At the contact of the Brno Batholith with the Moravicum and the Moldanubicum there is the third, best preserved Boskovice Furrow that continues to the NW of Městečko Trnávka (the Malotín Horst) trough to Potštejn into the Orlice Basin.

Fig. 24. Kozákov Hill (744 m) near Turnov. Permian basaltic andesites (melaphyres), the summit part is formed by a Tertiary basalt. The castle Trosky built on a Tertiary olivine nephelinite in the background. Postcard, around 1947.

Sources of Raw Materials in Prehistory: Important raw materials for chipped tools were Upper Carboniferous and Permian limnic silicites (formerly called cherts) known to us from the Krkonoše Piedmont Basin, the Intra-Sudetic, and the Plzeň Basins. Permian silicified wood (araucarian conifers) were sometimes also used for chipped artefacts. Vein and cavity fillings in Permian basaltic andesites (melaphyres) made up by SiO_2 minerals (mainly jasper, chalcedony, and agate) primarily from the Krkonoše Piedmont Basin were also used for these purposes. Melaphyres were suitable for grinding stones, acid Permian volcanites (rhyolites, rhyolite ignimbrites, formerly quartz porphyries, e.g. from Kamenné Žernoseky in Bohemia) were widely utilised for rotary querns since the La Tène period. Permian fine-grained conglomerates, arcosic sandstones, and arcoses served also often as saddle stones of milling equipment (for example at South-Moravian Neolithic sites Vedrovice and Těšetice), arkosic sandstones and siltstones were favourite raw materials of Neolithic to medieval whetstones.

I.4.1.8. Platform cover of the Bohemian Massif

The platform cover of the Bohemian Massif has a decisive importance from the perspective of raw materials for chipped artefacts as it includes rocks from the beginning of Mesozoic, i.e. Triassic (according to some Czech geologists the Upper Permian sedimentary rocks should already be included into the platform cover) through to Quaternary. Jurassic and Cretaceous sediments are especially important; in the eastern part of Central Europe we find within them all significant silicites that were largely utilized in prehistory. The entire thickness of the pre-Quaternary sediments in the outcrop part of the Bohemian Massif is estimated at around 2,000 m, out of which the biggest part belongs to the Upper Cretaceous in the Bohemian Cretaceous Basin, where almost thousand metres were ascertained by drill holes. A characteristic feature of the platform sediments is their horizontal or very flat setting; the rocks are neither regionally metamorphosed nor folded. Due to this the contained silicites have excellent technological properties – they are only minimally cracked. There are local exceptions in the surroundings of the crystalline units thrusts over clastic sediments of Cretaceous age, where

their layers were raised or older sediments tectonically dragged out from their basement (Jurassic limestones at the Lusatian thrust in western Bohemia). From the platform sediments environment we are also aware of local occurrences of thermally metamorphosed Cretaceous rocks in the vicinity of penetrating younger Tertiary volcanic bodies, or Lower Tertiary (Miocene) rocks in the surroundings of naturally burnt-out banks of brown coal (the Most and Louny regions).

As is magmatic rocks concerned, only volcanites or subvolcanites are present in the period of platform development, no granitoids originated. Origin of laterite or kaoline-rich weathering crusts within several time stages (Lower Cretaceous, Upper Cretaceous to Miocene) was very important; within these periods siliceous weathering products with a character of variously coloured chalcedonies or opals were created on serpentinites, or in some places these are only silicified, decomposed serpentinite (siliciophite). Similar siliceous weathering products in smaller quantities could also be formed on other metamorphic rocks, e.g. on marbles or gneisses. On the rocks rich in quartz various types of siliceous duricrust emerged – in the Bohemian Massif these orthoquartzites are called „sluňáky" (sun boulders), or possibly chert breccias in the surroundings of occurrences of rocks rich in cherts. In the prehistoric times both siliceous weathering products and orthoquartzites were profusely utilized for chipped artefacts in southern Moravia, southern Bohemia, Lower Austria, and to a smaller extent also in Bavaria and south-western Poland.

Mesozoic (Fig. 25)

Triassic

Its areal spread within the territory of the Czech Republic is very little; we are only aware of it from the south-eastern margin of the Krkonoše Piedmont Basin, the Trutnov-Náchod Basin, and both wings of the Intra-Sudetic Basin inclusive of its continuation in Poland. Here it continues above the Upper Permian sediments.

Triassic rocks in the territory of Bohemia are exclusively continental sediments, which are designated as the Bohdašín Formation. After the find of a footprint of a bipedal dinosaur of the *Theropoda* Marsh (1881) suborder the originally acknowledged the Lower Triassic age required an amendment to the Middle to Upper Triassic as well. The lower part of the formation is represented by red-coloured polymict conglomerates and coarse-grained feldspathic sandstones; the upper part consists of whitish kaolinite sandstones. They are interpreted as deposits of flow-through lakes and ephemeral rivers. The most

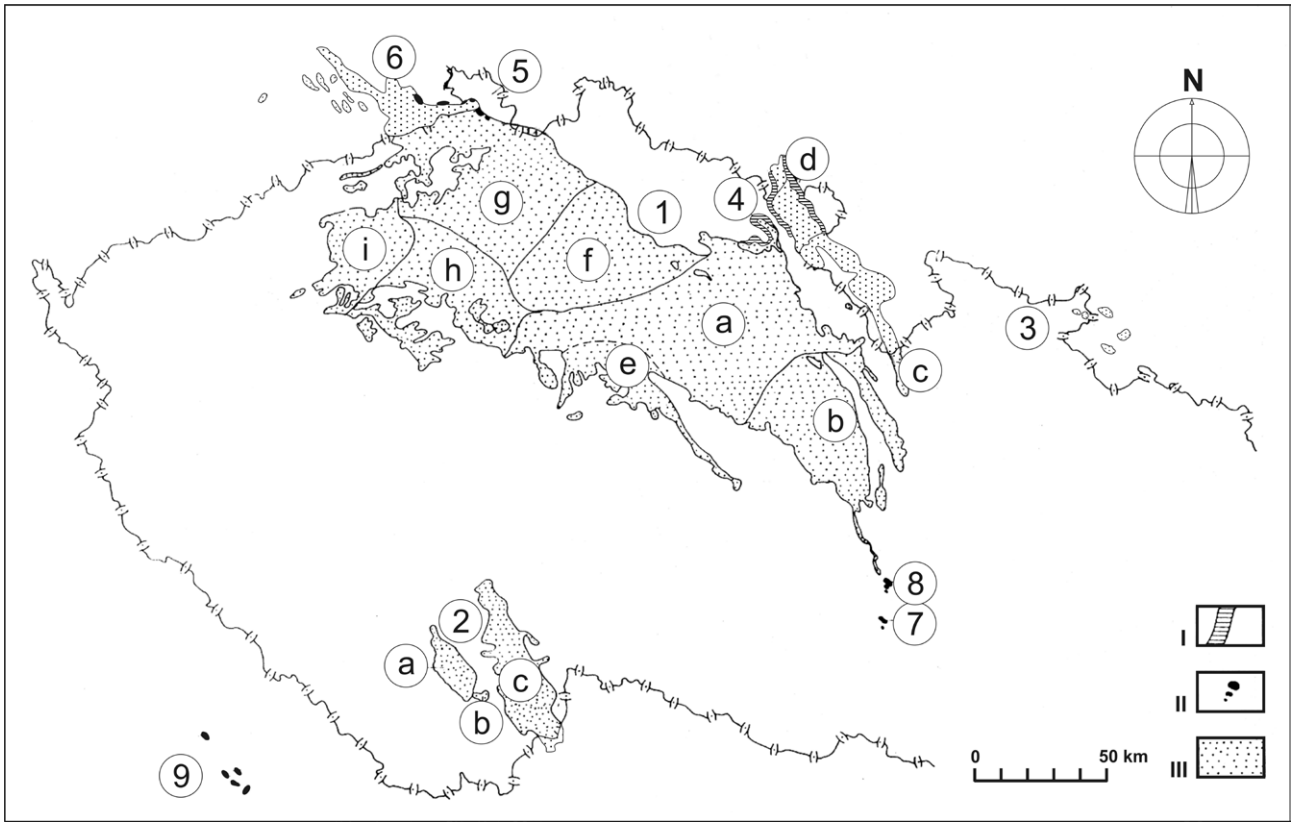

Fig. 25. Distribution of Mesozoic sediments inside the Bohemian Massif. Compiled using a map of Suk et al. (1984). I – Triassic, II – Jurassic, III – Cretaceous. Numbers in circles: 1 – Bohemian Cretaceous Basin with individual regions a-i, 2 – Cretaceous of South Bohemian Basins (a – Budějovice Basin, b – Nová Ves Basin, c – Třeboň Basin), 3 – Cretaceous near Osoblaha and Głubczyce, 4 – Triassic of the Intra-Sudetic Basin and NE part of the Krkonoše Piedmont Basin, 5 – Jurassic occurrences near Krásná Lípa (Bohemia), 6 – Jurassic occurrences in Saxony, 7 – Jurassic limestones in Brno, 8 – Jurassic limestones at Olomučany and the Lower Cretaceous to Cenomanian Rudice Formation, 9 – Jurassic limestones near Ortenburg and Flintsbach (Bavaria).

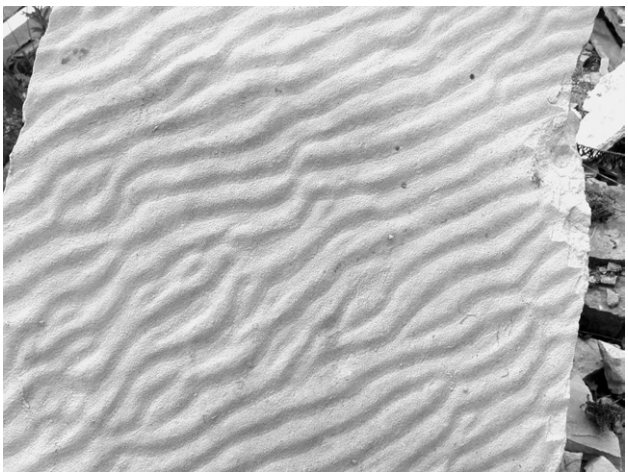

Fig. 26. Havlovice – Krákorka quarry (district of Trutnov). Triassic sandstone with ripple-marks. Photo by the autor, 2006.

Fig. 27. Bílá hora Hill – one of the Jurassic occurrences in Brno. First half of the 60th in the 20th century. Archives of the author.

important site is the Krákorka Quarry (U devíti křížů), cadastral area of Havlovice, Trutnov district (Fig. 26).

Not only continental deposits of "Buntsandstein" (variegated sandstone) on the Triassic basis but also marine carbonates rich in fossils, corresponding with the "Muschelkalk" development (Middle Triassic) are represented on the north-eastern margin of the Bohemian Massif in Polish Lower Silesia (southern surroundings of the Opole town in Poland). In Upper Triassic (Keuper) a site with discovery of Triassic vertebrates, including one of the oldest dinosaurs in the world – the herbivorous archosaurus *Silesaurus opolensis* – was ascertained near the village of Krasiejów towards the end of the 20th century. The site of discovery in the complex of alluvial and lacustrine red claystones is unique in the whole of Europe. Occurrence of cherts from the lower part of the "Muschelkalk" in the Górazde layers is of interest from the perspective of raw materials for chipped artefacts.

Jurassic

As far as the chipped artefacts raw materials are concerned, this is the most significant geological period of both the Bohemian Massif and the whole of Central Europe, although occurrences of Jurassic sediments in the outcrop part of the Bohemian Massif are very limited in terms of area. In northern Bohemia these are four small tectonic slices at the Lusatian thrust in the southern part of the Varnsdorf projection (Doubice, Kyjov, Brtníky, and the Bělá brook valley) represented by calcareous sandstones and conglomerates on the basal part, dolomites, dolomitic limestones, higher up by limestones with cherts of the Upper Jurassic age (Oxfordian, Kimmeridgian). Jurassic rocks were mostly removed by denudation; currently the best occurrence is the Vápenka Natural Reserve in the cadastral area of Kyjov near Krásná Lípa. According to published data from the 19th century the local limestones contained concretionary cherts.

In Moravia Jurassic sediments are preserved as a sunken denudation relic in the south-eastern continuation of the Blansko trough near Olomučany (central part of the Moravian Karst). The end of Middle Jurassic (Callovian) and Upper Jurassic (Oxfordian, Kimmeridgian) are evidenced stratigraphically. The basal sandy limestones and conglomerates are overlain by marlites (opokas) with layers of cherts, and limestones with concretionary cherts are uppermost.

The second area containing Jurassic limestones in Moravia is on the eastern margin of Brno city – Hády, Stránská skála, Bílá hora (Fig. 27), and Švédské šance Hills. Their largest occurrence is on the Stránská skála Hill, where three parts are usually differentiated in the profile, namely: lower cherty limestones (35 m), a layer of crinoidal limestone (5 m), and upper limestones with striped cherts (10 m). Cherts from the Moravian Jurassic occurrences were intensely utilized in the primeval era.

Other minor but very significant occurrences of Jurassic limestones with cherts are found on the southern margin of the Bohemian Massif in Bavaria. These denudation relics are situated mainly to the west of Passau, and to the south of the Danube in the surroundings of Ortenburg (these are called the Ortenburg Jurassic), one site is even to the north of the Danube (Flintsbach).

Limnic Lower Cretaceous to Cenomanian

Currently a majority of geologists consider the Rudice Formation to be the only sediments of Lower Cretaceous or Cenomanian age in the Bohemian Massif. These continental sediments, with only briefly transported particles, which were originally more widespread in the central part of the Moravian Karst, are nowadays preserved only in the south-eastern continuation of the Blansko trough, i.e. in the area among the villages of Rudice, Olomučany, and Babice. The incoherent sediments are sunken in "geological pipes" created in the basement Devonian limestones. Dark clays with lenses of goethite iron ores lie on the base, stiff light clays higher up are followed by the so-called cherty layers (gravel sands to sandstones with kaolinite matrix), further on there are variegated layers formed by alternating of white or brownish-red coloured clays, siltstones, and sands. White to brown-yellow sands

to sandstones are preserved most highly. The entire thickness at the best surveyed Rudice-Seč site amounts to 70–80 m (Fig. 57). Cherts of the Rudice Formation are not of a very high quality, therefore they were utilised primarily towards the end of Upper Palaeolithic at the territory of their natural occurrence and the nearest vicinity.

Upper Cretaceous

Surface occurrences of the Upper Cretaceous age are divided into the following units:

Bohemian Cretaceous Basin (inclusive of the Intra-Sudetic Basin and the Králíky trough Cretaceous);

Cretaceous sediments in the South-Bohemian Basins;

Cretaceous deposits near Osoblaha in Czech Silesia.

Bohemian Cretaceous Basin

Bohemian Cretaceous Basin is the vastest and most important unit with the Cenomanian to Santonian stratigraphic range. The maximum thickness ascertained is 964 m in a boreholl. Areal spread of the Bohemian Cretaceous Basin was originally much larger (in the south it is assumed to have spread through to Havlíčkův Brod and Brno). The most often used litostratigraphic classification includes six formations, namely:

Peruc-Korycany Formation (Albian? – Cenomanian);

Bílá Hora Formation (Lower Turonian);

Jizera Formation (Middle – Upper Turonian);

Teplice Formation (Upper Turonian – Lower Coniacian);

Březno Formation (Coniacian);

Merboltice Formation (Santonian).

Except from the Peruc Member these are marine sediments. The main rock types are sandstones (Fig. 28), marlstones (opokas), rarely clayey limestones. The Bohemian Cretaceous Basin is the most significant source of underground water in the Czech Republic; uranium ores used to be mined out here as well as sporadically small banks of brown coal, nowadays glass sands and construction stones are extracted. Bedded layers of bluish-grey cherts (spongolites), which were much favoured in the Palaeolithic and Mesolithic, emerge only in the Lower Turonian Bílá Hora Formation at the margins of the Bohemian Cretaceous Basin (in the central part this formation is covered by younger Cretaceous sediments). High-quality fine-grained quartz sandstones of the Jizera and Březno Formations were abundantly used in prehistoric ages as whetstones; silty marlstones rich in sponge spicules (opokas) of the Bílá Hora Formation were easy to process as construction and decoration stone. According to published data one of the oldest items of the Bohemian plastic art – the head of a Celtic hero from Mšecké Žehrovice – is an example of object made of this rock.

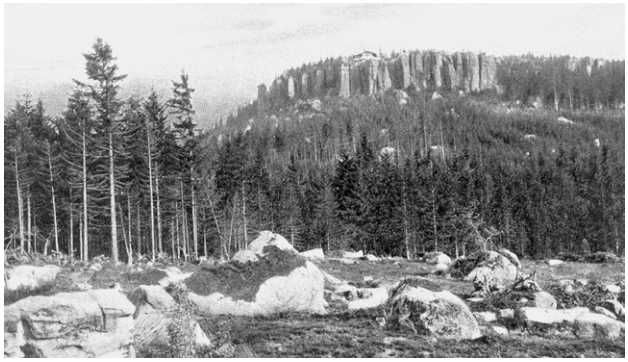

Fig. 28. Góry Stołowe Mts., Szczeliniec Wielki Mt. (919 m). A conspicuous table mountain built of Upper Cretaceous sandstones with finds of prehistoric chipped and polished artefacts in its surroundings. Postcard, 1904.

Cretaceous sediments in the South Bohemian Basins

These are continental (lacustrine and alluvial) sediments that are designated as the Klikov Formation. From the stratigraphic point of view they represent the Middle and Upper Santonian. No occurrences of raw materials (cherts) for chipped artefacts have been described in papers devoted to geology of the mentioned basins (it is the České Budějovice and Třeboň ones).

Cretaceous rocks of the Osoblaha area

On the surface there are a few minor relics of Cenomanian sands to sandstones, a drill captured over 250 metres of Turonian to Coniacian siltstones and claystones. The Cretaceous of the Osoblaha area is related with more extensive occurrences of Upper Cretaceous near the Opole town in Poland. Minor occurrences of silicified sandstones to spongolites are known within surface outcrops.

Sources of Raw Materials in Prehistory: Mesozoic cover of the Bohemian Massif is the most significant source of silicites, although it is only preserved in denudation relics. High-quality cherts are primarily a part of Jurassic limestones in Moravia and Bavaria; their secondary resources found in the Lower Cretaceous, Tertiary, and Quaternary sediments were also largely used. Cretaceous spongolites were utilized for chipped artefacts as well. Quartz sandstone of the Cretaceous age represented one of the best raw materials for whetstones; as a well-workable stone the marlstones (opokas) served for prehistoric plastic art.

Tertiary

During Tertiary, especially Palaeogene, the Bohemian Massif was predominantly a dry land. In the Palaeogene (Eocene, Oligocene) fluvial and lacustrine sedimentation was in progress in the Krušné hory Piedmont Basin and in the South Bohemian Basins. Only on the SE slope of the Bohemian Massif marine Palaeogene sediments (the Nesvačilka Formation) are preserved in two troughs – Nesvačilka and Vranovice. They achieve up to over 1 km thickness and are formed by basal conglomerates, brownish claystones with siltstone laminas, and fine-grained sandstones.

Beyond the mentioned basins intense weathering was under way in the warm and wet tropical climate. Remnants of siliceous, kaolinite and laterite weathering crusts are preserved at a number of places. Siliceous duricrusts emerged practically on all rocks containing

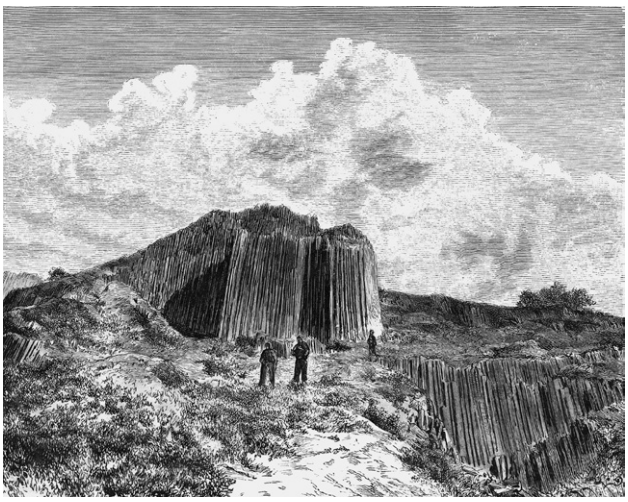

Fig. 29. Kamenický Šenov – Panská skála Rock, northern Bohemia. One of the most famous neovolcanic occurrences of Tertiary age with perfect columnar jointing. The NE margin of the České středohoří Mts. Drawing around 1886. Archives of the author.

quartz, and their orthoquartzite relics are known under the term sun boulders. The main period of their genesis was probably the Oligocene. Kaolinite crusts were generated on rocks rich in feldspar (Carboniferous and Permian arkoses, granitoids, orthogneisses), laterites originated on ultrabasic rocks (serpentinites, peridotites).

Leaving aside the predominantly marine sedimentary filling of the Carpathian Foredeep, which is characterized below within the Western Carpathian area in the territory of the Czech Republic, the Tertiary continental deposits are spread especially in the Krušné hory Piedmont Basins (the Ohře rift) and South Bohemian Basins; moreover protrusions of the Zittau Basin reach into Czech territory in northern Bohemia. Apart from that, clusters of small denudation relics are known from numerous places both in western and central Bohemia, sporadic occurrences are also found in the Bohemian-Moravian Highland. In the Krušné hory Piedmont Basins the Tertiary is represented in a broad stratigraphic range from the Eocene Staré sedlo Formation to "cypris" Formation, which corresponds with the Karpathian stage. Furthermore, the Pliocene fluvial and lacustrine clays and sands (the Vildštejn Formation) sedimented after a hiatus in the Middle and Upper Miocene. Layers of brown coal are of Oligocene age (the Josef coal bed in the Sokolov Basin) on the one hand, and of Lower Miocene age on the other hand (the Anežka and Antonín coal beds and their analogies). Sedimentation in the Krušné hory Piedmont Basins was significantly influenced by the volcanism of the Doupovské hory Mountains and the České středohoří Mts. (Fig. 29). Apart from volcaniclastics the olivine basalts to basanites, tephrites, trachybasalts, trachytes, phonolites, and in the central part also sub-volcanic bodies of intermediate and acidic rocks are abundantly represented (Cajz, ed. 1996).

Although the South Bohemian Basins contain sediments from the apparently Oligocene Lipnice Formation through to the Pliocene Ledenice Formation, the period in between is also filled with large strata gaps. The sedimentation in the South Bohemian Basins was influenced by the action of the sea from the Carpathian (or Alpian) Foredeep at least twice, as is evidenced by the occurrences of halophilic and brackish diatoms. Petrographically there are mainly clays, diatomites, and sands or gravels.

Sources of Raw Materials in Prehistory: The greatest significance was attained by Palaeogene orthoquartzites from the Krušné hory Piedmont Basins; in Bohemia these became favourite raw material for chipped tools. In a great part of the Bohemian Massif it is possible to find relict orthoquartzites (sun boulders), the chipping of which into a coarse-shaped industry became renowned especially in central Moravia. In the course of Tertiary our territory was hit by unique natural glasses from the group of tectites – moldavites, out of which we are also aware of chipped artefacts. Tertiary basalts from the České středohoří Mountains as well as from other occurrences were often polished and drilled for battle axes. Tertiary sandstones served as whetstones.

Quaternary

In the course of Quaternary we distinguish areas affected by continental glaciation and an extraglacial area in the Bohemian Massif. The extraglacial area is further divided into territories with a prevailing denudation (highlands) and territories with a prevailing accumulation (lowlands).

The continental glacier intervened into the territory of the Czech Republic twice – in the last but one Saalian glaciation (corresponding with the Riss stage in the Alpine terminology) and in the older Elsterian stage of glaciation (corresponding with the Mindel). In northern Bohemia, the Šluknov and Frýdlant protrusions and the Bohemian part of the Zittau Basin were glaciated (altogether around 1,700 km^2). In northern Moravia and Silesia the surface covered with glacier, designated as the Odra area, was larger (approx. 2,750 km^2). Glacial

Fig. 30. Žabčice in southern Moravia, sandpit. Alternation of Pleistocene fluvial sands and gravels with numerous pebbles of quartz, cherts and pieces of silicified woods. Photo by the author, 2000.

sediments are represented by tills that form moraines, and among boulders they contain rock materials from the area of Scandinavia, Baltic, and Poland. We are also aware of glacilacustrine and glacifluvial sediments from the Ostrava region.

The majority of the Bohemian Massif was situated in the periglacial region, in which an intensive mechanical weathering was under way and a permanently frozen soil (permafrost) of tens of metres thickness existed. Some of our mountain ranges (Šumava, Krkonoše, Hrubý Jeseník, Králický Sněžník, and Beskydy) contain evidence of mountain glaciation from the Last Glacial period. Depending on substrate and shape of the terrain, the deluvial deposits were formed on the slopes (solifluction tongues, block fields, and slope loams). Fluvial terraces of gravels and sands (Fig. 30), wind-blown loess and sands were deposited in the accumulation regions. In the course of interglacials and interstadials soils were formed in the warmer climate.

Sources of Raw Materials in Prehistory: Glacigenous sediments (as accepted *sensu lato*), which contain erratic flints of both Maastrichtian (the Uppermost Cretaceous) and Danian (the Lowermost Tertiary) age, are of cardinal importance. Prehistoric humans always turned back to this resource when the contacts with mines producing high-quality South or Central Poland raw materials were interrupted because of various social changes. Silicites (prevalently flints) from glacigenous sediments might be acquired as by-products of agricultural activities in the Neolithic and later. In the Palaeolithic an important role was also played by quartz pebbles from Pleistocene fluvial terrace gravels, whereas in the Neolithic and Eneolithic the pebbles of amphibolites, quartzites, serpentinites and other rocks were popular as their shapes were predetermined for the manufacture of polished artefacts.

I.4.2. Małopolska Massif (Małopolska Highland)

As a result of a multiple Pleistocene glaciation the vast territory of northern and central Poland (Niż Polski) is overlapped by Quaternary sediments on the bedrock of which tiny areas of mostly unconsolidated Upper Tertiary clays, sands, and gravels protrude from time to time. Apart from the already mentioned Bohemian Massif and the Western Carpathians solid Pre-Tertiary rocks crop out also in the Malopolska Highland in south-eastern Poland, where three partial units are usually hived off, namely the so-called Silesian-Cracow Monocline (monoklina śląsko-krakowska, Wyżyna Śląsko-Krakowska) approximately among the cities of Opole – Cracow – Wieluń, the Holy Cross Mountains (Góry Świętokrzyskie) with the adjacent surroundings, and the Lubelska Highland (Wyżyna Lubelska) in the wider surroundings of the city of Lublin.

A geological overview of the Silesian-Cracow Monocline may be found in the geological guidebook of the Cracow vicinity (Gradziński 1972); the same author also compiled a geological map of the Cracow surroundings at the 1: 100 000 scale (Gradziński 1993). The oldest rocks appearing on the surface of this territory are of the higher Middle Devonian (Givetian) age, and are represented by dark dolomites and limestones. Clayey limestones with brachiopods and stromatoporoidal limestones originated in the Upper Devonian. These are followed by Lower Carboniferous rocks, again of marine origin, which gradually evolved from the Devonian formations, and feature the character of the so-called carbonaceous limestones (in the surroundings of Dębnik), but in the western part of the region conglomerates, greywackes, and shales of the Culmian development emerged. In the course of Namurian and Westphalian (Upper Carboniferous), sedimentary rocks are represented by sandstones and shales with coal interbeds; towards the end of the Upper Carboniferous (in the Stephanian) the so-called Kwaczala arkose sedimented already with no interbeds of coal. Finds of silicified wood (araucarites) are known from the arkoses. In the course of the Permian the Cracow region was a dry land with only a local sedimentation of freshwater limestones (martwica karniowicka); the Myślachowice conglomerates that were deposited in the surroundings of Dębnik are somewhat younger. Close to the end of Lower Permian, extrusions of andesites and basaltic andesites (formerly porphyries and melaphyres) and sedimentation of volcaniclastic deposits (tuffs and tuffaceous sandstones) occurred during terrestrial volcanic activity. No rocks of the Upper Permian age are known from this area.

Mesozoic sedimentation was commenced in the Lower Triassic by variegated sandstone (Buntsandstein); at the beginning these were freshwater sands and gravels, later on marine limestones and dolomites. Then it continued in the Middle Triassic by the so-called Muschelkalk that comprises several types of limestones – Gogolin, Górażde (these contain cherts in their bottom part), terebratula, ore-bearing dolomites, diplopore (algal) dolomites, and by the sedimentation of clays, siltstones, sandstones and dolomites towards the end of the Triassic.

From the viewpoint of raw materials for chipped artefacts the Jurassic is most significant. At its beginning the Cracow region was again a dry land with a local sedimentation of fireclays. In the Middle Jurassic sea penetrated into the observed territory, and sedimentation of sands and sandstones occurred; the Callovian stage is represented by sandstones, sandy limestones (oolitic in places) and glauconite marls, and at the close of Middle Jurassic a layer of stromatolite limestones was deposited. The Upper Jurassic began with the sedimentation of red clays, higher on grey, whitish, or greenish clays. Then rocks characteristic for the Upper Jurassic appear, i.e. laminated limestones, massive limestones with cherts, and heavy-bedded limestones with cherts. Finely laminated limestones with banded cherts were formed towards the end of Upper Jurassic limestone complex sedimentation (Korzkwa, Sudol, and Bonarka in Cracow).

The Cretaceous sediments are represented in the period of time from the Albian to Maastrichtian, on the base by sands and quartz conglomerates, since the Turonian

there appear limestones with sandy or rudaceous inclusion, and marlites and marls containing cherts prevail in the uppermost part.

The Holy Cross Mountains are considered the easternmost continuation of the European Variscan orogen. Palaeozoic sediments are represented in the scope from the Lower Cambrian to Upper Permian (Książkiewicz et al. 1965). The Cambrian comprises various types of shales, quartzites, greywackes, and sandstones. The quartzites build the highest peak Łysica (612 m) and creat a vast block field on its slope. In the course of the Ordovician the sedimentation in the northern, central, and southern parts differs. In the north black shales with graptolites were deposited, in the upper part with interbeds of siltstones and sandstones, in the middle part glauconite sandstones protrude followed by limestones, shales, and marlites. In the south there are interesting basal greywackes and shales with interbeds of chalcedony cherts, the rest of the Ordovician consists of various types of primarily clayey shales with graptolites. Similarly the Silurian is represented by shales with graptolites, locally with interbeds of greywackes and limestones, with lydites occurring at the base. A variegated sedimentation (shales, sandstones, limestones, and dolomites) was under way in the Devonian; moreover it was different in the northern and southern part. From the viewpoint of possible raw materials for chipped tools it is necessary to mention the Upper Devonian Kostomłoty layers, from which we know limestones with cherts. The Lower Carboniferous sediments are represented by shales with interbeds of limestones and lydites on the base, higher on black or variegated shales with interbeds of greywackes, limestones, and tuffaceous sandstones prevail. The Upper Carboniferous and Lower Permian sediments don't occur as the territory was a dry land. Shallow-water red calcareous conglomerates, marlites and locally black or dolomite limestones were sedimented in the Upper Permian.

From the perspective of various types of silicites, the Mesozoic (Triassic to Cretaceous) sediments in the northern surroundings of the Holy Cross Mountains (Wyżyna Kielecko-Sandomierska) are of special significance; these became well-known as early as in the 1920s due to geological mapping performed by J. Samsonowicz (Samsonowicz 1929) when he found for the first time prehistoric mines in the territory of Poland, near Krzemionki Opatowskie. Mesozoic rocks are characterized in greater detail in the description of silicites (Polish archaeologists call them as flints) – banded, spotted, and chocolate ones from this territory.

In the Lubelska Highland rocks of Cretaceous age – silty marlstones (opokas), marlstones, limestones, and chalk protrude from below loess. The chalk contains nodules of flint (Bolewski & Parachoniak 1978, 140) at the outcrops in the surroundings of Chełmo Lubelskie, Kornica, Wola Nosowska, and others. Not very high quality silicified clastic rocks containing chalcedony and opal are present as well; by Polish geologists they are denominated as "gezy".

I.4.3. Western Carpathians

This recent mountain chain of eastern to western routing was formed during the Alpine orogenesis towards the end of Mesozoic (in the Cretaceous) and in the Tertiary. The geological border on the Eastern Alps is placed into the Carnuntum Gateway, i.e. to the south of the current course of the Danube in the Děvín Gateway. In the flysch range area the geographical boundary related to the Eastern Carpathian Mountains is usually placed into the Łupków Pass, whereas the geological boundary is put over to the east, as far as the Uh River valley, in the Central Western Carpathians to the eastern hillside of the Slanské vrchy Mts. and the Humenné Horst (Maheľ 1986, Biely ed. 1996). Thus this mountain range protrudes primarily in Slovakia, but it also reaches the territory of north-eastern Austria, Moravia and Silesia, southern Poland, and northern Hungary. From the viewpoint of plate tectonics interpretation the Western Carpathians are divided into three principal tectonic units, see Fig. 31 (Kováč & Plašienka et al. 2002):

- Outer Western Carpathians that include the Flysch Belt, the Carpathian Foredeep, and the Vienna Basin;
- Central Western Carpathians formed by the Pieniny Klippen Belt (Oravicum), Vahicum, Tatricum, Veporicum, and Gemericum;
- Inner Western Carpathians situated in Hungary to south-eastern Slovakia and built by the Meliaticum, Turnaicum, Bükkicum, Transdanubicum, and probably also Zemplinicum superunits (Kováč & Plašienka et al. 2002).

These three principal belts are divided by two sutures resulting from the closure of the Meliata and Vahic Oceans. The more southern Meliata Ocean divided the inner and central belt, it closed towards the end of Jurassic, and today its relics are found in the Meliata Unit (Meliaticum). The supposed Vahic Ocean is believed to represent a continuation of the South Penninic Ocean from the Alps; its closing is assumed towards the end of Cretaceous to Lower Palaeogene, and the geological unit containing the rocks from its area is called the Vahicum.

I.4.3.1. Outer Western Carpathians

A system of basins called the Carpathian Foredeep stretches alongside the outer margin of the Carpathian Flysch Belt (the so-called Alpine front). It continues uninterruptedly the Alpine Foredeep, and is filled with the Miocene, prevailingly incoherent sediments (sands, gravels, and clays), solid calcareous sandstones or algal limestones occur less often. Gravels are of interest from the viewpoint of chipped artefact raw materials as in places they contain high concentrations of pebbles or only slightly rounded fragments of cherts, sometimes with a black surface (the Eggenburgian to Ottnangian gravels in the Krumlovský les Highand, the Lower Badenian basal clastic rocks in Brno-Líšeň, the Otaslavice gravels, the Kroměříž Formation of the Karpatian age in front of the flysch nappes, the Hollabrun gravels), or possibly up to several percent of radiolarite pebbles appear in the Lower

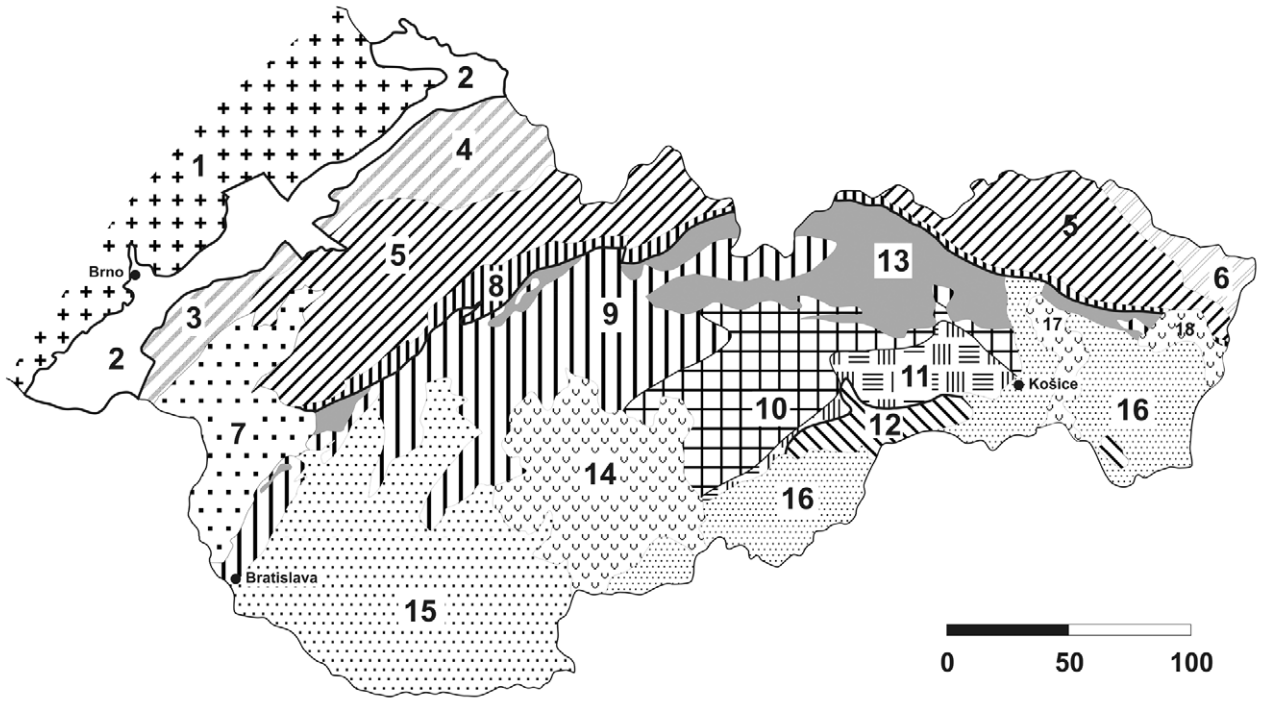

Fig. 31. Basic geological division of the Western Carpathians in Slovakia and Moravia. 1 – eastern margin of the Bohemian Massif. The Outer Western Carpathians: 2 – Carpathian Foredeep; Silesian-Krosno Nappe Group: 3 – Pouzdřany and Ždánice Units, 4 – Sub-Silesian and Silesian Units; 5 – Magura Nappe Group, 6 – Dukla Unit, 7 – Vienna Basin, 8 – Pieniny Klippen Belt. The Central Western Carpathians: 9 – Tatricum, 10 – Veporicum, 11 – Gemericum; 12 – the Inner Western Carpathians; 13 – Central Carpathian Palaeogene Basin; 14 – neovolcanics in central Slovakia; 15 – Danube Basin; 16 – East Slovak Basin and South Slovak region; 17 neovolcanics in the Slanské vrchy Mts.; 18 – neovolcanics in the Vihorlat Mts.

Badenian gravels (the Badenian basal clastic rocks in the surroundings of Mušov, southern Moravia). The Miocene formations rarely contain minor layers of menilite cherts (e.g. the Limberg Beds near Limberg, 7 km to the south of Eggenburg, Austria), algal (formerly Lithothamnion) limestones that represent one of the few solid rocks in the Carpathian Foredeep filling; in the Brno region these are of the Lower Badenian age. For this reason they were sometimes used as saddle querns (e.g. Hradisko in Brno-Obřany); apparently they became best known as a stone for the impressive circular structure from the first half of the 6th century AD on the Žuráň Hill to the east of Brno that was intepreted as a mausoleum of the Langobardian king Wacho (Poulík 1995).

Another Neogene basin is located at the contact of Western Carpathians and Eastern Alps. It is the Vienna Basin that reaches into the Lower Moravia Graben, the Záhorská Lowland, and the surroundings of Vienna in Austria, and holds possibly the most interesting Pleistocene gravels of the Danube or its predecessors containing radiolarite pebbles from the Alps. The same applies for the Danubian Basin although the radiolarites are of very poor quality, broken by a net of small cracks healed by white calcite.

The Carpathian Flysch Belt is much more interesting; it is divided into the outer Krosno-menilite (or Silesian-Krosno) and inner Magura Groups of nappes. As ensues from the name itself, a part of the individual nappe units of the outer group is the Middle Oligocene menilite formation with layers of menilite cherts. Small concretional cherts are described from the Ernstbrunn limestone in Pavlovské vrchy (Dvořák & Růžička 1966, 219). Other raw materials are layered cherts of the Baška Formation (the Baška development) and the Lhota Beds with the Mikuszowice cherts (the Godula development) of the

Fig. 32. Carpathian Flysch Belt, Magura Nappe Group. Unique globular jointing of sandstone near the village of Megoňky, 8 km NW of Čadca, Slovakia. Diameter of the huge stone sphere is 1.65 m. Drawing by T. Přichystal.

Fig. 33. Pieniny Klippen Belt, valley of the Dunajec River in the Pieniny Mts., Polish – Slovak frontier. Photo by the author, 1993.

Silesian Unit. Perfect ball-shaped jointing of sandstones to conglomerates (Fig. 32) in the flysch rocks at the Slovak-Moravian border (Klokočov, Vyšné Megoňky) attracts the attention of amateur interested persons, who speculate about their artificial origin.

The flysch belt obviously yielded a number of high-quality quartz and arkosic sandstones, from which battle-axes of the Corded Ware culture were manufactured in SE Moravia, or they were used as whetstones, querns or millstones. From time to time volcanic rocks of the teschenite-picrite association known to us from the Godula development of the Silesian Unit between Valašské Meziříčí and Bialsko-Biala in Poland, or basaltic andesites and trachyandesites from the eastern surroundings of Uherský Brod (the Magura Group) were used for polished industry.

I.4.3.2. Central Western Carpathians

This mountain range is divided into three superunits from W to E, namely the Tatricum, the Veporicum, and the Gemericum. The more easterly units are thrust over the more westerly. The border of Central Western Carpathians on the Outer Western Carpathians is the already mentioned Klippen Belt (Fig. 33), and the Meliata Unit (or the Rožňava thrust) on the Inner Western Carpathians.

The Tatricum consists of eleven so-called core mountains (Maheľ 1986): Malé Karpaty, Považský Inovec, Strážovské vrchy, Žiar, Tríbeč, Velká Fatra, Malá Fatra (Fig. 34), Ďumbierské Nízké Tatry and Tatry Mts., the northern part of Branisko Mts. and Humenské vrchy Hills. These always comprise a crystalline core of Hercynian granitoids and Lower Paleozoic to Proterozoic metamorphic rocks and their Upper Carboniferous to Lower Cretaceous sedimentary cover. They are followed by nappes of the Fatricum (formerly the Krížna nappe) and of the Hronicum (formerly the Choč nappe). In the prehistoric times cherts from the Mesozoic complexes of both the cover unit and the Fatricum to Hronicum nappes could be chipped for artefacts although they very often tend to be intensely cracked. The thermally metamorphosed greenschists of the Pezinok-Pernek Group in the Malé Karpaty Mts. were utilised for polished tools in the Neolithic, similar to amphibolites that emerge in all the core mountain ranges. Apparently a number of other metamorphites were used for these purposes but their pebbles were usually taken from the Slovak rivers. Similarly axes with groove were used for the primeval extraction of copper ores in the Špania dolina-Piesky (the Starohorské vrchy Mts. to the N of Banská Bystrica; Fig. 35); the axes were manufactured for example from big pebbles of Lower Triassic quartzites that crop out at the base of Mesozoic rocks in the Tatricum.

The Veporicum emerges in the Pre-Tertiary basement of the central Slovakian neovolcanites, in the eastern part (Králova Hoľa Mt.) of the Nízké Tatry Mts., in the Veporské and Stolické vrchy Mts., further on in the southern part of the Branisko Mts. and in the Černá hora Mts. Its northern boundary is the Čertovica thrust; the Lubeník-Margecany line is considered its southern boundary. The Veporicum consists of a pre-Alpine crystalline complex of a similar type as in the Tatricum, i.e. originally probably a Lower Paleozoic volcanic to sedimentary complex underwent a low to medium degree Variscan metamorphosis that reached amphibolite facies in places, and migmatization occured as well. Apart from metamorphites there is a characteristic vast Veporic plutone and several lesser granitoid massifs out of which the Rochovce Massif is of the Cretaceous age. The sedimentary cover in the northern part of the Veporicum is called the Veľký Bok Unit, and it is known to us from the northern slopes of the eastern Nízké Tatry Mts., in the NW part of the Vepor Mts. and in the Zvolenská kotlina Cauldron in the Ľubietová belt. It includes sedimentary sequencies of Permian to Lower Cretaceous age. Similarly to the Bohemian Massif the Permian sediments are of continental origin, and contain a horizon of volcanites. They are overlyied with Lower Triassic quartzites, Middle Triassic limestones to dolomites, and Upper Triassic calcareous shales (the Carpathian Keuper) above them. In

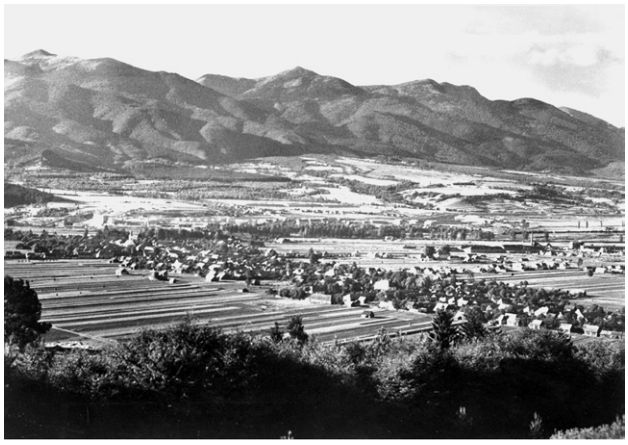

Fig. 34. Slovakia, Central Western Carpathians, characteristic morphology of the Tatricum. A view from the NW slope of the Velká Fatra Mts. over the Turčany Basin with the Váh River towards the core mountains of Malá Fatra. Postcard, 1965.

Fig. 35. A view towards the Starohorské vrchy Mts. from the town Banská Bystrica, central Slovakia. Evidence on prehistoric copper mining in the Old Bronze Age has been found in their summit part at the locality Piesky near the village of Špania Dolina (around 800 m). Postcard, 1955.

the course of Jurassic various types of limestones prevailed, sometimes containing cherts and even radiolarites. In the south of the Veporicum the sedimentary cover of Upper Carboniferous to Triassic age is formed by the Foederata Unit.

Thus during the prehistoric times the Veporicum could yield a wide range of rocks both for polished implements (basic metamorphites) and millstones (granitoids), whetstones (Permian sediments), or even chipped artefacts (cherts, radiolarites).

The third superunit of the Central Carpathians is called the Gemericum (Gemeric Zone), and it differs from the preceding two by an overall lower degree of metamorphosis. The assemblage of rocks forming its southern and central parts is usually called the Gelnica Group (Upper Cambrian to Lower Devonian), and it consists of flysch cycles of clastic sediments with occurrences of lydites, black shales, sometimes even carbonates on the base, and an abundant occurrence of prevailingly acid to intermediary volcaniclastics. The sedimentary cover of the southern part of the Gemericum comprises the continental Lower Permian Rožňava Formation, and the shallow-marine Upper Permian to Lower Triassic Štítnica Formation.

The northern part of the Gemericum is built by the Rakovec and Klátov Groups. The Rakovec Group consists of slightly metamorphosed sediments and submarine basic volcanites (spilites) of probably Devonian age, the Klátov Group is a higher metamorphosed complex of gneisses and amphibolites. The metamorphic rocks of the Gemericum were intruded by minor Late Hercynian (Permian) granitoid bodies, in comparison to the granitoids of the Tatricum and the Veporicum significantly more leucocratic (two-mica, muscovite or tourmaline granites, greisenized in places). The Gemeric crystalline rocks are followed by almost 1000 m thick formation of Lower Carboniferous marine sediments with bodies of carbonates (often magnesites). The Lower Palaeozoic complexes are transgressively overlapped by the Dobšiná Group of Upper Carboniferous age, or the Permian Krompachy Group with subalkaline rhyolite volcanism.

I.4.3.3. Inner Western Carpathians

They emerge in SE Slovakia and NE Hungary. Maheľ (1986) placed their northern border on the Rožňava thrust but the current Slovak geologists stress out the Meliata Ocean suture that is sometimes designated as the Rožňava suture (Kováč & Plašienka et al. 2002, 39). Thus the Inner Western Carpathians include the territory of the Slovak Karst (the Észak-Borsodi karszt in Hungary), the North Hungarian mountain ranges of Aggtelek, Rudabánya, Szendrö, Bükk, Uppony, and Darnó (built by units of the Silicicum, Turnaicum, Meliaticum, and Bükkicum), and the Transdanubian Range (Dunántúli Középhegység in Hungary; geologically it is the Transdanubicum). Some geologists also include the easternmost occurrences of the crystalline rocks with their Late Palaeozoic and Mesozoic envelope sequence near Zemplín (the Zemplinicum); according to others it is a part of the Veporicum belonging to the Central Western Carpathians.

Depending on this, the southern border of Inner Western Carpathians is either placed at the Zemplín-Zagreb fault line (Maheľ 1986), or more to the south to the so-called Central Hungarian line. It is necessary to mention there are somewhat different concepts of the divisions of Western Carpathians and the large geological units within the Hungarian territory (Haas, ed. 2001). A volcanic mountain belt of Tertiary age stretching from the Tokaj-Zemplén Mts. in the east (Fig. 36) to Börzsöny in the west is important from the perspective of raw materials for both chipped and polished artefacts.

The Silicicum (the Silicic nappe, named after the Silica municipality 12 km S of Rožňava) is a geological superunit comprising the highest non-metamorphosed nappes, which were partly moved through to the territory of the Veporicum and the Gemericum in Central Western Carpathians, partly overlap the Meliata Unit in the Inner Western Carpathians. It consists of sediments of Upper Permian to Upper Jurassic age although from the viewpoint of distribution limestones and dolomites of the Middle to Upper Triasic that build the Spiš-Gemer Karst, the Slovak Karst, and the Aggtelek Karst are totally dominant. A number of caves significant from the archaeological viewpoint originated in these rocks (e.g. Domica, Majda-Hraškova Cave, Jasov Cave).

The Meliaticum (Meliata Unit) is named after the Meliata municipality 20 km SW of Rožňava. It mostly emerges in tectonic windows under the nappes of the Silicicum and the Turnaicum. The unit is mostly built by Jurassic flysch complexes inclusive of radiolarites and bodies of ophiolites containing significant blueschists that were polished for Neolithic axes and shoe-last adzes.

The Turnaicum (after Turňa nad Bodvou, 26 km E of Rožňava) again features the character of several partial nappes that emerge in the overlay of the Meliaticum but they underlay of the Silicic nappes. It consists of

Fig. 36. Inner Western Carpathians are bordered in the south by Tertiary volcanic mountains. The Tokaj-Zemplén Mts. are the easternmost ones. Photo by the author, 1989.

sediments of Upper Carboniferous to Upper Triassic (maybe to Jurassic) age, with a prevalence of Middle and Upper Triasic rocks: platform carbonates, pelagic carbonates, shales, marlstones, sandstones, in places also volcanites.

The Bükkicum (after the Bükk Mountains in Hungary) is characterized by Palaeozoic (Upper Carboniferous, Permian), Triassic, and Jurassic sediments, to a lesser extent volcanic complexes.

The last unit called the Transdanubicum surfaces in the Transdanubian Mountains (the Balaton Hills, Bakony, Gerecse, Vértes, and Buda Mountains). It is formed by slightly metamorphosed Palaeozoic rocks (phyllites with metavolcanites and limestones of Ordovician to Lower Carboniferous age); Upper Variscan granitoids are known to form the Velence Mts. The Upper Carboniferous is mainly represented by conglomerates. Continental sediments (clastic rocks and evaporites) on one hand and marine dolomites on the other settled in the course of Upper Permian. Various types of dolomites, calcareous grits, limestones, and marls appear primarily in the Triassic, limestones with cherts and sometimes layers of tuffs occur in the Middle Triassic. Cherty limestones also appear during Lower Jurassic, the Lókút Formation with siliceous marls and radiolarites is significant in the Middle Jurassic. The Gerecse Mountains contain interesting Lower Cretaceous conglomerates with pebbles of ophiolites, which could be used for polished industry in the primeval ages.

I.4.4. Eastern Alps

As was stated in the foreword, the issues of lithic raw materials of Eastern Alps are so complex that they cannot be resolved in this monograph. Nevertheless as some geological units of the Eastern Alps border on the Bohemian Massif in the south, step into Lower Austria, the Burgenland, and western Hungary, their very brief characteristic will be provided as well.

The Eastern Alps again feature a conspicuous zonal structure: from north to south it is possible to differentiate a molasse zone (the Alpian Foredeep that continues the Carpathian Foredeep), the flysch zone (that continues Outer Western Carpathians), Northern Calcareous Alps, and the crystalline Central Eastern Alps. The Eastern Calcareous Alps protrude in North Italy and Slovenia, and do not step into the studied territory of Central Europe (e.g. Černík & Sekyra 1969).

The molasse zone (the Alpian Foredeep) is a belt of varying width on the foreground of the Alps, and covers a part of the southern slopes of the Bohemian Massif. It comprises Tertiary sediments of Upper Eocene to Lower Miocene age that originated in various environments from continental to relatively deep sea. These are primarily clastic sediments, anoxic shales, light clayey limestones to marlstones (Eocene to Oligocene); schliers (stratified calcareous clays), siltstones, sandstones, locally also conglomerates containing a material from the Alps sedimented during Miocene; in Upper Miocene unconsolidated sands and gravels represent the so-called upper freshwater molasse.

The Eastern Alps flysch belt steps into the studied territory in the area of the Wienerwald Highland, in which three nappes are hived off, namely Greifenstein, Kahlenberg, and Laab. Lithologically the flysch itself consists of shales, siltstones, sandstones, the klippen belts lining the individual nappes are important. The Gresten Klippen Belt is the main one, the other klippen zone St. Veit (or Ober St. Veit Klippen Belt) reaches the area of Vienna with the well-known Antonshöhe Hill of prehistoric extraction of radiolarite. The Ybbsitz Klippen Belt is situated on the margin of the Kahlenberg nappe. The rocks of both the flysch belt and the klippen occurrences were most recently characterized in detail in a monograph by Wessely et al. (2006).

The Northern Calcareous Alps are a 40 to 50 km wide belt consisting of vast nappes of Mesozoic carbonates (limestones and dolomites). Northern nappes of the Bajuvaricum, in the central part called the Tirolicum and in the south the Juvavicum are hived off within the Northern Calcareous Alps. On their southern margin an interesting unit emerges consisting of slightly metamorphosed Palaeozoic volcano-sedimentary complexes. The Austrian geologists designate it as the "Grauwackenzone".

The Central Eastern Alps step into eastern Austria and western Hungary by geological units that are designated as the Penninicum and the Austroalpinicum. From the viewpoint of prehistoric lithic polished tools primarily the Penninicum is of interest; it is built by fragments of the oceanic crust (ophiolites) and deep water oceanic sediments of Jurassic to Cretaceous age. In the ophiolite complexes it was possible to obtain serpentinites, gabbros, basalts including their volcaniclastics, and plagiogranites. Glaucophanites are present as well. The rocks of the Penninicum emerge on the eastern margin of Alps in four tectonic windows; from N to S these are the Meltern, Bernstein, Köszeg-Rechnitz, and the southernmost Eisenberg windows. The chapter on raw materials of polished artefacts deals with high-quality serpentinites

from Bernstein and greenschists from Felsöczatár near the Austrian-Hungarian border (the Köszeg-Rechnitz tectonic window) that were used in prehistoric times.

I.4.5. Pannonian Basin System

As is obvious from Fig. 6 or Supplement/Photo 1, from geomorphological perspective this system comprises the Big Danube Lowland (Alföld) and the Little Danube Lowland (Kisalföld) – both situated mainly in the territory of Hungary, and the Vienna Basin (the Wiener Becken that reaches to Slovakia, Moravia, and Austria). The lowlands are filled mostly with soft and incoherent Miocene sediments (clays, sands, gravels, more rarely limestones or sandstones), although these protrude to the surface only in places as they are additionally overlapped by Pleistocene river gravels and sands, or vast accumulations of eolian loess and wind-blown sands – see the geological map of Hungary, e.g. Fülöp, ed. et al. (1984). Moreover, Holocene flood loams as the most recent are spread on large areas alongside all mighty rivers (Danube, Tisza, Körös, Váh, Hron, Morava, and Thaya). Thus the entire territory in general lacks high-quality solid rocks that had to be imported in the primeval era. Apart from the mentioned Eastern Alpine and Western Carpathian units, which adjoin these basins or step into them on the margins, the ascents of the basement Mesozoic to Paleogene rocks and Tertiary neovolcanites in the Transdanubian Mountains (Dunántúli Középhegység), and Palaeozoic and Mesozoic rocks in the south Hungarian Mécsek and Villányi Mountains were of great importance.

Out of the raw materials of the Transdanubian Mountains it is possible to mention e.g. Triassic cherts that were utilised by the people with Bell Beakers in the area of Budapest and its surroundings. Radiolarites obtained in the south of Hungary in the Mécsek Mts. near Pécsvárad and Magyaregregy were processed near Zengövárkony in vast workshops, which were so fascinating to Czech geologist K. Žebera during his study journey of Hungary in 1953, that he wrote about "billions of billions" of artefacts (Žebera 1955, 485).

I.4.6. Fennosarmatian Platform

In the geological literature it is also called the East European or Russian Platform, and in the studied territory it forms a basement of north-eastern Poland, Belarus, and the Ukraine (Fig. 7). From gemorphological point of view, this territory basically corresponds with the East European Plain. On consultation with a geologic map (Supplement/Photo 1, Teschke et al., 1978) it is obvious that the Mesozoic sediments of the Malopolska Highland are continued by vast occurrences of the Cretaceous and Jurassic sediments in the Volhyno-Podolian Highland (the Volyno-podolskaja vozvyšennost). Geologically this is the Halych-Volhynia Syneclise, which is situated between the Ukraine Shield and the Carpathian Foredeep, and its old rock basement in the depth exceeding 3 km is covered by Palaeozoic to Quaternary sediments. Out of the Tertiary molasse sediments the Cretaceous carbonates with silicites emerge to the surface in the wider surroundings of the Bug River and continue through the surroundings of Lviv to the south, where – together with Jurassic sediments (mostly clays and glauconite sands) – they appear primarily in the valley of the Dniester River and its north-southern tributaries. In the course of Upper Cretaceous pure carbonates of the chalk character deposited there and the very high quality silicites present in it may be therefore designated as flints. In the primeval era the flints of the Volhyno-Podolian Highland were transported as far as the territory of Poland and eastern Slovakia.

As already mentioned the old Proterozoic basement rises to the surface in the area of the Ukraine Shield to the east of the Halych-Volhynia Syneclise. One of its parts is the geological unit of Volhynids (Ovruchids), from litostratigraphic viewpoint formed by the Ovruch Group. From its bottom part, designated as the Tolkatchev Group 1.2 to 1.5 billion years old (Mísař 1987, 78) originate slightly metamorphosed pink to red shales, from which whorls were manufactured on a large scale in the Early Middle Ages and distributed throughout north-eastern Europe. They normally occur in eastern Poland and sporadically even in Moravia and Bohemia.

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I.5. Applied methods

I.5.1. Determination of chipped lithic artefacts

During more than 35 years of the author's cooperation with archaeologists in determining the raw materials of chipped artefacts it was necessary to build up a particular comparative collection of the potential raw materials – mainly silicites but also other rocks and minerals used in prehistoric times. These potential raw materials have been described in detail by various methods; on the grounds of databases acquired this way they are compared with the raw materials of artefacts. The most significant group of raw materials for chipped artefacts is represented by silicites (siliceous rocks), which are very difficult to differentiate from one another. Moreover, geologists often differ in their opinions how to designate silicites from natural outcrops, with which their age, the surrounding rock as well as the geological unit are known. The determination of a several-centimetre flake of an unknown provenance is much more complicated.

With silicites it is primarily necessary to document the character of concretions or the thickness of layers, the relation to the surrounding rock and its age, the colour and surface of cortex, the transition between cortex and the silicite matter, the colour and lustre of the silicite matter, jointing, veinlets, enclosures, and fossils. It is recommended to use the Munsell colour chart for the objectification of the colour description. In some cases X-ray diffraction analysis has proven to be necessary for ascertaining the representation of the individual SiO_2 modifications; it is suitable to establish microhardness or loss of ignition. Determination of the chemical composition expressed by the percentage of main oxides exemplifies the characteristic of a silicite but does not suffice for deliberation on its provenance. Determinations of trace elements, rare earths or isotopes, although more expensive, are very useful but the artefacts get damaged or destroyed. A solution for these determinations on small artefacts is the laser ablation method that only leaves a minute crater visible by a microscope on the surface of an artefact. Another non-destructive method for assessment of trace elements is represented by application of portable X-ray fluorescence spectrometer (Innov – X Analyser ALPHA).

A very important method is the determination of microfossils, which practically always occur in silicites, unfortunately in various conditions of preservation. However this task often requires cooperation with specialists in the individual groups of microfossils (radiolaria, foraminifera, sponges, moss animals, sea urchins etc.).

A creation of a specific methodology necessitated by determining of collections composed of many-thousand Neolithic chipped artefacts has proven to be most effective. The author was first faced with this challenge in 1979 when determining more than 5 000 chipped pieces from the Neolithic site Těšetice-Kyjovice near Znojmo (Přichystal 1984). The impossibility of carrying a petrographic thin section out of every artefact was obvious; moreover it has been found out earlier on that a majority of high quality silicites were very much alike in two-dimensional thin sections. The procedure of the above methodology is as follows: every artefact is examined under the stereomicroscope, when it was immersed in water beforehand, or water was applied on it as an immersion liquid (Fig. 37). After the application of water the raw material of the artefact becomes at least partly transparent enabling a description as to the colour, clarity or tarnishing of the silicite matter, inclusions, pigmentation, microfossils, possibly also embedded silicate minerals. On the grounds of this three-dimensional description the artefact is compared to the raw materials from geological collecting localities.

Mineralogists have been using the immersion liquid method for years upon determining the so-called transparent heavy minerals as it was difficult to prepare thin sections out of the separated small minerals. Examining them as submerged into an immersion liquid, i.e. a liquid the light refraction index of which is close to the refraction index of the examined minerals that makes these minerals translucent has proven to be more elegant. Heavy minerals require using of special chemicals with a high light refraction index like acetylene tetrabromide or methylene iodide; unfortunately these chemicals are dangerous to human health and have to be worked with under special conditions.

As silicites consist of various SiO_2 minerals (mainly quartz, chalcedony, opal) the light refraction indexes of which vary around 1.53, water with a light refraction index around 1.33 is sufficient to make them translucent (the value for air is 1.00). Fig. 38 shows the differences between the appearance of parts of a silicite, to which water has been applied as an immersion liquid, and the parts

Fig. 37. Determination of raw materials in water immersion under the stereomicroscope. Photo by the author.

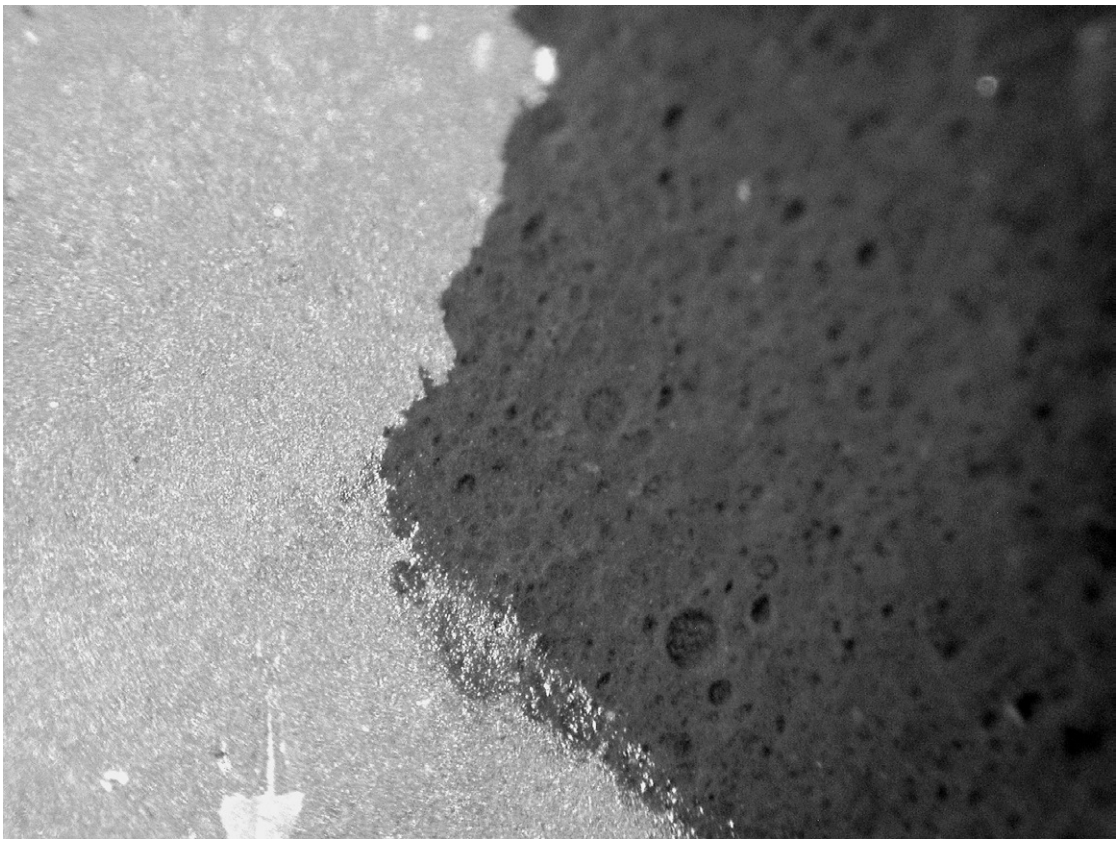

Fig. 38. Appearance of radiolarite under the stereomicroscope. The radiolarians are well visible in the right side of the picture where the water layer is spread as an immersion liquide. Photo by the author.

without water under the stereomicroscope. Every artefact may be examined by this method without suffering damage; in this monograph most silicites and other raw materials are characterized on the grounds of their appearance in water immersion under the stereomicroscope.

Out of other methods the so-called splinter method may be applied – this means that an artefact is not damaged by cutting out its part for a thin section; instead a mere thin, translucent splinter is knocked off and examined under the polarizing microscope. Obviously in a number of new found raw materials it is impossible to do determination without a petrographic thin section and its study under the polarizing microscope.

The study of SiO_2 minerals (especially rock crystal) that also used to be chipped as attractive materials both in the Palaeolithic and Neolithic requires a different approach. Recently the examination of enclosed fluid inclusions (Fig. 79) has proven to be effective with them as it enables to determine the temperature of their formation. To classify the strikingly coloured siliceous weathering products of serpentinites, which are, from the mineralogical point of view, represented by chalcedony with relics of silicate and opaque minerals, it is often sufficient to measure their magnetic susceptibility by a portable kappameter as magnetite grains are usually present in them and they have a higher magnetic susceptibility comparing other siliceous raw materials.

Determination of the provenance of natural glasses, among chipped artefacts prevailingly represented by obsidians, is carried out on the grounds of assessment of trace elements and rare earths. The obsidians are in fact speedily chilled acid volcanic rocks the trace and REE chemistry of which differs according to the geotectonic position of the volcanism.

Clastic siliceous rocks and the other rocks are mainly examined by means of petrographic thin sections under the polarizing microscope. With fine-grained sediments (pelites) X-ray diffractographic ascertainment of the clay mineral content has proven successful; it may also be performed by infrared spectroscopy or differential thermal analysis.

I.5.2. Determination of polished stone tools and the other lithic industries

A basic classification of the raw material with no damage to the artefacts may again be carried out under the stereomicroscope provided the researcher is experienced in this type of assessment. Measuring of magnetic susceptibility by a portable kappameter has proven to be very suitable for the differentiation of some types of metabasites or for the determination of patinated serpentinites (Fig. 39). The next step is to prepare thin section and to study it under the polarizing microscope: this usually enables a reliable classification of the rock. Primarily with volcanites (but also with other igneous rocks) it is necessary to determine the chemical composition and to express this in the form of main oxides on the grounds of which the rock may be plotted into the TAS diagram

Fig. 39. Measurement of magnetic susceptibility using portable kappameter. Photo by the author.

(total alkali – silica) and classified in an exact manner (Streckeisen 1980, Le Bas et al. 1986). Upon studying metabasites, serpentinites, marbles, basalts, and other rocks the ascertainment of their provenance turns out to necessitate the study of chemistry of the rock-forming minerals by the electron microanalyzer (microprobe). For a reliable classification of minerals from the main mineral groups diagrams have been elaborated into which the chemical composition ascertained by the microprobe is plotted. The most often used ones include the classification for pyroxenes by Morimoto (1989), or for amphiboles by Leake et al. (1997). An important contribution to the cognition of basalts and their metamorphosed equivalents is the determination of trace elements and rare earths, on the grounds of which it is possible to make good comparisons to rocks from geological units as there is a high-quality geological database because of geotectonic classification. With artefacts it is also beneficial to determine radioactive elements K, U, and Th, as for these large-scale comparative databases may be built through

Fig. 40. The author measuring of K (%) and U, Th (ppm) contents using portable gamma-spectrometer at a boulder of orthoquartzite near Bechyně, southern Bohemia. Photo by J. Fröhlich.

measuring of rocks at outcrops or boulders by a portable gamma-spectrometer (Fig. 40). One measurement takes about 3 to 5 minutes, the result being an ascertainment of the K percentage, and U, Th in ppm.

The issues of utilization of the geochemical data may generally be concluded that a determination of trace elements or rare earths merely in the raw material of an artefact will only be helpful provided these data have been established at the potential sources earlier on during geological research, or provided there exists a speedy and cheap method (like e.g. the gamma spectrometry above) through which we may build the comparative basis ourselves. Other methods include the utilization of cathodoluminescence for the study of marbles, or infrared spectroscopy and differential thermal analysis for the research of lutaceous rocks.

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II.
RAW MATERIALS OF CHIPPED LITHIC ARTEFACTS

Chipped artefacts represent a dominating and, very often, the only preserved relics after the Old Stone Age hunters; they did not lose their importance even in the course of the Young Stone Age, when the Neolithic farmer still used them, apart from tools prepared by the new techniques of polishing and smoothing. Their renaissance may be observed in the Eneolithic with the production of luxury flint daggers and axes, sometimes imitating metal items. The decisive techniques used were represented by chipping, hammering, chipping away, and sledging. In their making the Old Palaeolithic man used the simplest way, when he stroke a pebble or a chert nodule against a stone block (the so-called Clacton technique), thus creating usually massive flake with a big bulb of percussion. A typical feature of the Middle Palaeolithic, commencing roughly 300 000 years ago, is the newly used technique of a prepared core and the Levallois technique. At the beginning of the Upper Palaeolithic stone working has entered a more advanced stage due to the preparation technique of a prismatic shaped core to chip off flakes from; the length of the flakes exceeded their width a number of times – the blade technique. The then top products, i.e. surface worked artefacts, usually leaf-shaped points, occur as early as during the Upper Palaeolithic. The Gravettian hunters of Dolní Věstonice were commonly able to chip off blades of up to 10 cm length (exceptionally even 13.5 cm) from the silicites in use to modify them to instruments by retouch afterwards. A level of a more advanced quality in making of chipped tools is represented by the Eneolithic tools, in particular silicite daggers imitating metal patterns, and chipped silicite (flint) axes. From that era we are aware of deposits of blades, ca 15 cm long, even in Central Europe; probably the longest ones originate from the graves of the Tiszapolgár culture in eastern Slovakia and are 15 to 18 cm long (Šiška 1970, 172). The chipping of blades that long was obviously dependent not only on the technique, but also on the corresponding size and high quality of the raw material, which was, in this case, represented by up to 0.5 m long concretions of flint from the Volhyno-Podolia Highland in the Ukraine.

Fig. 41. Obsidian cores in the Anatolian Civilizations Museum in Ankara, Turkey. The biggest one is about 0.4 m high. Photo by the author, 1994.

The peak perfection in the chipping technique is represented by the silicite blades from the Eneolithic necropolis in Varna (4600 to 4200 BC) that have the unbelievable length of 39.7 cm in the grave No 43, and the longest even 44 cm in the symbolic grave No 1 (Ivanov & Avramova 2000, 50, 27). Our predecessors were able to perform the same wonders not only with silicites but also with obsidian, as supported by nearly 40 cm high obsidian core with negatives of chipped off blades (Fig. 41) exhibited in the Museum of Anatolian Civilisations in Ankara, the Turkish capital. The presence of the super-long blades in the Varna graves, together with the world's oldest gold or with jadeitite axes, indicates that these were prestigious products, and their usage proper was only secondary.

II.1. Classification of the raw materials for chipped artefacts

In Central Europe at present there are several hundred resources of lithic raw materials known to have been worked into chipped artefacts in the primeval era, or with which their utilisation may be reasonably assumed, and it is only a question of time when these may be found in some collection of chipped industry. Their terminology and characteristics have gone through a long-term historical development as these issues used to develop in a largely independent and uncontrolled manner in each of the Central European countries. Nowadays a majority of researchers feel the requirement of a certain unification of the terminology.

Since 1979 the author of this book have published a few times both in the Czech and international special volumes (e. g. Přichystal 1984, 1997, 2010) a proposal for classification of raw materials for chipped artefacts into five groups according to their origin: silicites (siliceous rocks), minerals of SiO_2, natural glasses, clastic siliceous rocks and the others. This classification started to use a number of other authors in the Czech Republic and till recent time no negative comments have been raised against. The raw materials for chipped artefacts mentioned in this book are divided in this way as well. Earlier, the author prepared also a preliminary catalogue of local and imported chipped raw materials used in the Czech Republic including their abbreviations and numerical codes (Přichystal 2006).

Proposals for division of raw materials used in the prehistoric times for polished and chipped artefacts have been published also by next researchers, e.g. Binsteiner (1993). His division is partly in harmony with that of the author (e.g. the definition of flint and chert), partly it could be possible argue against (e.g. gabbro and peridotite cannot be included in the group of granite; andesite, basalt and diabase in the group of quartz porphyry, etc.).

It is possible to agree with Pawlikowski's (1989) opinion on necessity to standardize the petrographic designations of rocks used for chipped artefacts (and it is much more accepted for raw materials of polished artefacts,

see the chapter concerning greenschists and metabasite rocks). As is raw materials of chipped artefacts concerned, a really problem is represented by different views of individual national specialists, e.g. in the mentioned contribution of M. Pawlikowski „chert is a variety of flint" whereas in the Czech, Slovak, English and American terminology it is inversely (see e.g. Allaby & Allaby, eds. 2003; Bates & Jackson, eds. 1987). Other problems are usually connected with classification of jasper (red chalcedony of hydrotermal origin) and quartzites because it is necessary to distinguish between the orthoquartzites of sedimentary origin and the metaquartzites of metamorphic genesis.

Slovak authors Ozdín and Mesiarková (2006) tried to classify natural siliceous masses from the mineralogical point of view. They divided raw materials into a) SiO_2 minerals without water, b) SiO_2 minerals with water or other volatiles, c) silicites, d) natural glasses. It is necessary to have exceptions to this paper as is concerned their classification of orthoquartzite, metaquartzite and porcellanite in the group of silicites.

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II.2. Silicites and their sources. The terms silicite, chert, and flint

Silicites are undoubtedly the most significant raw materials for chipped artefacts in Central Europe. They are sedimentary siliceous rocks originating from chemical, biochemical, or diagenetic precipitation of SiO_2 and consisting of its various mineral modifications, first of all of cryptocrystalline quartz, chalcedony, and opal; in some cases also tridymite and alpha-cristobalite are ascertained. The contents of other cementing material than siliceous or clastic (fragmentary) components may not exceed 10 %. This group is capable of embracing all chert types (including flint as one of its varieties), radiolarites, spongolites, lydites, phthanites, and limnic silicites. They form concretions (nodules) or layers, particularly in limestones and other carbonate rocks, in absolute majority of cases of marine origin. Where they settled in lake sediments, they are designated as limnic silicites.

As a well-defined term from the viewpoint of petrography, the silicite may be recommended in all cases where the researcher is not sure of a reliable classification of a raw material, where he/she wants to use a general term for this extensive group of raw materials, or where differing opinions exist as for its designation due to historical development (this particularly relates to the different perceptions of the terms chert and flint). The decisive factor for placing of an unknown silica substance among silicites is the find of microfossils, or their parts, in the silica groundmass. This term may not comprise such SiO_2 minerals as quartz, rock crystal, jasper, chalcedony or opal substances that have originated from weathering or due to hydrothermal activity, natural glasses, or clastic silica rocks. Silicite is more unambiguous than the sometimes used terms silex or silexite (i.e. the French terms for flint and chert); moreover, the term silexite is understood by some authors of geological literature as a silica rock of the magmatic origin.

Within this group of raw materials the terms flint and chert present a specific problem. Their names themselves deserve a brief analysis. Their Czech names probably stem from the appearance of the flakes of both of these raw materials, as being found by farmers when ploughing in the 19th century; the flakes have often evoked parts of animal hoofs or horns. In the Czech etymological dictionary (Machek 1997, 439) is a little different explanation of the word flint: „It is a result of metaphor that compares a stone striking fire from another stone to a claw buried

into the meat". The similarity to a horn is also fixed in other languages ("hornstone" in English; "Hornstein" in German; "rogowiec" in Polish; "rogovik" in Russian; „rohovec-pazúrik" in Slovak; in Hungarian, a hoof is called "köröm" and flint is "körmöcske"). The Czech synonym striking stone, the German "Feuerstein", and the Hungarian "tűzkő" are related to its use for making fire, and are older than the Czech words for flint and chert.

In the Czech scientific literature the terms flint and chert began to be used as late as towards the end of the19th century; in the older literature we only come across the term striking stone or word containing in its core the consonants "kř". So Thomas Jordan from Klauznburk in the year 1580 (the issue 1948, 38) called stone "that is used for making fire from the steel" as "škřemení". In his overview of the mineral resources of the Kingdom of Bohemia, Balbín (1679) has mentioned the striking stone, that it occurs everywhere throughout Bohemia, and that the author personally has been using onyx and carnelian as the striking stones for many years. Jungmann (1837) in the Czech – German dictionary and in the same time also Presl (1837, 117) in his book "Description of minerals or Mineralogy" were the first authors designating the striking stone as "pazaur or pazaurek", in addition to it J. S. Presl the term "pazaurek (Feuerstein)" has defined in the same way as the recent petrography. He did not know the word "rohovec" (hornstone) and instead of it he wrote "dreswa (Hornstein)". The first Czech field archaeologist – Priest Václav Krolmus whose results were published by K. V. Zap originally in the journal "Pautník" (Krolmus & Zap 1846) and later in the journal "Památky archeologické a místopisné" – did not know the terms of J. Jungmann and J. S. Presl and for the raw materials of chipped artefacts he devised the word "křemitce" (something like the modern term silicites) or he used "prohledeň" (translucent quartz), recently abandoned term for the rock crystal. In a number of issues of his "Minor Geology" (e.g. Frič 1903) A. Frič, an important Czech geologist of the latter half of the 19th century, prefers the term striking stone (and he sometimes adds the synonym flint or firestone). On the contrary, Klvaňa (1882, 59) in his records of minerals from Moravia and Silesia has mentioned both chert and flint as the minerals from Maloměřice near Brno (now a part of Brno). The English name "flint" probably originates from the Old English word "flyht" (= flight; the original names were fyrstan, flynt) related to its use for arrowheads (Tomkeieff 1983).

As a result of the historical development there is no conformity existing in the European geological literature regarding the definition of flint and chert either. In the Anglo-Saxon literature, the definition of flint as a special variety of chert (or of silicite as the case may be) originating from the chalk rock of the Cretaceous (Maastrichtian) age prevails (Pfeiffer, Kurze & Mathé 1985; Trewin & Fayers 2005). The Czech and Slovak petrographers and geologists (Hejtman 1957; Petránek 1963; Konta 1973; Mišík, Chlupáč & Cicha 1985) usually apply the term flint in compliance with Anglo-American authors. All other silicites of marine origin may be designated as cherts. According to the prevailing fossils their names may be further specified as radiolarite, spongolite, and diatomite. However, it is true that in some countries the definition of these two rocks is based on a different principle. In particular, the Russian (e. g. Švecov 1948) and Polish (Bolewski & Parachoniak 1978) scientific literatures define flint (krzemień, silex) as concretional siliceous rock, whilst stratified silicite is defined as chert (czert, silexit). Yet it is hard to be in agreement with this concept as the same silicite very often forms both concretions and horizontal layers. Similarly, the definition of flint cannot be based on the fact that it appears to the observer as a high-quality, well-chipping material, sharply bordered against the limestone mass as we are again aware of silicites from a single outcrop showing different stages of silicification, and therefore with differing above-mentioned properties. Due to the historical development, in the Czech and Slovak Republics flint was supposed to be a silicite of erratic origin from the sediments of the continental glaciations, and all local silicites were designated as cherts. Later on, this designation was taken over by e.g. Polish colleagues, who wrote about cherts of Stránská skála, cherts of Krumlovský les Highland, although from the perspective of the Polish classification they should have designated them as flints.

Moreover, in the English archaeological literature we find the phenomenon that practically all well-chipping raw materials are designated as "flint, chert, hornstone", and usually only obsidian, rock crystal and orthoquartzite are differentiated but not always. Modern English and American earth sciences dictionaries do not use or do not recommend using the term hornstone. As has already been pointed out by a number of authors, the terms flint and chert were very often used without a clear definition, or as synonyms, thus being rather profane in view of a correct terminology. Therefore it is right to use the petrographically well-defined term silicite in all unclear cases, or in the events of a different conception. In this book the author used the term silicite in all cases of raw materials that are designated differently in Poland and in the Czech Republic, e.g. silicites of the Cracow-Częstochowa Jurassic.

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II.2.1 Silicites of glacigene or glacial sediments (erratic silicites, prevalently flints)

Background: These important raw materials are referred to separately, prior to the sources of the individual Central European countries, due to the fact that they used to be acquired in the territories of more states. The silicites of glacigene or glacial sediments (erratic silicites) are usually called in the papers as flints but such designation is correct only for those being of Maastrichtian age (see discussion in the previous chapter). Therefore from the beginning of his cooperation with archaeologists in the 1980s A. Přichystal has preferred the term silicites of glacigene sediments. In the Czech language there is another problem because the term "glacial" has meaning "in the glacial stage", so we have to use the term "glacigenní = glacigene" that means "connected with a glacier directly and indirectly", similarly to a number of other Czech sedimentologists and geologist (see Fairbridge & Bourgeois, eds. 1978, 360; Zeman & Demek 1984, 99; Kukal 1986, 253; Kovanda in Chlupáč et al. 2002, 370) and incorporates not only morainic sediments (the till) but the glaciofluvial and glaciolacustrine deposits also. In English written papers the authors usually use the word "glacial", but e.g. Fairbridge & Bourgeois, eds. (1978, 360) also propose the term "glacigene" in the sense mentioned above. Another possibility is the prefix erratic (stone, boulder, flint) from the Latin word "erraticus" that means transported by ice sheet and deposited in an area of dissimilar rock type.

Location: In the course of Pleistocene the continental glacier affected a vast area covering the northern part of the today's Germany, from the northern part of the Rhine valley as far as the Krušné hory (Erzgebirge) Mts., practically the entire Poland (except for the Carpathians and some parts of the Bohemian Massif in the south), north Bohemian forelands, a substantial part of the Czech Silesia; it pervaded farthest to the south through the Moravian (Odra) Gateway in north Moravia – almost to the main European watershed, but did not exceed it. But a very small part of melting waters probably reached the Bečva River basin, so one can find reputedly totally rare northern erratic material in the fluvial sediments of the Morava River (Gába 1988). Going to the east, the continental glacier affected a substantial part of Byelorussia and pervaded even to north-western Ukraine (Fig. 42; Supplement/Photo 1).

Geological Setting: The area of Central Europe had been affected by the continental glacier at least twice in the course of the Elsterian and Saalian glacial periods (or the Mindel and Riss glacial stages in the Alpine terminology), in northern Poland even three times (also during the last, Würm glacial). The glacier transported silicites (flint and cherts) from extensive occurrences of the Cretaceous (Maastrichtian) chalk and Lower Tertiary (Danian) carbonates in Denmark and the Baltic to the northern part of Central Europe. Besides them in places other silicites can be found, e.g. from the Cracow-Częstochowa Jurassic, Cretaceous spongolites etc.

Macroscopic Appearance: A prevailing part of silicites from the glacigene sediments reach only several centimetre size and a small weight, and an absolute majority of them does not exceed the 0.75 kg weight, although even big pieces have successfully been found from time to time. For example in northern Moravia and Silesia erratic silicites weighing 8 and 12 kg are known from the sand pit in Polanka nad Odrou; the author of this monograph possesses a flat, brownish grey piece weighing 21.5 kg (dimensions 33 x 25 x 16 cm) from the sand pit in Libhošť (Supplement/Photo 12), and the heaviest erratic silicite found so far originating from Bohušov is a part of a private collection of Mr P. Dybowicz from Opava and weights 29.5 kg. There are not known so big pieces from the glaciated area in northern Bohemia; probably the biggest one with the dimensions 29 x 20 x 16 cm and weight about 10,5 kg comes from Horní Řasnice (verbal communication of J. Víšek).

The contents of silicites in the glacigene sediments of Moravia and Silesia are not high; for example in the region north of the Jeseník town they represent merely 0.3 to 3.1 % of all psephite components, and 10 to 15 % of erratic material on the average (Gába 1972, 1977).

The same author has pointed out that there are two basic types of erratic silicites in northern Moravia and

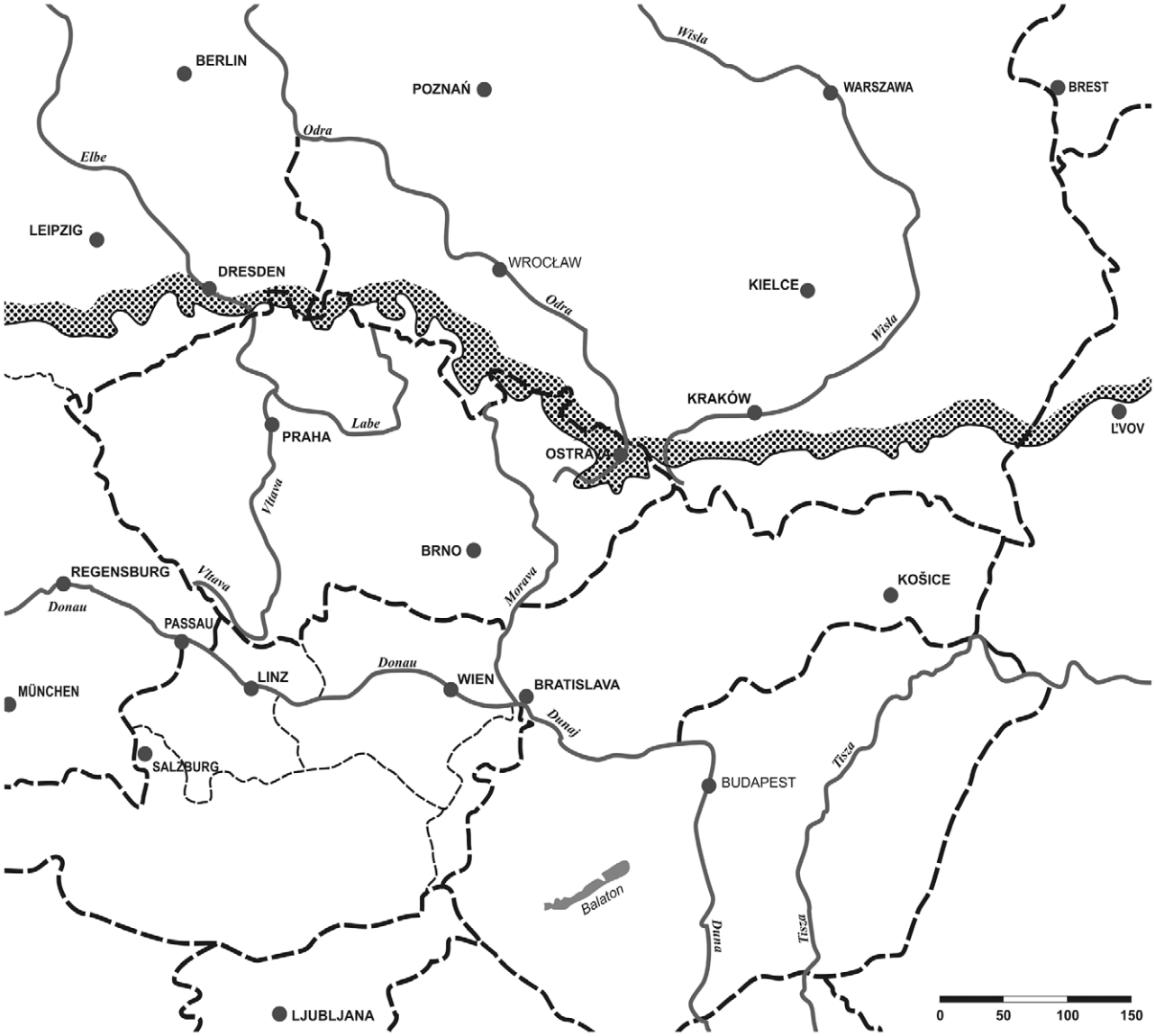

Fig. 42. Southern limit of the Pleistocene continental glaciation and natural distribution of erratic flints in eastern Central Europe.

Silesia. The dominating type originates from the bryozoan limestones of the Danian (Tertiary) age. Typically, its shape is flat, its colour is brownish grey to grey (on the surface the colour changes to yellowish or brownish red due to weathering), it contains non-translucent, lighter to whitish enclosures of centimetre sizes and plentiful fossil relics, in particular of *Bryozoa* (Fig. 43; Supplement/Photos 6 to 11). According to Gába & Pek (1999, 75) there has been determined only the species *Coscinopleura angusta* Berthelsen, 1962, as numerous are to be found the genus *Spiropora* and *Steginopora*, there are usual prints of Cidaroide sea urchin spines (less of their cores), especially of the genus *Tylocidaris.* Brachiopodes, molluscs and asteroids are scarce. It is difficult to determine the frequency ratio of both silicite types as it is very changeable, but e. g. in the Vidnava area (Czech Silesia) the Danian silicites represent about 45 to 55 % and the percentage of the Maastrichtian ones varies between 16 and 30 % of all silicites. Because of their flat shape the Danian silicites were often used for axes in the Eneolithic (Fig. 43).

The other basic type is represented by typical flint in terms of the Czech petrography, as it originated from the Maastrichtian (Cretaceous) chalk (Supplement/Photos 2 and 3). Its concretions often feature a very rugged surface with many cavities that tend to be filled with a white substance containing plentiful fungi spicules and foraminiferal tests (Supplement/Photos 4 and 5). The colour of the silicite substance is dark to black; the Foraminifera and Hystrichosphera are usually present as microfossils. Most of the Cretaceous flints contain relics of animal Fungi, imprints of mollusc valves (the *Lima, Lyropecten* and *Pinna* genera have been determined so far) and relics

Fig. 43. An axe made of erratic silicite of Danian age with nume. rous *Bryozoa.* Length of the axe is 9.4 cm. Corded Ware culture. Rymice near Holešov, district of Přerov. Photo by the author.

Fig. 44. An axe with length 7.7 cm made of dark erratic flint of Maastrichtian age. Probably Corded Ware culture. Čelechovice na Hané, district of Prostějov. Photo by the author.

of echinoids are common, stem articles of crinoids and other fossils occur as well (Gába & Pek 1999, 73). The Maastrichtian flint appears among the Eneolithic silicite axes rarely (Fig. 44) because of their irregular shape.

It is necessary to realise that, in the course of its movement, the continental glacier affected a vast territory consisting of the Maastrichtian chalk and the Danian limestones; thus it will obviously be possible to distinguish a number of varieties within the framework of the two mentioned basic erratic silicite types. These Scandinavian and Baltic silicites (flints) have been described in detail by Högberg & Olaussen (2007). The glacier also eroded further sources of silicites, in particular in the southern part of Poland, which may then occur among erratic materials in a greater or smaller area. First of all we have to mention silicites of the Cracow-Częstochowa Jurassic that are known, for a rather long period, to have a significant representation in the surroundings of the primary occurrences (Gojść), probably the Jurassic silicites occur in the glacigene sediments in the southern part of Opole (Groszowice) and it is possible to follow them apparently as far as to the state border of the Czech Republic and rarely can be found probably in the Ostrava region. Till now it is not clear if siliceous rocks of the Opole Cretaceous and Triassic can be found among erratic materials.

Reliable proofs of the raw material origin from glacigene sediments are the finds of traces of shifting by the continental glacier – exaration striae (Fig. 45), that may rarely be detected even on artefacts where they feature relics of their original surface. For example they were successfully determined on some Magdalenian artefacts from the Ochozská Cave in the Moravian Karst (Přichystal 2002).

Stereomicroscopic Appearance: According to Gába & Pek (1999), only the *Coscinopleura angusta* Berthelsen 1962 species has been determined yet as is *Bryozoa* in the Danian erratic silicites concerned. Especially the *Spiropora* and *Steginopora* genera are abundant, imprints of spicules (less often of cores) of cidaroid Echinoidea, in particular of the *Tylocidaris* genus, are quite common. Brachiopodes, pelecypods, and sea asters are scarcer.

Thin Section: Considering the enormous variability of silicites in glacigene sediments, here it is possible to give only schematic description of a typical erratic flint found near Leknica in SW Poland. The siliceous groundmass is very fine-grained to cryptocrystalline, so it looks almost isotropic in crossed polar. In places it contains elongated or circular relics of microfossils (prevalently spines of sea urchins) filled by fibrous chalcedony. There are usually no inclusions either pigmentation.

Other Analyses: Efforts to distinguish erratic silicites from those of the Cracow-Częstochowa Jurassic on the basis of trace elements (Přichystal 1994*)* are of interest. Due to hitherto small numbers of analysed samples it cannot be reliably decided about the significance of the content differences. Preliminarily, higher contents of Ba and lower contents of Cu in erratic silicites have been ascertained in comparison with the other mentioned raw material.

Prehistoric Use: These silicites in spite of their diversity and a long transportation by the continental ice sheet belong to the most important Central European raw materials used with various intensity during the whole prehistoric times. The use of erratic silicites for the production of chipped tools has been undoubtedly known in Moravia and Silesia as early as from the Middle Palaeolithic (the Šipka and Kůlna Caves, see Valoch 1975; Acheulian handaxes from Silesia, see Svoboda, Macoun & Přichystal 1991). In the Upper Palaeolithic they represented a decisive source for the stations in the area of glaciations (Petřkovice), in the Maleník and Tučín Highlands above the Moravian Gateway (Pavlovice u Přerova, Lhota), and on the western slopes of the Nízký Jeseník Upland (Olomouc-Droždín, Šternberk region). They also played an important role at the Palaeolithic sites around the penetration of the Morava River through the Carpathian Flysch Belt and on the slopes of the Drahany Highland, opposite to the opening of the Moravian Gateway (Ondratice, Drysice, e.g. Přichystal 2001). They undoubtedly prevail even at the Gravettian sites at Předmostí,

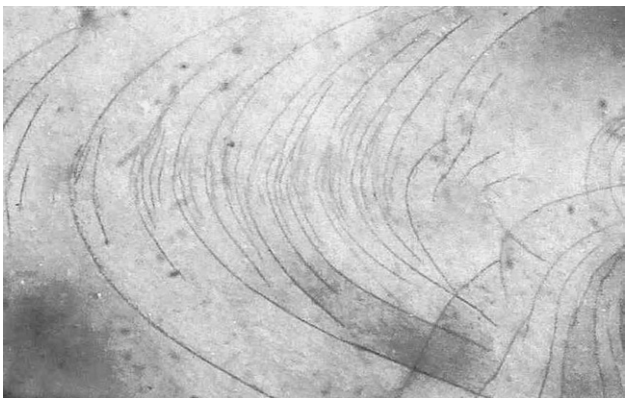

Fig. 45. Traces after pushing of an erratic flint by continental ice sheet. They are preserved on the surface of chipped artefact from the Magdalenian site in the Ochozská cave (southern part of the Moravian Karst). Length of the picture is 11 mm. Photo by the author.

Dolní Věstonice, and Pavlov, though exact petrographic studies to distinguish them from the also possible raw materials of the Cracow-Częstochowa Jurassic or from the flint of the Volhyno-Podolian Highland have not been concluded yet. Similarly at some Aurignacian stations of the Prostějov and Olomouc regions the question of the origin of nearly overall patinated silicites has yet to be uniquely answered, but even there the silicites from glacigene sediments apparently dominate. The erratic silicites prevail at the most Neolithic settlements in the Upper Moravian Basin (Supplement/Photo 14).

In the area of glaciations there are some places with glacigene sediments where besides natural flint chips one can find also artefacts or where prehistoric mining has been described. In the thirtieth of the 20th century German archaeologists noticed the extraction of erratic silicites at the village of Maków near Pietrowice Wielkie, 9 km to the west of Racibórz, district of Katowice, southern Poland (Supplement/Photo 13). According to them, the mining was in progress by funnel pits or ditches with the depth of 4–5 m in a moraine of the Riss age covered by a thin layer of loess (for the last time see Lech 1999; in the catalogue of the Bochum museum the site has the number PL 13). Flint picks had been found as the mining tools. Near the exploitation site there are settlements of the Linear Pottery culture and the Funnel Beaker culture.

With no doubt we can suppose more localities with prehistoric exploitation of erratic silicites in the area of continental glaciations. The most promising are places where besides natural chips is possible to find often artefacts, e.g. in the surroundings of Nový Jičín, in the fields above the recent sandpit at Bernartice nad Odrou in northern Moravia or in the area of Krnov in Silesia (Supplement/Photo 15).

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II.2.2. Silicites of Bohemia

II.2.2.1. Proterozoic phthanite (Fig. 46)

Background: According to Frič (1903, 43), the Czech word "buližník" comes from the Russian and originally it had meaning "a paving stone" or "a pebble". In Bohemia there are called in such way the oldest Proterozoic silicites built of quartz. The terms "lydite, phthanite, touchstone" are used for the pre-Mesozoic black silicite variety in other languages also. The lydite got its name after the Kingdom of Lydia in the Minor Asia. This black stone served for examination of gold genuineness using its wiping traces. The phthanite has been mentioned as a raw material for stone artefact already by Priest V. Krolmus (Krolmus & Zapp 1855, 91) even if in that case ("phthanite hammer with bored hole") the raw material determination was very probably wrong.

Location: Phthanites are spread in the arch-shaped zone from the western to central Bohemia (Fig. 46). Than, they are hidden under sediments of the Bohemian Cretaceous Basin and crop out in the Železné hory Mts. again. For example in the Plzeň region there are the localities of Radyně, Ostrá hůrka, Starý Plzenec, the quarries of Bečvárka and Rozárka, Ejpovice, Bušovice, and Malá Doubrava north of Klatovy. They may also be found in the surroundings of Radnice and Skryje; and in Borovy, Zálesí, and Vodokrty in the Přeštice area. Furthermore, the phthanite bodies we know south of Kladno and running through the west surroundings of Prague as far Stará Boleslav (Kněživka near Tuchoměřice, Kozí hřbety near Horoměřice, Přezletice, Kojetice near Brandýs nad Labem). In Prague and its close vicinity these are Šárka, Ládví, Letky, Kralupy, Erš, and Krliš near Tursko. In the Železné hory Mts. occurrences of phthanites are rare and their bodies rather thin. They mostly occur in the area between Chvaletice and Zdechovice.

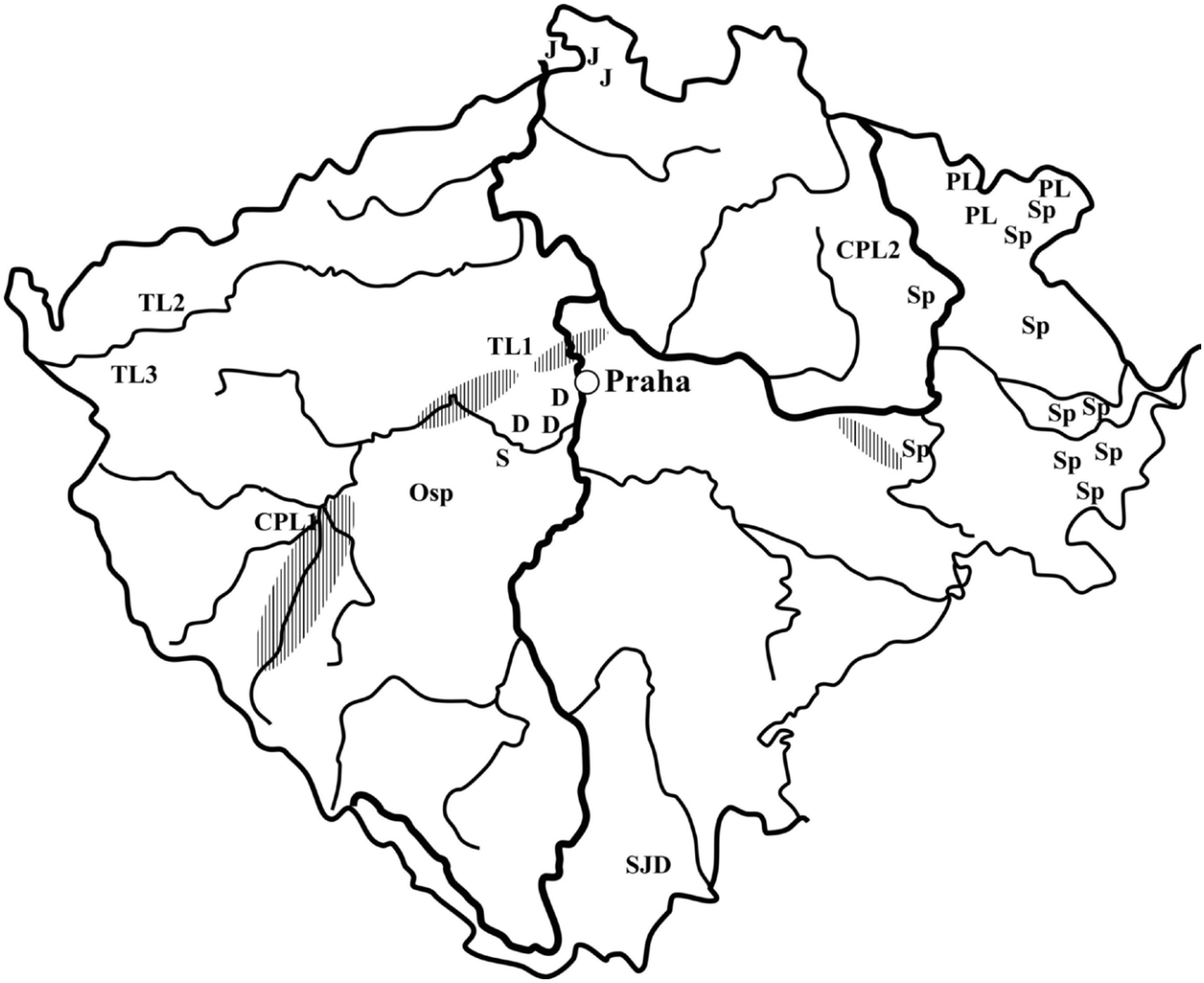

Fig. 46. Sources of silicites in Bohemia (Czech Republic). Vertical hatch – occurrences of Proterozoic phthanites in the Barrandian and Železné hory Mts., Osp – Ordovician spongolite at Mílina, S – Silurian silicified shale to chert at Liteň, D – Devonian chert and radiolarite in the Prague Basin of the Barrandian, CPL1 – Upper Carboniferous to Permian limnic silicites at Líně near Plzeň, CPL2 – limnic silicites of the same age in the Krkonoše Piedmont Basin, PL – Permian limnic silicites in the Intra-Sudetic Basin, J – Jurassic cherts near the Bohemia/Saxony border, Sp – Cretaceous spongolites in eastern Bohemia, TL – Tertiary limnic silicites: TL1 – on the SE slopes of the Džbán Mt., TL2 – Lomnice near Sokolov, TL3 – Mokřina near Mariánské Lázně; SJD – Tertiary silicified clays to diatomites of the Zliv Formation at Lipnice.

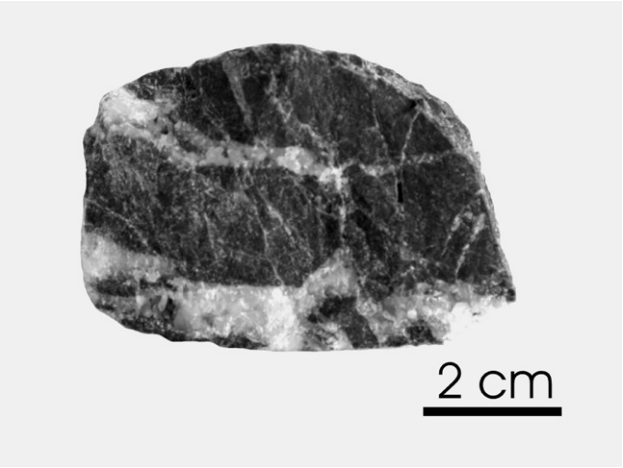

Fig. 47. Phthanite with white quartz veinlets, Přezletice NE of Prague. Photo by the author.

Apart from lens-shaped bodies the phthanites secondarily occur as pebbles practically in all younger conglomerates (Palaeozoic, Cretaceous) and in Pleistocene gravel terraces, for example of the Vltava River directly in Prague (Supplement/Photo 18).

Geological Setting: Phthanites represent the oldest silicites in Central Europe with which the time of origin has been reliably evidenced. They are of Upper Proterozoic age and they mainly occur in the Kralupy–Zbraslav Group of the Barrandian Proterozoic; smaller localities are also known in the north-western part of the Železné hory Mts. within the Chvaletice (Chvaletice-Sovolusky) Proterozoic, or they may possibly occur in the Proterozoic rocks of the so-called island zone closed within the Central Bohemian Pluton. Their genesis is connected with hydrothermal solutions rich in silica that accompanied Proterozoic submarine volcanism. From the viewpoint under observation, the most important undoubtedly are phtanites in the Barrandian Proterozoic. As this unit has been intensively folded, the individual phthanite horizons were tectonically changed into lens-like formations, dozens to hundreds of meters long, mutually unrelated. Being very hard and weathering resistant rocks, they create marked small rocks (knobs) in the landscape.

Macroscopic Appearance: They are prevailingly compact, however porous types are also reported (Vodokrky, Sovolusky). The colour of the rock varies from grey-black (N2), for example in Ládví, to medium pale grey (N6) – Šárka. Even grey-pink phthanites with white and incarnadine spots are known from the Šárka valley. Due to a weak metamorphosis they are usually interlaced by thin veinlets of white quartz with the thickness of about 0.0X – X mm (Fig. 47). The rock is often cracked up in an irregular manner and there are coatings or spots of limonite or brightly pigmented clay minerals appearing on the cracks.

Stereomicroscopic Appearance: Even if we spread water as an immersion liquid on, the silicite mass does not become translucent as it is in the case of younger Palaeozoic and Mesozoic silicites, so the phthanite has the same property as the common quartz. The black coloured varieties (Přezletice, Ládví, pebbles from gravel terraces of the Vltava) are non-translucent including their thin margins, the grey ones (Šárka) are translucent moderately. It is typical a lot of quartz veinlets sometimes thin only as a hair. Bigger quartz veins can have cavities with small rock crystals (Přezletice). Some phthanite pebbles show evident lamination. In its silica mass there are seen no microfossils using the magnification of a stereomicroscope.

Thin Section: From the petrographic point of view, it is in fact a monomineral rock consisting of fine-grained quartz, usually pigmented by amorphous carbon substance (partially almost graphite). As these are the oldest silicites in Central Europe, fossils may be found just very rarely. In isolated cases spherical microorganisms of uncertain systematic affiliation classified to the group *Acritarcha* and probably relics of algae (Chlupáč 1988), were found in them under a great magnification (2,500x).

Other analyses: A summarising elaboration of the Bohemian phthanites has been carried out by the group of authors (Dubanská et al. 1977). According to x-ray analyses they consist in fact only of alpha-quartz, in isolated cases minerals of kaolinite group have occurred as well as hematite, graphitic substance, and calcite. Even a chalcedony was described from Mirošov. Furthermore, pyrite, chalcopyrite, and their secondary products, i.e. azurite, malachite, aragonite, gypsum, wavellite and the so-called callaite (a clay mineral coloured green or blue by copper compounds) have been mentioned in the phthanites. From the chemical point of view these are highly pure silicites (the mean SiO_2 values vary around 98 %), the contents of all other main oxides are only around 0.X % with exception of Al_2O_3 and the overall iron expressed as Fe_2O_3 exceed the value of 0.5 %. Out of the trace elements there are interesting occurrences of biogenous elements V, Cu, and U, on the basis of which Dubanská et al. (1977) succeeded in the classification of phthanites into geographically separated groups. Furthermore, these authors state that the average values of the amorphous carbonic substance vary around 0.4 % (the values alternate from 0.026 to 0.95 %). Higher contents of Au, Ag, Cr, Hg, Mo, Pd, Sb, Sn a V are typical for the Proterozoic silicites (Korečková, Mrázek & Weiss 1987) what is interpreted by origin of SiO_2 connected with undersea hydrotermal springs. Comparing average abundance of Au in the Earth's crust (so called clarke), the contents of Au in some phthanites are 10–18 times higher (40–73 ppb).

Prehistoric Use: According to the data in specialised literature, the phthanite was used as early as in the Lower Palaeolithic (Přezletice, Tmaň), then through the Middle and Upper Palaeolithic, and Mesolithic to the Neolithic. For example Žebera (1958, 143) stated he has found an industry chipped entirely from phthanite on several sand dunes with the stations of Mesolithic man in the Labe (Elbe) region. Parts of phthanite pebbles (0.5 % of the overall number of artefacts) occurred in an extensive collection of chipped industry at the well-known Mesolithic

station in Hořín near Mělník (Přichystal 2000). In younger periods phthanite pebbles were often used as percussion implements.

II.2.2.2. Ordovician spongolite

Background: Spongolite is a silicite being substantially built of sponge spicules or it originated by diagenesis prevalently from them. The term introduced the French sedimentologist L. Cayeux in 1897. In Bohemia it was Prague geologist Kettner (1916) who mentioned occurrence of the Ordovician spongolites in the frame of the "Mílina layers" as the first. Přichystal (1997) drew attention to their possible using in the prehistoric times.

Location: The Mílina Formation crops out in the Prague Basin of the Barrandian in the sheets of geological map 1:50 000 12–34 Hořovice (between Strašice and Komárov, description of outcrops see Mergl 1993) and 12–32 Zdice in a narrow belt from the Holý Hill and Opyš through Točník up to Vraní Rock south of Svatá (Mašek, ed. 1992). A typical locality is the Mílina Hill near Olešná, south of Hořovice (the Brdy Highland).

Geological Setting: It is the oldest Palaeozoic silicite in the territory of Bohemia and the Czech Republic. The spongolite forms a part of the Mílina Formation, which is of Lower Ordovician (Tremadocian) age. The formation is 10 to 15 m thick and in its upper part there are, apart from spongolites, the interlayers of greywackes and siltstones. The spongolites usually represent 40 or more % of this formation. According to Kukal (1992, 217), the silica in these silicites has volcanic origin and he interpreted as originally chemogene silicites also the lenses of iron quartz in the basal Třenice Formation.

Macroscopic Appearance: In the Mílina Formation the spongolites make up lenses, thin layers and benches several dozens of centimetres thick. The colour of the silicite groundmass is mostly greyish red (5R 4/2) with pale yellowish green (10 GY 7/2) spots or veinlets so that, macroscopically, they are very difficult to distinguish from the Alpine-Carpathian Jurassic radiolarites, only the silicite groundmass lustre is lower (Supplement/Photo 19).

Stereomicroscopic Appearance: The siliceous groundmass is not translucent even at a chip margins and smudges of detritic material are visible in it. In some samples one can find numerous lighter phantoms after sponge spicules (Supplement/Photo 20).

Thin Section: Kukal (1985) described the only modification of SiO_2 in Ordovician silicites – quartz, both in microcrystalline and fibrous forms. Its content usually varies between 90 and 95 %. On the basis of the prevailing microfossils (sponge spicules) these silicites may be classified among spongolites. Z. Kukal describes a plentiful detrital admixture of these and that is why the spongolites may pass over to red clay-type shales or greywackes both laterally and vertically. It has been confirmed by a newly prepared thin section of the spongolite from the Mílina Hill in which there are smudges and schliers of clastic quartz and altered feldspars (Supplement/Photo 21). Small mica lamellae are irregularly spread within the whole chert. Using the crossed polars, the siliceous mass has isotropic appearance; on the other hand there is visible variably intensive clouding by brown organic pigment when we observe a thin section in plane-polarized light. Relics of microfossils and younger quartz veinlets are without the pigment.

As far as fossils are concerned, sponge spicules and phosphate cups of brachiopodes are present. The individual genera and species of brachiopods in the Mílina Formation have been described by Mergl (1993). Fragments of trilobites, ostracods and gastropods are found as well.

Other Analyses: Two chemical analyses of green and rose chert from the Mílina Formation (the Krušná hora beds in that time) has been published by Veselý (1925): SiO_2 – 90.93 and 97.03 %, Al_2O_3 – 3.79 and 1.15 %, Fe_2O_3 – 0.32 and 0.23 %, FeO – 1.08 % and traces, MnO and MgO – traces, CaO – 0.36 and 0.39 %, K_2O – 0.61 and 0.37 %, Na_2O – 0.82 and 0.27 %, loss of ignition 1.91 and 0.74 %, total sum 99.82 and 100.18 %.

Prehistoric Use: For the time being, the presence of Ordovician spongolites was only exceptionally ascertained among Pre-Neolithic artefacts of southern Bohemia, explicitly the artefact No. 716 in the collection from Putim I can be mentioned (Přichystal 2006). However a revision should be worth carrying out in respect of the assumed Alpine-Carpathian radiolarites occurring in the Mesolithic and Neolithic chipped industries in the Bohemian Karst. It is impossible to exclude that in some cases these are just Ordovician spongolites of the Barrandien area.

II.2.2.3. Silurian silicified shale to chert of the Liteň Formation

Background: Name of the formation is deduced from the village of Liteň near Beroun. Prošek (1952, 98) was probably the first who mentioned "the Liteň shale" as a raw material for chipped artefacts at the end of the Magdalenian at various sites in the Bohemian Karst, especially in the Děravá Cave near Beroun. He believed to be a raw material originated by thermal (contact) metamorphism around a Silurian diabase. Later the term appeared in papers of S. Vencl and B. Klíma. From the point of archaeological praxis the term is suitable because of its brevity and if it is explained what is the correct meaning in reality the name could be possible to accept. Unfortunately, the term Liteň shale is not in harmony neither with the contemporary lithostratigraphic division of the Silurian in the Barrandian nor it is introduced in the Encyclopaedic Dictionary of Geological Sciences (Svoboda, ed. 1983). In geological literature the attribute "Liteň" was gradually connected with a substantive beds, than formation and in the end of the 20th century even a group. According to the latest division of Silurian sediments in the Barrandian (Chlupáč et al. 2002), the silicified shale to chert occurs in the frame of the oldest Silurian sedimentary rocks having the name Želkovice Beds. These beds together with the next two superposed Litohlavy and Motol Beds (for all of them a shaly development is characteristic and they correspond to the Lower Silurian) form the Liteň Formation. It is necessary to mention that a reader can find also the

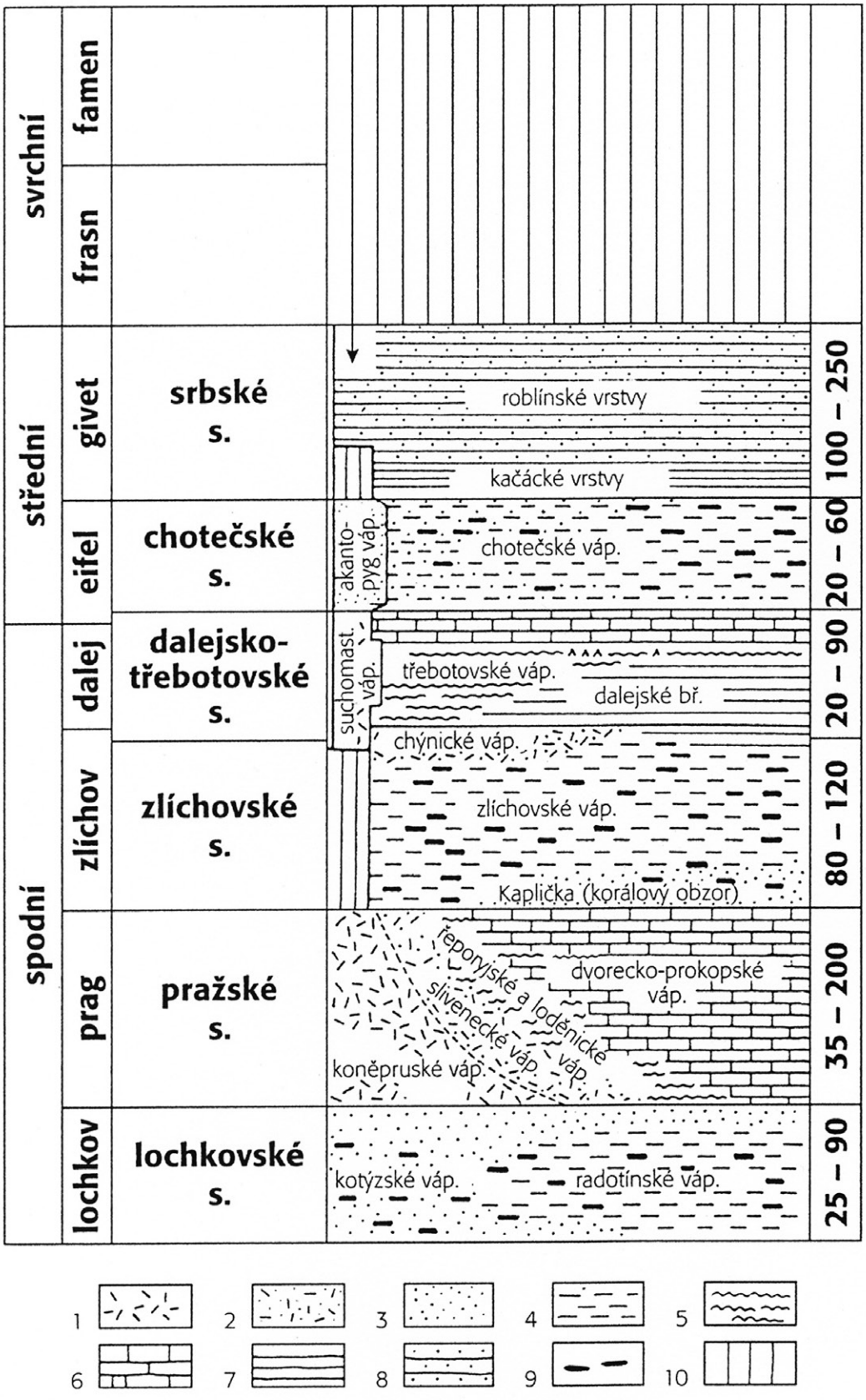

Fig. 48. Occurrences of cherts in Devonian formations of the Barrandian (after Chlupáč 1988). 1–6 – various types of limestone, 7 – calcareous shales, 8 – siltstones and sandstones, with minor quantities of argillaceous shales (flyschoid sediments), 9 – abundance of cherts, 10 – stratigraphic hiatuses. Czech words and abbreviations: spodní, střední, svrchní – Lower, Middle and Upper Devonian, vrstvy – layers, s. – formation, bř. – shale, váp. – limestone. Thickness of the formations in metres is in the right part.

term Liteň Group (Kříž 1998, 82) because that author had to use the noun group when he changed the Želkovice, Litohlavy and Motol Beds for formations. On grounds of the continuation of the original term used in the archaeological literature, the term silicified shale to chert of the Liteň Formation (Želkovice Beds) is used in this book according to Chlupáč et al. (2002).

Location: The Liteň Formation crops out in the Prague Basin of the Barrandian at the basis of Silurian rocks as two branches of a synclinorium with NE – SW direction. The southern branch runs between Černošice and Želkovice, than via Tmaň and Suchomasty is turned to the northern branch and continues from Koněprusy up to Řeporyje – see geological map 1:50 000 sheet 12–41 Beroun (Havlíček, ed. 1986). Author of this monograph studied samples from an outcrop 1 km NW of Karlík (5 km NE of Hlásná Třebáň).

Geological Setting: The oldest Silurian rocks – the Želkovice Beds – that are a part of the Liteň Formation, contain numerous silicified shales to cherts. It is supposed they originated in the deepest parts of the Silurian basin while in its marginal parts an alternation of silty shales and siltstones has been accumulated. By their age these rocks correspond with the Llandovery stage; the silicified shales with cherts cover eight graptolitic zones (Kříž 1992) and their overall thickness is 16 to 24 m.

Macroscopic Appearance: The raw material shows the appearance of black coloured, laminated silicified shale (Supplement/Photo 22). Parts of graptolites may occur on the bedding planes.

Stereomicroscopic Appearance: The black aphanitic siliceous mass is not translucent neither its thin margins nor after spreading water on its surface. A bedding structure is indicated by bedding planes and by alternation with a few mm thick lighter silty laminae visible in the weathered parts. No microfossils have been found in the cherts and their siliceous mass is not scratched with a knife.

Thin Section: A black chert sampled by S. Vencl at the settlement of Karlík is represented by a very fine silicified clayey rock that is clouded by an organic pigment (organic carbon). Its content can reach in the rocks of Želkovice Beds up to 6.04 % (Kříž 1992, 121). Bigger partly rounded silty grains of quartz, lamellae of muscovite, less also parts of feldspar are spread in the siliceous mass, in places these clastic components form thin laminae (Supplement/Photo 23). Reddish brown ferric oxides are accumulated in places in small circular formations, partly they fill probably relics of fossils.

Prehistoric Use: As regards the occurrences in prehistoric industries, Vencl (1990) specifies the use of Liteň shale at the Mesolithic localities of the Bohemian Karst (for example Hostim, Radotín). Svoboda (1977, 134) describes this raw material from the Mesolithic stations in the Polomené hory Hilly land in northern Bohemia (Stvolínky I and II). According to Klíma (1974, 29), a very similar material should have appeared as far as in the Magdalenian industry in the Pekárna Cave in the Moravian Karst; in table on the page 38 of the same publication he has already designated 25 artefacts as the Liteň shales. Nevertheless a present revision has shown that the confusion with black, stratified chert of the Olomučany type has occurred. The Olomučany chert has source in the Moravian Karst, and was introduced into specialised literature later (see chapter Silicites of Moravia and Silesia).

II.2.2.4. Silurian cherts of the Kopaniny and Přídol Formations

General Overview: According to Kukal (1992, 217), both layered and nodular cherts occur in limestones of the Kopaniny and especially Přídol Formations. The layered cherts are represented sometimes by typical spongolites (spiculites) with accumulations of sponge spicules and radiolarians. Mikuláš et al. (2003) have described in detail cherts from the Přídol Formation in the surroundings of Karlštejn and Trněný Újezdec. They form dark layered thinly laminated cherts with numerous sponge spicules and relics of ostracods in the lighter laminas. Axial small channels of spicules have been filled by pyrite. The length of spicules similarly as ostracods can reach over 1 mm.

Prehistoric Use: Prehistoric chipping of these cherts has not been described till the present time.

II.2.2.5. Devonian cherts of the Radotín and Kotýz limestones

General Overview: These limestones represent the oldest Devonian rocks of the Barrandian (Lochkov age) and are a part of the Lochkov Formation (Fig. 48). The Radotín limestone crops out especially in the SE branch of the Prague Basin where forms prevalent part of the Lochkov Formation with thickness 25–80 m. The facial development of the Lochkov Formation with prevalence of the Radotín limestone is typical for the area south of the line Kosov – Srbsko – Zadní Kopanina – Prague-Podolí, on the other hand, the Kotýz limestone is distributed north of the line (see Chlupáč et al. 1992, 156); thus from the spatial point of view they substitute each other. Black cherts are common particularly in middle and higher parts of the Radotín limestone.

Fig. 49. A concretion of chert in the Kotýz limestone under the Karlštejn Castle, the Barrandian. Photo by the author.

Cherts in the Kotýz limestone are altogether numerous as well and they are grey or reddish coloured. As a rule, they fade out in the highest parts of these limestones. Their a few decimetres big circular nodules weathered out from the Kotýz limestone for example on the southern slope under the Karlštejn Castle (Fig. 49) above the road running from the local square along the Budňany Brook. The cherts are usually strongly cracked, they have not translucence even on thin margins and contain plentiful silty admixture.

Prehistoric Use: Chipped artefacts of these raw materials have not been described yet.

II.2.2.6. Devonian cherts of the Dvorce-Prokop limestone

General Overview: The Dvorce-Prokop limestone represents more than 160 m thick series consisting mostly of grey micritic or biomicritic well-bedded nodular or platy limestones of the Lower Devonian (Pragian) age. It is a part of the Praha Formation. Its stratotype is the Černá rokle Ravine near Kosoř. Cherts occur only locally, generally in the upper part of the limestone (at the southernmost outcrops near Liteň and Všeradice), but they can be found in the lower part as well (Chlupáč et al. 1998, 111).

Prehistoric Use: There are no proofs on the use of these cherts in prehistoric industries so far.

II.2.2.7. Devonian cherts of the Zlíchov limestone

Background: The name of limestone is derived from the SW part of Prague called Zlíchov. In archaeological literature the cherts of the Zlíchov limestone are mentioned for the first time by Vencl (1990, 238) when he identified them after a consultation with I. Chlupáč with the dominant local raw material used at Mesolithic sites in the Bohemian Karst (so called chert of the Bohemian Karst type). Based on the recent stage of knowledge it is evident that the prevalent part of "cherts of the Bohemian Karst type" is represented by radiolarites of the Choteč limestone (see below).

Location: Their typical occurrences are in Prague-Zlíchov, under the lower part of the Barrandov bridge at the Barrande Rock (Fig. 17), in the valley of Hluboká near Karlštejn and at other places of the Prague Basin of the Barrandian.

Geological Setting: The Zlíchov limestone is the prevalent rock type of the Zlíchov Formation (Lower Devonian, the Zlíchovian stage) and it is missing only at the lowermost and uppermost parts of the formation. Plentiful, irregular nodules of black cherts are present in this grey to dark grey bioclastic to micritic limestone.

Macroscopic Appearance: The chert nodules commonly exceed the 10 to 15 cm sizes (Supplement/Photo 24); however in places they contain entire systems of fine cracks grown over by thin calcite coatings. The colour of the cherts is dark, usually dark grey (N3) to greyish black (N2). Anyway they are darker than the surrounding limestone. The surface of nodules has often a lighter whitish-grey cortex with a thickness of 1–2 mm.

Stereomicroscopic Appearance: The nodules are sharply bordered against mother limestone, their siliceous mass has a grey translucence and contain numerous black and yellowish inclusions. The black ones are elongated or fragmented and probably represent graphitized organic matter. It is in harmony with information of Kukal (1962, 76) on a higher content of organic carbon in the cherts in comparison with surrounding limestones and shales. The lighter yellowish to ochre coloured inclusions have very often square, rhomboidal or oblong shape (somewhere it is possible to recognize rhombohedrons) and it is clear they represent small crystals of carbonates (especially of dolomite).

Thin Section: Detailed description of the cherts from Zlíchov limestone in thin sections can be found in a paper of Petránek (1951). Cryptocrystalline SiO_2 is dominant and using a higher magnification one can distinguish clusters of chalcedony in the apparently isotropic siliceous mass. Carbonates are present partly as idiomorphic rhombohedrons of dolomite with diameter of about 0.06 mm partly as irregular calcite accumulations (Supplement/Photo 25) or its younger veinlets. In the cherts above the so-called "Chapel Coral Horizon" there are silicified relics of tentaculites filled with bigger spherolitic aggregates of chalcedony or clusters of quartz grains. Sponge spicules can be also found. Relics of fossils are conspicuous when we observe a thin section only with plane-polarized light because they have not brownish coloration by an organic pigment as the surrounding siliceous mass. Weathered (limonitized) small pyrite crystals are also visible in the cherts.

Other Analyses: The approximate composition of the black chert substance from the Zlíchov formation base (the so-called "Chapel Coral Horizon") is specified by Kukal (1964): the SiO_2 content varies around less than 95%, the organic carbon makes up 0.11%. This author also presents how the silica content in the cherts of the Zlíchov limestone varies even within one nodule from 86 % in its central part to 98 % in the concretion's margin. From the viewpoint of mineralogy the absence of opal in nodular cherts and, conversely, its regular incidence in stratified cherts of the even older Lochkov and Přídol Formations is of interest.

Prehistoric Use: As regards their prehistoric utilisation, see the discussion on silicites (radiolarites) of the Choteč limestone in the chapter II.2.2.9.

II.2.2.8. Devonian cherts of the Třebotov limestone

General Overview: The Třebotov limestone is markedly nodular, micritic limestone, deep red to brownish red in its bottom layers. Its age is the uppermost Lower Devonian (Dalejan). Pale cherts have been described from the highest parts of the Třebotov limestone, for example in the surroundings of Roblín (Chlupáč et al. 1992, 184).

Prehistoric Use: For the time being we are not aware of their use in the prehistoric chipped industries.

II.2.2.9. Devonian radiolarites of the Choteč limestone (cherts of the Bohemian Karst type)

Background: J. Svoboda and F. Prantl defined the Choteč limestone in 1948 as mud and organoclastic limestone in places with cherts. The name has been derived from the village of Choteč SW from Prague. I. Chlupáč performed their redefinition when as the stratotype has been determined a quarry on the southern slope of Škrábek Hill at Choteč (greater detail see Chlupáč et al. 1998, 126). From archaeological point of view it was Vencl (1970, 1990) who drew attention to prevalent local greyish-black chert among Mesolithic artefacts in the Bohemian Karst and proposed its name "chert of the Bohemian Karst type". Later, Přichystal (2004) identified it with the radiolarites of the Choteč limestone.

Location: As the youngest limestone in the Barrandian it crops out roughly in the axis of the Prague Basin between Prague and Beroun and the radiolarites are spread especially in its NE part, it means from the SW margin of Prague (Hlubočepy; Fig. 50) through Holyň, Chýnice and Choteč up to Karlík.

Geological Setting: The Choteč limestone is a typical rock of the Choteč Formation of the Middle Devonian (Eifelian) age. It is represented by dark grey to greyish black micrite or bioclastic sparite. The limestone contain plentiful relics of fossil fauna that have been introduced for example by Chlupáč et al. (1998, 128): trilobites, tentaculites, goniatites, thin-shelled molluscs, brachiopods, ostracods, transported parts of corals, stromatoporoids and moss animals.

Macroscopic Appearance: The prevalent rock type is represented by thinly stratified, dark grey to black-grey limestone with inserts of carbonaceous shale and irregular clusters to thin layers of radiolarites (Havlíček et al. 1958, 106; Chlupáč 1988, 138). In the surroundings of Hlubočepy, Holyně, Chýnice, and Choteč the thickness of these thinly stratified limestones with plentiful laminated cherts varies between 30 to 40 m. The radiolarites are always dark, usually layered and with lighter laminae (Supplement/Photo 26).

Stereomicroscopic Appearance: In the dark cherts with lighter laminae, which were sampled by the author of this monograph from the Choteč limestone in the Vysoká quarry in Prague-Hlubočepy, the contents of radiolaria, as seen by a stereomicroscope, are relatively low, and the cross-sections of radiolarians are better visible in the light laminae than in the black silicite substance (Supplement/Photo 27). The similar characteristic has the raw material named as the chert of the Bohemian Karst type at some archaeological localities. At the Mesolithic site Hořín near Mělník there is typical for the chert markedly developed marginal yellowish-grey part that can dominate occasionally in a whole elongated nodule, the lamination as characteristic as well. Numerous circular phantoms after radiolarians occur both in grey or bluish-grey siliceous mass and especially in the imperfectly silicified marginal parts; that is why the raw material can be termed as radiolarian chert to radiolarite.

Thin Section: It was studied a thin section of the radiolarian chert from the quarry Vysoká in Prague-Hlubočepy (Supplement/Photo 28). The rock is imperfectly silicified and in places the calcite accumulations prevail with isolated circular objects filled by silica aggregates and having usually a diameter up to 0.2 mm, exceptionally up to 0.5–0.6 mm. Parts of other fossils are usually filled by calcite. Bigger circular objects have a distinct radial arrangement of elongated silica fibres and sometimes a zonal texture. The smaller circles can be interpreted as cross-sections of radiolarians, the bigger ones with the zonal texture represent probably sponge spicules. Towards to the chert centre number of siliceous parts increases, they join together and gradually form the prevalent mass in which on the contrary the carbonates form lobed small islands.

Fig. 50. Abandoned quarry Vysoká in Prague-Hlubočepy, occurrence of the Devonian Choteč limestone with beds of dark radiolarites. Postcard, 1934.

Other Analyses: Separated radiolarians found in a rest after the dissolved Choteč limestone from the quarry Nad tratí in Prague-Hlubočepy have been described from the paleontological point of view by Čejchan (1987). He ascertained on the one hand radiolarians with a spherical tests that partly considered as entactiniid ones, the systematic affiliation of remaining spherical radiolarians was not able to determine; on the other hand the non-spherical radiolarians placed to the genus *Ceratoikiscum* DEFLANDRE 1953. The diameter of radiolarian tests varies around 0.15 mm. Besides numerous radiolarians he found only sponge spicules. It is almost sure the analogical radiolarians are present in the chert layers as well. Conodonts have been found in the lower part of the Choteč limestone.

Prehistoric Use: Vencl (1990) stated that at the Mesolithic stations in the Bohemian Karst area the dominating raw material is black-grey chert of the Central Bohemian origin, which he has named the chert of the Bohemian Karst type. As a raw material this chert appears also out of the Bohemian Karst – in about 7% of the 2,663 artefacts it was described for example at the well-known Mesolithic settlement in Hořín near Mělník (Přichystal 2000). On the basis of a discussion with I. Chlupáč, S. Vencl has arrived to the opinion that this was most probably chert from the Zlíchov limestone (see above). Although it cannot be excluded that at some archaeological localities both cherts were

being used (it is also from the Zlíchov limestone) and they could not be differentiated macroscopically, all signs attest for the identification of the Bohemian Karst cherts with radiolarites from the Choteč limestone. The complicated nature of the differentiation between the individual Silurian and Devonian cherts of the Barrandian is also shown by the statement of Skutil (1953, 723) relating to a flake originating from the Aurignacian settlement in Prague-Řevnice. Having consulted F. Prantl, J. Pelíšek and J. Sekanina, the pre-eminent specialists of that time, J. Skutil has described a "prismatic flake of a blackish material of a radiolarian chert from the Silurian Motol Beds (from the closest vicinity of Zdice), which was used by the Bohemian Palaeolithic man settled in the caves". Nowadays the Motol Beds are placed into the Liteň Formation, in the framework of which cherts are referred to in the Želkovice Beds (see above Chapter II.2.2.3. "Silicified shales to cherts of the Liteň Formation") but the "siliceous shales and chert rock locations" are also described on the basis of the Motol Beds. Of all Silurian or Devonian cherts there, our best authority on the Barrandian, Professor I. Chlupáč, designates only the Devonian cherts of the Choteč limestone as radiolarites (Chlupáč in Svoboda Jos. et al. 1964, 56; Chlupáč 1988, 138). Therefore I am of the opinion the archaeological name of the chert of the Bohemian Karst type should be identified with radiolarites of the Choteč limestone. Indeed, it is evident that a special research would have to be devoted to the cherts of Barrandian as the potential raw materials for the chipped artefacts of the prehistoric times.

II.2.2.10. Upper Carboniferous and Permian limnic silicites (cherts) of the Krkonoše Piedmont Basin

Background: Occurrences of red cherts, known among the collectors as sedimentary carnelians or "meat-red stones", are described from the Permian – Upper Carboniferous sediments of the Krkonoše Piedmont Basin. We can regard them as the oldest Central European limnic silicites. Their utilization has not been registered yet in the prehistoric times but it was described chipping of distinctively layered black cherts alternating with silicified siltstones of the Permian age.

Location: The Krkonoše Piedmont Basin lies in the northeastern Bohemia and from the geomorphological point of view it corresponds to the Podkrkonošská pahorkatina Hilly land. It is represented by a large sedimentary structure from the interval of Upper Carboniferous (Westphalian D) to Middle Triassic being situated between the crystalline rocks of the Krkonoše Mts. and Zvičina Ridge. In the west it is bordered by the Lužice overthrust, in the east by the Intra-Sudetic Basin filled again by the Upper Carboniferous to Middle Triassic deposits. Limnic silicites crop out in a few horizons especially in the large surroundings of Ploužnice (Semily district) – Stará and Nová Paka, Mezihoří, Cidlina, Železnice, Rovensko and somewhere else (Fig. 46).

Geological Setting: Presence of reddish or grey cherts has been described from calcareous or tuffitic beds (horizons) of the Krkonoše Piedmont Basin. From the point of their sedimentation environment they can be indicated with no doubts as limnic silicites. One horizon of occurrences is tied to the Upper Carboniferous sediments of the Semily Formation (Stephanian C) in the Nová Paka anticline, the axis of which passes in the Kumburk – Nová Paka – Pecka line. A part of this formation is also a several dozens of meters thick the Ploužnice horizon with tuffites, in the bottom part of which there are variably coloured kaolinite claystones with very plentiful grey or red limnic silicites (cherts), by collectors the so-called carnelian horizon in the surroundings of Ploužnice (Tásler, Havlena & Prouza 1981, 135). Other silicites appear as a part of the Horní Kalná horizon (pastel bright marlstones, siltstones, grey limestones), which is located in the Prosečné Formation already of the Lower Permian age. Tásler (1979, 126–128) states that in the Lower Permian formations of the Krkonoše Piedmont Basin the silicites appear locally together with other horizons as well (for example in the Chotěvice Formation near Mladé Buky).

Macroscopic Appearance: Samples from the area of Nová Paka show the local red limnic silicites ("sedimentary carnelians") have character mostly irregular chips than nodules (Supplement/Photo 29). Their dimensions do not reach 6 cm. The chips are sharply limited against very fine-grained mass of clayey limestone (it reacts with dilute HCl) and they are bordered by a thin white hem (probably a result of weathering). Sometimes a few of them with various diameters form accumulation that could be interpreted as formerly one piece, in addition small reddish detritus appears in their vicinity. They are also chips of these limnic silicites with banded structure, which does not correspond to their shape. That is why the author of this book suggests as the most probable explanation of their genesis they are not silicite nodules in situ but they originally formed chemogenous silicite (geysirite) layer later broken up and its parts were shortly moved.

Stereomicroscopic Appearance: Chips of meat-red silicites have a lot of cracks that never continue into the surrounding rock. Red pigmentation is distributed irregularly and there is visible a whitening of the silicite mass around cracks (Supplement/Photo 30). A very fine-grained black mineral is spread in it as well. Some of whitish porous chips in places resemble parts of molluscs. Magnetic susceptibility is very gently higher ($0.01–0.02 \times 10^{-3}$ SI). Dark layered cherts of Permian age could represent limnic silicites that are a part of stratigraphic sequence and originated probably by precipitation in a lake.

Thin Section: Mineralogy of the Upper Carboniferous and Permian cherts from Stará and Nová Paka, Mezihoří pod Bradlem, Cidlina pod Táborem, the surroundings of Železnice and Rovensko was solved by Slavík (1941). He specifies that cherts are both meat-red and grey to black, compact, and less compact and white on the periphery of the nodules. In thin sections he discovered microcrystalline quartz, chalcedony, and quartzine, the latter one usually forming spherulites. Small bunches of red hematite pigment are concentrated especially in the centres of the spherulites.

Prehistoric Use: As far as the use of the Upper Carboniferous and Permian limnic silicites concerned, for example 93 % of the Mesolithic chipped industry from Hřibojedy (Trutnov district) is made of a low-quality, grey to greyish black laminated silicite with light ochre spots or thin layers; reddish shades occur in an inferior quantity (Vencl 1991, 10–13). Šafář (1991, 21) assumes this raw material was carried from the surroundings of Hostinné where the Lower Permian Horní Kalná horizon with limnic silicites is supposed to rise to the surface.

II.2.2.11. Permian limnic silicites (cherts) of the Intra-Sudetic Basin

Background: Comparing the Krkonoše Piedmont Basin, local limnic silicites are rather out of interest. Polish archaeologist J. Bronowicki called attention to the utilization of lower quality dark layered cherts (limnic silicites) at Mesolitic localities in the Polish part of the Intra-Sudetic Basin.

Location: The Intra-Sudetic Basin is spread by its lesser extensive part in the territory of the Czech Republic in so called the Broumov Spur, the prevalent part lies in Poland roughly among Kamienna Góra, Walbrzych and Kłodsko. Limnic silicites crop out in the surroundings of Horní Vernéřovice (the Vernéřovice horizon), Bečkov, Radvanice and Chvaleč (the Bečkov horizon). The Vižňov horizon can be followed in the whole Broumov area.

Geological Setting: Limnic silicites are connected with two limestone horizons (the Vernéřovice and Bečkov ones). The Vernéřovice coloured horizon has an average thickness about 10–15 m. Grey limestone with limnic silicites forms the central layer usually about 0.5 m thick, maximally up to 1 m (Tásler et al. 1979, 85). It is stable within all its cropping part; the bedrock and top wall is built by blackish-grey claystones to marlstones with content of fish scales and teeth. The Bečkov horizon is thicker (30–50 m). Carbonate rocks form layers in dm thickness, rarely up to 1 m, grey limestones with silicites are present only locally. In some places the horizon is divided into three beds; one thick attitude represented by grey to dark-grey limestones with dark cherts and accompanied by bituminous claystones and marlstones crops out at the type locality of Bečkov.

Additional small limnic silicite occurrences are connected with the Vižňov and Hejtmánkovice limestone horizons in the Martínkovice Beds of the Broumov Formation (Lower Permian). Small silicite concretions and lenses can be found in the lower Vižňov horizon, only their streaks appear rarely in the middle Hejtmánkovice horizon and in the uppermost Jetřichovice horizon the limnic silicites are missing (Tásler et al. 1979, 106–107).

Macroscopic Appearance: Limnic silicites form only small concretions to lenses similarly like in the Krkonoše Piedmont Basin. They have meat-red, smoky grey or black colour. Description of the silicites from the Polish part of Intra-Sudetic Basin is introduced in the chapter II.2.6. Silicites of Poland.

Prehistoric Use: From the Czech part of Intra-Sudetic Basin it has not been announced yet while is very probable because the similar raw material appears at near Mesolithic sites in Poland, for example at Ratno Dolne north of Wambierzyce (Bronowicki & Bobak 1999).

II.2.2.12. Upper Carboniferous and Permian limnic silicites (cherts) from Líně near Plzeň

Background: Limnic silicites from western Bohemia had not been considered as prehistoric raw materials in published papers until recently. Řezáč (2006) drew our attention from this point of view to an important source of limnic silicites with an area of more than 3 hectares lying at the NE margin of Líně (a village about 10 km to the SW from the centre of Plzeň).

Location: Large occurrences of the Upper Carboniferous and Permian sediments form filling of a few basins of western and central Bohemia: the Plzeň, Manětín, Radnice, Žihle and Kladno-Rakovník Basins. The source of limnic silicites at Líně in the Plzeň Basin has been described by the above mentioned author: "One place of finds crops out near the road to Plzeň in the field gently declining to the Luční Brook, another lesser one is in a saddle between two conspicuous hillocks west of Líně and to the right of the road to Zbúch".

Geological Setting: Limnic silicites are a part of the Líně Formation of the Upper Carboniferous (Stephanian C) and may be Lower Permian age. The prevalent fluvio-lacustrine and desert eolian sediments contain two important Zdětín and Klobuky horizons in which there are also limnic silicites besides many-coloured partly tuffitic aleuropelites. These horizons can be correlated from the viewpoint of flora and lithology with the Ploužnice horizon in the Krkonoše Piedmont Basin (for instance see Havlena 1983, 261).

Macroscopic Appearance: The raw material forms layers up to thickness of 25 cm, possibly lenses up to 1 m long. At the layer margin the limnic silicite changes in a yellowish silicified sandstone and than into a feldspathic sandstone. It is possible to flake from it artefacts with conchoidal fracture and sharp edges. Its colour varies in honey shades to reddish-brown one (Supplement/Photo 31).

Stereomicroscopic Appearance: Some samples have a brecciated structure that is conspicuous especially at margins of layered attitudes where the chips of red silicite occur in a yellowish groundmass. Red pigmentation is not spread in the silicite mass uniformly but it forms small clusters. The limnic silicites are affected by numerous transversal cracks.

Thin Section: Using one polar it is possible to see only transparent siliceous mass with a dense net of fine cracks. Some parts are coloured by ochre pigmentation of iron compounds in which there are preserved structures of plant stems with characteristic arrangement of increasing rings. In crossed polars it can be distinguished fine- to medium-grained chalcedony, in places with conspicuous coarse-fibre development filling the plant relics (Supplement/Photos 32, 33). The parts coloured by ochre pigmentation have in many cases a cryptocrystalline structure as well.

Prehistoric Use: According to Řezáč (2006, 24), the limnic silicite from Líně has been rarely found in collections

of chipped industry at two localities from the district of Plzeň-North: at Dolany (the Young to Late Bronze Age) and probably also at Senec (the Mesolithic).

II.2.2.13. Bohemian Jurassic cherts

Background: G. Bruder mentioned presence of cherts in the North-Bohemian Jurassic limestones in the eighties years of the 19th century. In all later papers it has been stated only their existence with no more detailed description.

Location: Small occurrences of Jurassic limestones in northern Bohemia are situated at the Lusatian overthrust to the SW of Krásná Lípa, explicitly at localities of Doubice, Brtníky, Kyjov and in the valley of Bělá Brook. The Jurassic limestones were so intensively extracted in the past that their outcrops were almost totally destroyed. Relatively the best preserved Jurassic sediments can be found in the Natural reserve Vápenka (11.58 ha, since 1969) in the cadastral territory of Kyjov near Krásná Lípa. It has been established on the south slope of the Vápenný Hill near the road from Krásná Lípa to Doubice and it lies about 1 km of Doubice.

Geological Setting: In Bohemia the Jurassic limestones with cherts form even smaller relics than in Moravia. These Bohemian petty occurrences crop out at the Lusatian overthrust as tectonic slices pulled out from the basement of Bohemian Cretaceous Basin. Their continuation in Saxony is represented by a few other small outcrops between the Czech state border and the northern surroundings of Pirna (more details see in the chapter II.2.5.). Time interval of the Bohemian Jurassic sediments corresponds to the end of Callovian through the Oxfordian up to the Kimmeridgian (Dvořák & Růžička 1966, 214). Sandstones with conglomerates form the base and above them there are bituminous clays and dark limestones. The higher part of the Oxfordian age consists of pale limestones with chert concretions (they are described only south of Brtníky). The ammonites *Epipeltoceras bimammatum* and *Lithacoceras achilles* represent characteristic fossils. Dolomites and red coloured sandstones are to be found besides dolomitic limestones in the Natural reserve Vápenka.

Macroscopic Appearance: Unfortunately, any more specific description of these cherts is missing and, moreover, no documentation samples of cherts have been deposited in the National museum in Prague or in the collection of Czech Geological Survey. The author of this book has not succeeded in acquiring at least a documentation sample of Bohemian Jurassic cherts so far.

Prehistoric Use: The Bohemian Jurassic limestones have been usually strongly tectonically crushed, that is why the more rigid cherts had to be intensively tectonically broken up as well, so we can suppose they were not probably suitable for flaking. Up to now, there is no evidence of their prehistoric utilisation.

II.2.2.14. Cretaceous spongolites of eastern Bohemia (type Ústí nad Orlicí)

Background: According to information of Vencl (1990, 235) it was a Czech geologist Karel Žebera who determined the raw material correctly for first time in a surface collection from Zářecká Lhota (12 km to the WNW of Ústí nad Orlicí) and mentioned also its local provenance. S. Vencl proposed to call the raw material as the chert of Ústí nad Orlicí type.

Location: Lower Turonian sedimentary rocks with layered cherts occur in the eastern part of the Bohemian Cretaceous Basin that is in geological and lithofacial division called as the Orlice-Žďár region. This is particularly in the sheet 1: 200 000 M-33–XXIII Česká Třebová where the Lower Turonian sediments with spongolites appear in the valley of the Svitava River and its tributaries in the surroundings of Březová nad Svitavou, within a narrow band adjoining the Permian of the Orlice Basin, and in the Potštejn anticline, which runs in the western surroundings of Ústí nad Orlicí, i.e. from Říčky through Řetůvka and Přívrat to Semanín. Vencl (1990, 235) assumes other sources at Dobruška, in the southern surroundings of Chrudim or more to the north at Hřibojedy (a village lying to the NW of Jaroměř). Besides the Orlice-Žďár region it is possible to find the Cretaceous spongolites also in the Bystrzyca Kłodska region that is spread over the Czech territory from Poland. Relics of Lower Turonian sediments with spongolites as a part of the Orlice-Žďár region appear also far to the SE in Moravia (they are characterized in the outline of Moravian raw materials in the chapter II.2.3.11).

Geological Setting: According to 1: 200 000 synoptic geological maps cherts rich in sponge spicules (spongolites) are bound to the significant Lower Turonian rock horizon with the *Inoceramus labiatus* pelecypod. Generally, on the major part of the Bohemian Cretaceous Basin the Lower Turonian rocks are overlain by younger formations, thus appearing only on the margin of the basin where they are captured in denudation sections or in cores of flat anticlines.

Macroscopic Appearance: The Turonian spongolites form up to 10 cm thick layers in silty to sandy marlstones (opokas). Their colour at outcrops varies usually from pale blue (5PB 7/2) to very pale blue (5B 8/2) – see Supplement/Photo 34. A usual feature of the raw material is a cube disintegration according to sedimentary surface and transverse joints.

Some spongolites that underwent weathering processes have honey brown colour (pale yellowish brown 10YR 6/2) and occur usually in a secondary position in the Tertiary or Quaternary gravels.

Stereomicroscopic Appearance: A sample from Řetůvka (district of Ústí nad Orlicí) shows an alternation of a few mm thick bands of well translucent bluish-grey chalcedony mass with bands coloured by cinnamon-brown pigmentation. Small chips of dark organic substance can be found in places as well. The characteristic microfossils are sponge spicules similar to short and furcate fragments of a white filament (Supplement/Photo 35).

Thin Section: Isometric accumulations of radial arranged chalcedony fibres with their dimensions around 0.1 mm prevail. In addition, they are usually present grains of clastic quartz or small leaves of muscovite. Circular or oval sections of sponge spicules have isotropic signs

using crossed polars but in their vicinity the chalcedony has radial structure.

Prehistoric Use: These cherts have played an important role right in the East-Bohemian Mesolithic where they dominate over the localities of Sopotnice, Řetůvka, Zářecká Lhota, but they appear as far as Dobruška (around 30%), in Pardubice and elsewhere (Vencl 1990, 235). S. Vencl has designated this as the chert of the Ústí nad Orlicí type; he states that its natural outcrops are not only at Řetůvka, but also in the immediate vicinity of Dobruška, Sopotnice, and Zářecká Lhota. This raw material has also been found at the Pre-Neolithic stations Tatenice 1 and Krasíkov 1 (eastern part of the Ústí nad Orlicí district) where their content ranges between 6.5 and 21% (Přichystal 1996), at the Mesolithic site of Pardubice about 45 km to the west of the sources it forms 11% (Vencl 1965). But we are not able to decide there from which part of east Bohemia the raw material comes.

II.2.2.15. Cretaceous spongolites of the Intra-Sudetic Basin

General Overview: Layers or lenses of chalcedonic spongolites in the scope of Lower Turonian siltstones to sandstones (rock horizon with *Inoceramus labiatus*) occur in the Intra-Sudetic Basin similarly as in the Bohemian Cretaceous Basin (according to Czech geologist the Cretaceous rocks in the Intra-Sudetic Basin are believed to be only special the Hejšovina development of the formerly more extensive Bohemian Cretaceous Basin). The spongolites are spread in the both basin limbs and they are used as important supporting horizons during geological mapping.

According to Dvořák (1979, 169) the spongolites have a dark grey to bluish colour and conchoidal fracture. Chalcedone mass is composed from fine-grained, filamentous or spheroidal aggregates. Sometimes there are present small grains of glauconite but more probably one can find quartz clasts. As microfossils there have been visible scattered sponge spicules built of chalcedony, rarely of opal.

Prehistoric Use: We cannot exclude the raw material appears among spongolite artefacts found by J. Bronowicki at Mesolithic sites in the SW surroundings of Kłodsko. Till recent time it is not clear if it is possible to distinguish them from the spongolites of Orlice-Žďár development in the Bohemian Cretaceous Basin (surroundings of Ústí nad Orlicí).

II.2.2.16. Bohemian Tertiary limnic silicites

General Overview: Limnic silicites could originate as accumulations of silica in water-bearing depressions overgrown by hygrophilous plants during the Lower Tertiary. Žebera (1955, 26; 1958, 16) mentions Central Bohemian Tertiary limnic silicites of the Kladno region that feature a compact appearance and contain a big volume of plant relics. According to him these occur in bigger quantities on the eastern foot of the Kožová hora Hill near Kladno and in the south-eastern part of the flat opoka Džbán Highland. Among limnic silicites should be included very probably also the siliceous porous mass from a Mesolithic site at Pardubice (Supplement/Photo 36) described by Vencl (1965). Its appearance ranges between whitish-grey to ochre coloured quartz and yellowish opal (the last mineral occurs especially in the vicinity of cavities). It is possible to find small and with difficulties determinated microfossils (probably relics of plants; Supplement/Photo 37) in the siliceous mass.

To the Bohemian limnic silicites can be also included siliceous rocks of menilite (opal) appearance coming from the abandoned village of Lomnice 3 km to the north of Sokolov (Krušné hory Piedmont Basins – the Sokolov Basin). The sample is to be seen in the exposition of the State Natural Reserve SOOS near Františkovy Lázně. According to a written message of P. Rojík who gave the sample to the exposition the mentioned siliceous rock form layered concretions to mounds in the crossing of Lipnice fault with the coal seam Antonín. The limnic silicite contains numerous tests of gastropods, pelecypods and non-deformed plants. The rock probably formed originally a Lower Miocene limestone that originated in the surroundings of underground water outflow, later it was karstified and silicified. Besides quartz there is present in traces cristobalite, rarely kascholong and rock crystal in rock cavities.

Kouřimský (1976) has mentioned another occurrence of grey-brown layered menilite silicite rock at Mokřina near Mariánské Lázně and even he has not excluded its using for jewellery. Layered concretions to short layers have been described as menilites, opals or diatomites and we know them from the Odrava part of the Cheb Basin. They form probably the upper part of so called Cypris Formation (according to a ostracod *Cypris angusta;* the Miocene, explicitly the Karpatian age) with natural localities at the eastern basin margin roughly in the line Kynšperk nad Ohří – Štědrá – Mokřina and the limnic silicites crop out in the lacustrine carbonate clay surroundings (I thank for the information again P. Rojík).

Prehistoric Use: The use of Bohemian limnic silicites in the prehistoric industries was noted by K. Žebera at Magdalenian site Kvíc near Slaný or at Ptíce near Unhošť where the Neolithic people with the Stroked Pottery processed them. The raw material from outcrops at Lhota pod Džbánem apparently pertains to this group as well (Hammer 1965, Vencl 1971); it was chipped during the Neolithic and Eneolithic in the surroundings of Mutějovice (Rakovník district).

II.2.2.17. Layered chert of the Putim type

Background: The author met the chert for the first time when he studied chipped artefacts from the complex of Pre-Neolithic sites Putim – Ražice above the pound of Řežabinec (Písek district) in southern Bohemia. A natural source of the chert has not been found till the recent time, that is why we call it preliminary as the chert of the Putim type according to the place of its use (Přichystal 2006, 355). Because of its low quality the author has not excluded the origin from southern Bohemia, may be from a silicified part of the Zliv Formation (Lower Miocene) in

the South Bohemian Basins. According to published information, some rocks of the Zliv Formation contain namely silicified clays with diatom tests (Čech at al. 1962, 126) but no chert occurrence has been described yet. That is why the provenance of the Putim type chert is not still solved.

Macroscopic Appearance: The chert forms thin layers with a thickness of 1.5–3 cm (usually about 2 cm). It has dark yellowish-brown colour (10YR 4/2) and from the both sides is bordered by a thin cortex with lighter colour (up to grey-orange, 10YR 7/4). The cortex is usually smooth and small accumulations of pyrite up to 1 mm are visible in places on it (Supplement/Photo 38).

For siliceous mass of the chert is typical an alternation of darker and lighter laminas and it cannot be scratched by the knife. Magnetic susceptibility of the chert measured by the portable kappameter is close to zero.

Stereomicroscopic Appearance: Many oval microfossil relics filled by translucent siliceous mass are typical for the chert (Supplement/Photo 39).

Thin Section: High content of iron oxides and hydroxides (limonite) and numerous circular siliceous microfossils are well visible. According to the microfossil diameter they probably represent relics of diatoms (Supplement/Photos 40, 41). A central opening and thicker outer test are distinguishable at some of them. They are filled by cryptocrystalline quartz or fine-fibrous chalcedony. Besides microfossils one can see small clasts of quartz, small mica sheets or rarely rounded crystals of zircon.

Prehistoric Use: In the course of our study of Pre-Neolithic chipped industries from southern Bohemia together with S. Vencl, artefacts made of this raw material were found only at Putim (Přichystal 2006). Later, one piece was determined by the author at the Late Palaeolithic site of Dolní Lhota near Klatovy (collection obtained by J. Eigner in 2011).

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II.2.3. Silicites of Moravia and Czech Silesia

Two basic geological and geomorphological units of Central Europe border in Moravia: the Bohemian Massif (Bohemian Highland) and Western Carpathians. The last thirty years' systematic research has shown there have been important silicite occurrences in the both units (Fig. 51) and, in fact, all of them were more or less used in the prehistoric times. The following text lines up silicites of the Bohemian Massif first; silicites of the Western Carpathians follow, always from the oldest to the youngest.

Silicites of the Bohemian Massif in Moravia and Czech Silesia

II.2.3.1. Devonian to Lower Carboniferous radiolarites of the Ponikev Formation

Background: First mentions on "phthanites" in the youngest sediments of Devonian age in the area of Konice (the Bouzov Highland) and in the area of Šternberk (the Nízký Jeseník Highland) appeared in old papers of E. Tietze and F. Kretschmer at the beginning of 20th century. Attention of the geological public has been drawn only by a special publication of Kettner (1932). Initially they were termed phthanites or lydites, later radiolarian cherts or radiolarites. Přichystal (1994, 46) introduced them as a possible raw material of chipped artefacts in the Palaeolithic.

Location: They have been discovered in many places of the Moravo-Silesian Klippen Zone, it means on a belt of scattered rocks of the basin development of the Devonian in the central part of the Moravo-Silesian Lower Carboniferous flysch called the Culm. The belt stretches from Sloup at the northern edge of the Moravian Karst through Krnov at the northern edge of the Nízký Jeseník Highland as far as Pokrzywna in Poland. The best know occurrences that might have been utilised in the Palaeolithic are found in the area of the Konice-Mladeč Devonian and in the southern or northern part of the Šternberk-Horní Benešov Belt (Šternberk and Krnov regions). However, they also appear in the highest parts of the Devonian formations in the Olomouc region near Grygov, Krčmaň or Čelechovice na Hané near Prostějov.

Geological Setting: Stratified dark cherts that occur close to the Devonian/Lower Carboniferous border are more or less known from the entire Variscan Europe, from the Góry Świętokrzyskie Mountains in the east through the Sudetes, Harz Mountains, Rheinisches Schiefergebirge as far as the Pyrenees and the English Cornwall in the west. In Moravia, from the viewpoint of the present-day geology this is the Ponikev Formation of the Upper Devonian to Lower Carboniferous age (Frasnian – Tournaisian) that consists of grey and, after weathering, brightly coloured silty and clayey shales with thin layers of laminated cherts (radiolarites).

Macroscopic Appearance: Radiolarites of the Ponikev Formation make up sharply bordered layers with the thickness ranging from 1 to 2 cm, maximally 10 cm (Supplement/Photo 42). Their colour is always dark to black; because of tectonic influence they can disintegrate into small cubes (e. g. in the area of Šternberk).

Stereomicroscopic Appearance: A sample from Láryšov south of Krnov (the northern part of the Šternberk–Horní Benešov Belt) has a laminated structure with rusty coloured margins and greyish-black central part, with frequent transversal cracks. Relics of radiolarians are represented by numerous oval cross-sections with diameters up to 0.5 mm being filled by translucent siliceous mass. Dark siliceous substance in their surroundings is clouded by pale clay or silty particles, besides them limonite pseudomorphoses after pyrite crystals big up to 0.7 mm are conspicuous (Supplement/Photo 43).

*Thin S*ection: Petrographic investigation of the Paleozoic radiolarites was described in detail by Koutek (1933) who has distinguished three varieties among them:

1. Rich in clay minerals with frequent radiolarians;

2. Rich in organic substance, nearly opaque in thin section, apart from the siliceous filling of the radiolarian tests;

3. Clayey, with carbonate "isles", and weak in the content of radiolarians.

The first variety is the most frequent, for example just in the surroundings of the type locality of the formation (the village of Ponikev near Konice). In thin section the silicite mass is built of cryptocrystalline quartz or chalcedony. A clayey substance is scattered in them as a brown pigment with sporadic thin sheets of sericite or chlorite. An occasional presence of petty columns of authigene tourmaline is of interest; the incidence of petty pyrite crystals replaced by limonite and rhombohedral carbonate crystals (also transformed to limonite) is common. Koutek (1933) considers the dominating radiolarians to be the representatives of the *Spumellaria* order; he assigns the petty spheres transformed into quartz to the *Cenosphaera* genus. Except for relics of short spines the ornamentation of the radiolarian tests has not been preserved. The diameters of radiolarians vary between 0.03 and 0.3 mm and their fillings are usually translucent. Shapes evoking mono-axon sponge spicules have been observed very rarely.

The second type (e.g. in the surroundings of Vojtěchov in the Konice area) is nearly opaque in the thin section due to the high presence of a carbonaceous organic substance. Silicon dioxide is prevailingly represented as quartz; numerous radiolarians are strongly deformed

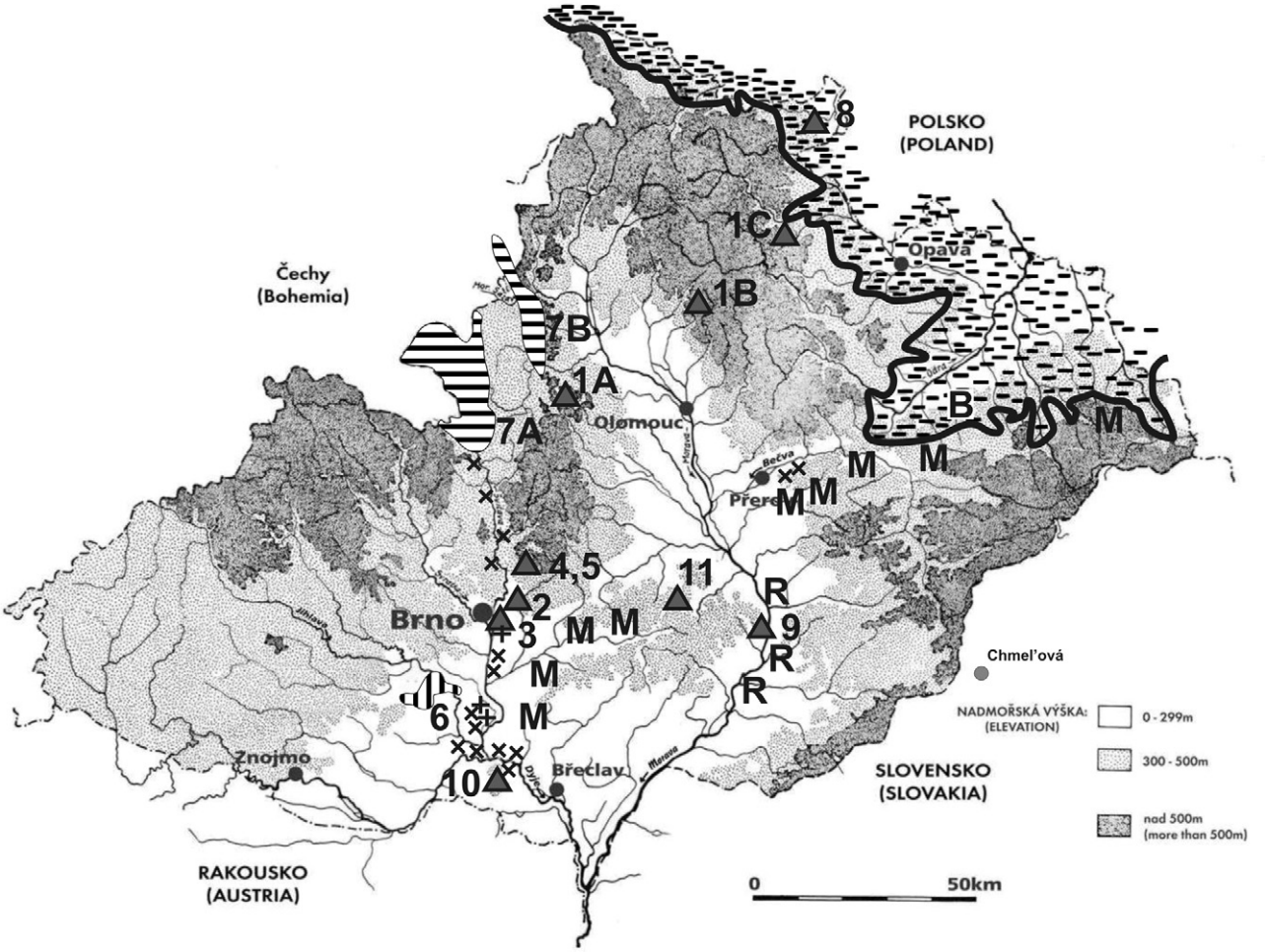

Fig. 51. Sources of silicites in Moravia and Silesia (eastern Czech Republic). The area of continental glaciation with erratic flints is marked by horizontal dashed hatch. Devonian radiolarites in the area of Konice (1A), Šternberk (1B) and Krnov (1C). Devonian to Lower Carboniferous cherts of the Hády-Říčka limestone in the southern part of the Moravian Karst (2). Jurassic cherts in Brno – Stránská skála, Bílá hora, Hády, Švédské šance Hills (3), at Olomučany in the central part of the Moravian Karst (4), their secondary occurrences in the Cretaceous Rudice Formation (5) and Pleistocene river gravels (+). Cherts in the Krumlovský les Highland (vertical hatch, 6). Spongolites at the SE margin of the Bohemian Cretaceous Basin (7A, 7B, horizontál hatch) and in the Cretaceous of the Osoblaha area (8). Cretaceous spongolites in secondary occurrences in Pleistocene (Pliocene) river gravels (x). Chert of the Boršice type in the Buchlovice area (9), cherts of the Pavlovské vrchy Highland (10), chert of the Troubky – Zdislavice type (11). Menilite cherts of the Carpathian Flysch Belt (M); silicified claystone, so called révaite (R) in gravels of the Morava River.

into pointed lenses. Carbonates are not present. The third type, with the calcium carbonate isles and nearly without any radiolarians, has been discovered near Hvozd, not far from Konice.

Prehistoric Use: Reliable proofs of their utilisation have not been described so far, but in view of the use of analogous raw material of the same age in Poland (Bardo-type radiolarite in the Góry Bardskie Mountains) it is highly probable they would also be ascertained among the chipped artefacts in central Moravia (the area of Konice) or in Silesia (the town of Krnov and its surroundings).

II.2.3.2. Devonian to Lower Carboniferous cherts of the Hády-Říčka limestone

Background: Occurrence of cherts in dark limestone of the Upper Devonian age at the southern margin of the Moravian Karst has been well known to Moravian geologists since the middle of the 20th century. For example Jaroslav Dvořák (in Kalášek et al. 1963, 82) described from this limestone both dark grey cherts and thin stripes of black radiolarites. Štelcl & Malina (1970, 32) believed they found the raw material (with their designation "Hornstein H3") at some Upper Palaeolithic sites in Moravia. However it is evident they have comprised under this chert (their Table 1 between the pages 30 and 31) also other dark Moravian cherts, probably chert of the Olomučany type or the Krumlovský les type cherts.

Location: In recent time these cherts have been introduced from the southern margin of the Moravian Karst, it is among the Hády Hill (NE part of Brno city), the village of Mokrá-Horákov and the village of Hostěnice. As resistant rocks, their natural chips are accumulated in eluvial

horizons in the fields or in the slope (deluvial) sediments above rock profiles in the quarry at the Hády Hill (Brno-Maloměřice), Lesní lom quarry (Brno-Líšeň) and in the quarries at Mokrá-Horákov.

Geological Setting: The Devonian to Early Carboniferous cherts form thin layers in the Hády-Říčka limestone of the Líšeň Formation (the uppermost part of the Moravian Karst development). According to the conodonts and foraminifers the Hády-Říčka limestone at the southern margin of the Moravian Karst corresponds to the stages Famenian to Tournaisian (Uppermost Devonian and Lowermost Carboniferous). Dvořák et al. (1993, 45) place it especially in the Middle Tournaisian and call the cherts as spiculites.

Macroscopic Appearance: Black stratified cherts reach the thickness usually about 5–8 cm, exceptionally up to 15–20 cm. They have a black colour and a conchoidal fracture. Light grey, smooth calcareous cortex has developed on their edges. As the Hády-Říčka limestone was folded, the cherts as its rigid part have been always afflicted with a net of thin cracks that are often healed by whitish calcite creating almost small veinlets in places (Supplement/Photo 44).

Stereomicroscopic Appearance: Silty and yellowish clayey admixture occurs in the dark siliceous mass together with numerous whitish sponge spicules of the simple shape and roughly 10x bigger cross-sections of sporadic radiolarians.

Thin Section: In thin section the siliceous substance has an intense yellowish-rusty clouding by organic matter, except for the numerous relics of sponge spicules (with central canals), bigger radiolarians and other fossils (parts of pelecypod valves) that are filled with a translucent recrystallised silica, sometimes with a characteristic chalcedony spheroidal texture (Supplement/Photo 45). Thus the cherts found in the quarry at Mokrá, Lesní lom quarry and the Hády Hill quarry have the character of spongolites (spiculites) or spongolitic cherts. On the other hand the natural chips of layered bluish-grey or greenish-grey cherts occurring in the fields to the east of Brno-Líšeň correspond rather to radiolarites.

Other Analyses: The chemical analyses of cherts from Mokrá have always proven a relatively high presence of $CaCO_3$ what is connected with plenty of cracks filled by thin veinlets of calcite. Čejchan (2005) separated radiolarians from phosphate attitudes within the Hády-Říčka limestones (and also from the Ponikev Formation). The found association has been rather heterogeneous with a prevalence of spherical forms of *Spumellaria*; from the viewpoint of age it corresponds to the Lower Carboniferous, probably to the Tournaisian.

Prehistoric Use: Although this is not a raw material of good quality due to being tectonically fractured, its occasional chipping has been recorded in the area of its natural occurrences, specifically at the surface Upper Palaeolithic site (apparently Magdalenian) Mokrá – quarry X, or among the cores at the well-known Magdalenian settlement in the Pekárna Cave (only about 1%; see Voláková 2001).

II.2.3.3. Moravian Jurassic cherts

Background: The most important Moravian raw material for chipped artefacts is represented by cherts of the Jurassic age. Occurrences of these cherts in the area of Brno, particularly "among Maloměřice, Klajdůvka and Šimice, rarely between the statue of Zderad and the village of Tuřany" has mentioned Klvaňa (1882, 39) in his publication Minerals of Moravia and Silesia. Large outcrops of Jurassic limestones were destroyed by denudation in the Cretaceous or Tertiary and only the resistant cherts have survived on the surface as natural chips or gravels, so it is very often impossible to distinguish the relict cherts and those coming from a few limestone outcrops. That is why Přichystal (1984, 212) proposed to call the whole group of such cherts as the Moravian Jurassic cherts. If we are able to find on the raw material more specific features and then to determine it more precisely, we use more exact designation such is Jurassic chert of the Stránská skála Hill or of the other primary outcrop, cherts of the Rudice Formation, cherts of the Krumlovský les type etc. Generally the term Moravian Jurassic chert can conclude all possible sources of cherts originally coming from Jurassic sedimentary rocks in Moravia as was recommended by Valoch (2002).

Location: The Moravian Jurassic cherts occur in gravels of the Lower Cretaceous and Cenozoic (Tertiary and Quaternary) age especially in the vicinity of the four denudation relics of Jurassic limestones in Brno and one in the central part of the Moravian Karst, i.e. in the eastern part of Brno, in the city districts of Líšeň, Židenice, Slatina, Šlapanice; further on they may be traced through Soběšice and Babice as far as the extensive occurrences in the Rudice Formation in the Moravian Karst. But the cherts of the Rudice Formation may be separated from this wide group due to some specific features; hence they are described separately. Similarly, cherts of the Krumlovský les type are described as a special group, being originally also primarily of the Jurassic age, but having a characteristic dark or black surface of pebbles or fragments.

Geological Setting: Recently the Jurassic limestones with cherts form in fact only four small denudation remnants at the eastern margin of Brno and one relic in the central part of the Moravian Karst, near Olomučany. It is evident that these relics of Jurassic sediments were not only connected in the geological past but also continued to the south-western Moravia, as evidenced by a quantity of Jurassic cherts in gravels of various ages, from the Lower Cretaceous to the Quaternary, around the whole southern and partly SW Moravia as well.

Macroscopic Appearance: Usually only slightly rolled concretions; more rarely they feature the shape of pebbles, without rough cortex remains on the surface, but more resistant silicified bulges may be preserved. The surface of Moravian Jurassic cherts is of the same grey colour as the chert substance, often with remains of a rolled cortex of pale ochre or whitish colour preserved. Usually clearly striped or spotted varieties are present, in which the plentiful spots of up to around 0.5 cm size

are created by fossil fragments. The Moravian Jurassic cherts may come to big dimensions, as proven by the find acquired during the construction of the Brno-Líšeň housing estate the weight of which is 59 kg (deposited in a collection of the author; Supplement/Photo 73). From Moravian Jurassic cherts we distinguish cherts with dark to black pebble-like or fragmentary surface and we designate them the Krumlovský les type cherts.

Stereomicroscopic Appearance: This group of raw materials is very variable so that is difficult to describe them by some specific features. The siliceous mass is usually non-translucent or only partly translucent because of low content of chalcedony. Parts of fossils, for example crinoids or sea urchin spines are commonly present.

Thin Section: Detailed description of a striped Jurassic chert from the sandpit in Brno-Černovice has been published by Mrázek (1976). Siliceous mass is prevalently recrystallized to quartz, chalcedony is preserved only rarely. Foraminiferans, radiolarians (?) and sea urchin spines represent usually visible microfossils. Dark colouring of some stripes is explained by a higher content of organic pigmentation. Grains of calcite and dolomite or small scales of mica can be found as accessory minerals.

Other Analyses: As is their chemistry concerned (Švecová 2004), the Moravian Jurassic cherts from gravels have minimal content of CaO (see the chert from Brno-Soběšice in Table 1) in comparison with the cherts from Jurassic limestone outcrops. It is undoubtedly connected with the processes of weathering and transportation. X-ray difractographic record published by Mrázek (1976) shows absolutely dominant quartz; in small amount there was ascertained calcite, dolomite and mica mineral.

Prehistoric Use: The Moravian Jurassic cherts have been chipped since the Lower Palaeolithic – see the famous finds at the Stránská skála Hill or in Brno-Černovice (Valoch 1996). A find of 21 chipped artefacts from a burial ground of the Proto-Únětice culture at Bedřichovice (district Brno-country) can be introduced as a typical example of the Moravian Jurassic cherts using. More than 60 % of the collection has been made of small partly rolled chert concretions (Přichystal 1985, 427); the relics of such surface are often preserved on the artefacts.

II.2.3.4. Jurassic cherts of the Stránská skála Hill (Brno-Slatina)

Background: The most important Jurassic cherts occur in the area of Brno-city agglomeration. The Stránská skála Hill represents from the viewpoint of geology and palaeontology a classical locality being assigned to the Jurassic period already in the eightieth years of the 19th century (V. Uhlig), a detailed study was carried out by Oppenheimer (1926). Attention of the Quaternary palaeontologists and archaeologists was attracted by an excavation of J. Woldřich in a small cave in the upper part of the Stránská skála Hill in 1910 where according to him there was found besides Lower Pleistocene fauna also evidence on contemporary presence of human predecessors.

Location: Stránská skála Hill (310 m) represents the largest and the most important occurrence of Jurassic limestones situated in the cadastral area Brno-Slatina. From the geomorphologic point of view it is an important point of the Šlapanice Hills. Because of unique palaeontological, botanical and archaeological finds, the Stránská skála Hill has been registered as a national nature reserve with an area of 16.79 hectare since 1976. The hill has shape of a cuesta (Fig. 52) with gently dipping slopes to the south and southeast and in contrary with steep slopes (in addition accentuated by old quarries) to the northwest.

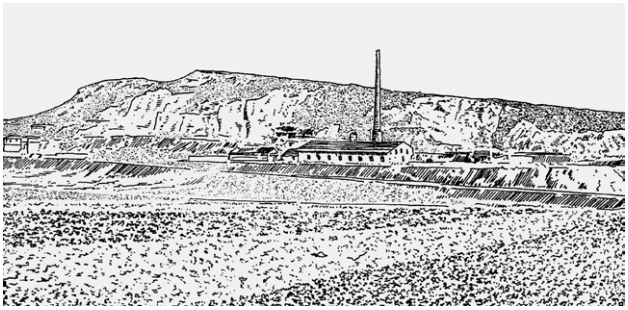

Fig. 52. A view towards the Stránská skála Hill in Brno at the beginning of the 20th century. Drawing according to a photo of that time by T. Přichystal.

Geological Setting: The total thickness of limestones is more than 80 m (unfortunately the bedrock has not been known) and they are divided into three parts (Eliáš 1969). The top of the Stránská skála Hill is built by 8 m thick formation of medium- to coarse-grained organodetrital and pseudooolitic limestones. Under this topical part there is roughly 4 m thick crinoidal limestone layer that was a subject of intensive medieval quarrying because of utilization as a popular decorative and building stone. The rocks below the crinoidal layer (with thickness of about 50 m) are formed by lumpy to pseudooolitic limestones with attitudes of organodetrital limestone, in the lower part with a slate disintegration and benches of massive dolomite. Speleological exploration of a small cave No.4 in the seventieth of the 20th century followed the limestone beds at least 15 m in the underlier and proved the occurrence of limestones without cherts (Burkhardt 1973).

Especially the uppermost limestones are intensively silicified and a banded structure is characteristic for the cherts. Silicification is manifested also in the lower part of crinoidal layer and irregular presence of cherts is visible in the underlying limestone beds (excluding the lowermost part known from the cave No. 4).

Macroscopic Appearance: Dimensions of chert concretions vary between 8–10 cm up to 40–50 cm, the big ones are especially above the crinoidal layer. The abundant prehistoric use was predetermined by their favourable spherical or loaf-like shapes (Supplement/Photo 46). The concretions have a rough whitish or brownish cortex with the thickness up to a few mm; the cortex is often preserved also on the artefacts. There are not present small hard bumps (in fact silicified microfossils) that we know on concretion surface of silicites from

Fig. 53. Chert of the Stránská skála Hill with a print of crinoidal stalk (length of the stalk is 3.6 cm). Photo by the author.

the Cracow-Częstochowa Jurassic in Poland or from the Ortenburg Jurassic in Bavaria. A thin dark band (about 1 mm) or a system of several such bands with a total thickness up to 1 cm is developed almost always just under the cortex, towards the central part of concretion it disappears. In contrary from the central parts there are known sharply limited brown-grey inclusions (so called petrosilexes built by quartz as is evident in thin section) and along them a non-conspicuous banding can appear again. The banding is in conformity with margins of concretion or shape of petrosilexes. This sign allows us to distinguish macroscopically the Stránská skála banded cherts from the well known Polish raw material – banded silicite of the Krzemionki type: the second one has a few systems of banding joining each other in various angles. Segments or parts of *Crinoidea* stalks are typical fossils visible already by naked eyes (Fig. 53; Supplement/Photo 48).

Cherts from the lower limestones (under the crinoidal layer) are usually grey and non-banded, arranged to lines parallel with layering. A spotted to brecciated structure caused by parts of fossils or chert chips in mm is conspicuous. Cherts from the upper limestones have attractive banded appearance that is visible on artefacts as well. Grey or whitish colour shades prevail but also in the limestones there have been found cherts with reddish, yellowish or bluish grey bands.

In 1982 the author had possibility to study a numerous collection of chipped artefacts from a workshop connected with the Funnel Beaker culture and found to the east of the Stránská skála Hill top. He distinguished within the collection nine basic chert varieties and results of the study are presented below (see also Supplement/Photo 47).

A: Prevalent raw material of artefacts in the workshop. The chert concretions have a non-spherical broken shape, the cortex is thin and rough, a little pale or whitish 1–2 mm thick zone or non-conspicuous band occurs below the cortex. The siliceous mass is prevalently homogenous (non-banded), translucent usually only at chip margins or in very thin flakes. The colour has a characteristic yellowish or olive-grey shade. The content of strongly silicified inclusions is very variable, sometimes are missing, sometimes can form almost half of a concretion. The inclusions have cloudy shapes with dimensions around one or more cm and their colour is lighter and brownish comparing the surrounding siliceous groundmass. They are totally non-translucent and having a grained appearance. In their vicinity it can be seen a thin whitish stripe or an indication of banding. In the workshop this variety was found especially in the form of cores.

B: Banded chert of whitish-grey colour, the siliceous mass is badly translucent, the structure is microbrecciated in places.

C: Low quality chert of whitish-grey colour with a non-banded siliceous mass and rough surface.

D: Non-banded grey to bluish grey variety with whitish petrosilexes and a white zone below the cortex.

E: The siliceous mass has a distinct yellowish shade and usually is banded.

F: The siliceous mass has a reddish-grey or red-brown colour and usually is banded.

G: Grey brecciated variety.

H: Dark blue to blackish-blue siliceous mass, usually banded.

I: Whitish or white-grey siliceous mass, sometimes banded, with a brown zone below the cortex.

Stereomicroscopic Appearance: The cherts from Stránská skála Hill are usually only badly translucent because of intense clouding by many whitish enclosures up to 0.1 mm; in the prevalently used variety "A" there are seen also bigger white enclosures that are represented with no doubts by chips of microfossils. In places there is a local clouding caused by very fine-grained white pigmentation in which cross-sections of sponge spicules form dark oval spots on the contrary. Rectangular cavities originated after dissolved calcite crinoidal segments. Alternation of 1–2 mm thick bands rich in chalcedony and poor in white enclosures with those overfilled by fine white enclosures is typical for the banded variety (Supplement/Photo 49).

Fig. 54. Archaeological excavation of the workshop for chert processing connected with the Funnel Beaker culture. Stránská skála Hill, surroundings of the spot height 310 m, 1982. Archives of J. Svoboda.

	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	Cr_2O_3	LOI	TOT/C	TOT/S	SUM
vzorek	hm.%	hm.%	hm.%	hm.%	hm.%	hm.%	hm.%	hm.%	hm.%	hm.%	hm.%	hm.%	hm.%	hm.%	hm.%
Stránská skála 1	93,77	0,2	0,85	0,02	2,59	0,02	<0,02	<0,01	0,02	0,02	0,021	2,1	0,61	0,03	99,62
Stránská skála 2	97,43	0,1	1,67	0,01	0,08	0,01	<0,02	<0,01	0,01	0,02	0,04	0,3	0,07	0,02	99,68
Stránská skála 3	94,17	0,21	1	0,02	1,84	0,04	<0,02	<0,01	<0,01	0,01	0,023	2,3	0,44	0,03	99,64
Stránská skála 4	95,36	0,25	3,13	0,02	0,13	0,03	0,03	0,01	0,02	0,02	0,042	0,6	0,09	0,03	99,64
Stránská skála 5	97,26	0,2	0,46	0,02	0,29	<0,01	<0,02	0,01	<0,01	0,01	0,012	1,4	0,12	0,02	99,68
Stránská skála 6	97,37	0,13	0,52	<0,01	0,32	<0,01	0,02	<0,01	0,03	0,01	0,013	1,2	0,15	0,03	99,62
Hády	94,28	0,46	0,47	0,05	1,52	0,07	0,11	0,02	0,02	<0,01	0,009	2,7	0,34	0,02	99,72
Bilá Hora	97,53	0,27	0,33	0,01	0,12	0,03	0,04	<0,01	0,03	<0,01	0,007	1,3	0,07	0,03	99,68
Švédské Valy	97,46	0,26	0,54	0,01	0,1	0,06	0,04	0,01	<0,01	0,01	0,012	1,3	0,06	0,04	99,81
Soběšice	98,08	0,12	0,45	<0,01	0,04	<0,01	0,02	<0,01	<0,01	<0,01	0,008	1,1	0,06	0,03	99,84

	Rb	Cs	Sr	Ba	Y	Zr	Hf	Nb	Th	U	V	Sc	Co	Ni	Cu	Zn	Mo	Ag	Cd	W	Au	Hg	Be	Ga	Sn	Pb	As	Sb
vzorek	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Stránská skála 1	0,7	<0,1	15,6	182,6	1	5,6	<0,5	<0,5	0,2	1,2	11	<1	4,1	16,8	6,7	9	0,8	<0,1	0,1	0,9	<0,5	0,18	<1	<0,5	<1	1,4	1,7	0,4
Stránská skála 2	<0,5	<0,1	2	24	0,2	6,7	<0,5	<0,5	<0,1	0,6	15	<1	0,9	23,1	13,9	2	1,7	<0,1	<0,1	1,1	0,8	0,04	<1	1,4	1	0,3	1,6	0,6
Stránská skála 3	0,6	<0,1	8,1	102,7	1	10,4	0,6	<0,5	0,1	0,3	11	1	1,2	13,5	7,6	12	1	<0,1	0,1	1,2	1	0,15	<1	0,6	1	0,6	1	0,3
Stránská skála 4	1,6	<0,1	5,8	79,3	1	1,4	<0,5	<0,5	0,4	1,9	16	<1	1,8	26	21,3	6	1,9	<0,1	<0,1	1,3	1,2	0,07	<1	1,1	3	2,5	3,9	0,6
Stránská skála 5	0,6	<0,1	8,5	110,3	0,6	3	<0,5	<0,5	<0,1	0,4	5	<1	0,8	6,2	3,2	2	0,5	<0,1	<0,1	0,6	2,9	<0,01	<1	0,6	<1	0,2	0,5	0,1
Stránská skála 6	<0,5	<0,1	8,9	106,3	0,6	1,3	<0,5	<0,5	<0,1	1,4	5	1	0,7	8,7	3,7	3	0,7	<0,1	<0,1	0,4	1,4	0,01	1	<0,5	1	0,1	0,8	0,2
Hády	4,1	0,9	14	97,2	2	4,5	<0,5	0,9	0,8	0,5	<5	1	0,9	6,3	3,9	2	0,3	0,1	<0,1	0,6	1,1	0,01	1	1,1	1	0,9	0,9	0,1
Bílá hora	1,1	<0,1	22,5	199,3	2	3,3	<0,5	<0,5	0,3	0,7	7	1	0,6	4,5	3,5	3	0,3	<0,1	0,1	0,3	1,2	0,01	<1	<0,5	<1	4,9	0,7	0,1
Švédské valy	1	<0,1	20,9	351,7	0,5	2,5	<0,5	0,5	<0,1	0,4	5	<1	2,2	9,4	3,9	2	0,7	<0,1	<0,1	0,7	6,3	0,04	1	0,5	<1	0,6	1,7	0,2
Soběšice	<0,5	<0,1	4,2	53,1	0,6	1,7	<0,5	<0,5	<0,1	0,2	<5	2	<0,5	4,2	2,1	<1	0,5	<0,1	<0,1	0,4	4	<0,01	<1	0,9	<1	0,4	<0,5	0,1

	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
vzorek	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Stránská skála 1	0,7	0,5	0,15	1,1	0,1	0,06	0,23	0,03	0,06	<0,05	0,08	<0,05	0,06	0,01
Stránská skála 2	<0,5	<0,5	0,02	<0,4	<0,1	<0,05	0,08	0,01	<0,05	<0,05	<0,05	<0,05	0,07	<0,01
Stránská skála 3	0,6	0,5	0,11	0,5	0,2	<0,05	0,15	0,04	0,08	<0,05	0,09	<0,05	0,13	0,02
Stránská skála 4	0,9	1,3	0,19	0,8	0,1	<0,05	0,12	0,02	0,1	<0,05	0,12	<0,05	0,07	<0,01
Stránská skála 5	0,6	<0,5	0,1	0,6	0,2	<0,05	0,16	0,02	0,05	<0,05	0,06	<0,05	0,07	0,01
Stránská skála 6	<0,5	<0,5	0,07	0,4	<0,1	<0,05	<0,05	0,02	0,08	<0,05	<0,05	<0,05	0,07	0,01
Hády	1,8	2,2	0,41	2,1	0,4	0,09	0,31	0,05	0,25	0,06	0,11	<0,05	0,18	0,01
Bílá hora	17	22,8	4,2	19,2	2,4	0,43	1,52	0,15	0,53	0,06	0,12	<0,05	0,14	0,01
Švédské valy	0,5	0,9	0,09	0,4	<0,1	<0,05	0,06	0,02	<0,05	<0,05	<0,05	<0,05	0,07	<0,01
Soběšice	0,5	0,5	0,07	<0,4	<0,1	<0,05	0,09	<0,01	0,07	<0,05	<0,05	<0,05	0,06	<0,01

Table 1. Chemical compostition (principal oxides, trace and rare earth elements) of Jurassic cherts in Brno and its surroundigs. Analyzed by ACME laboratories, Canada. Adapted after Švecová (2004).

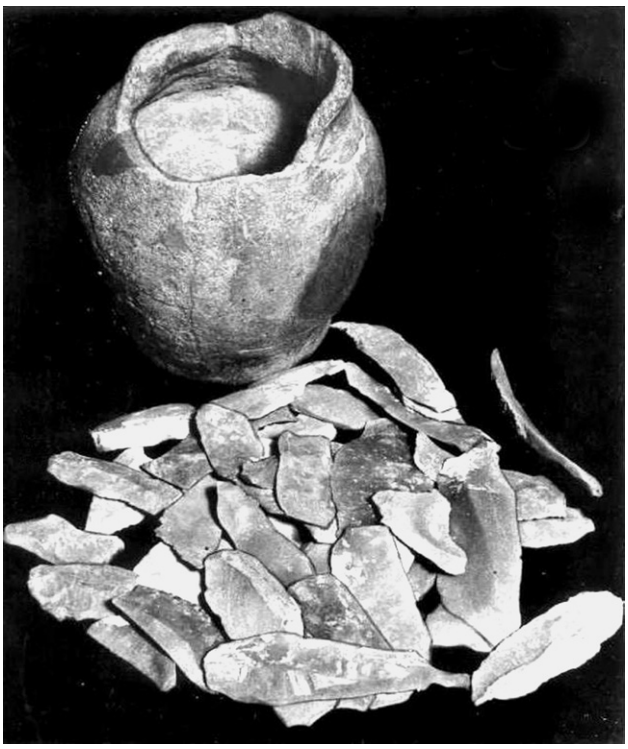

Fig. 55. The pot with treasure of 44 blades and blade chips found in 1982 in the workshop of the Funnel Beaker culture at Stránská skála. Archives of the author.

Thin Section: A detailed description of the Stránská skála cherts in thin section was carried out by Koutek (1926), recently in the scope of master thesis of Švecová (2004). Cryptocrystalline quartz prevails, in parts rich in microfossils relics there is usually present fibrous chalcedony (Supplement/Photo 50). Foraminiferans, radiolarians, parts of bryozoans, crinoids, pelecypod and ostracod valves can be found as microfossils. Sponge spicules commonly with preserved axial canal having brown pigmentation are numerous as well. The crinoidal segments were more resistant to the silicification and that is why they have preserved a characteristic lattice structure to be filled by a calcite crystal. Similarly the ostracod tests can have preserved calcium carbonate filling.

Other Analyses: Determination of the main oxides, trace elements and rare earth elements (REE) in the Stránská skála cherts can be seen in the Table 1; the results were obtained in the scope of a research project of the author and the master thesis of Švecová (2004). The occurrences of main oxides are rather stable that is consequence of a high presence of SiO_2. The biggest differences one can see in the determinations of CaO (0.04–2.59%) because of its preservation in some microfossils (it has been proved by the investigation of thin sections). Episodically higher contributions of clayey material in the chert structure are expressed in variable contents of Al_2O_3. The content of REE (Table 1) in the Jurassic cherts of the Brno area is very low, often even under their detection limits, what is characteristic also for the Stránská skála cherts. An exception is represented by a chert from the Bílá hora Hill with substantially higher REE and some increasing can be seen also in a sample from the Hády Hill. In the both cases the cherts come from the basis of Jurassic limestones that was influenced by contribution of clayey substance or fine-grained detritus from surrounding (recently underlying) rocks. The bedrock of the Jurassic of the Bílá hora Hill is built by metamorphic rocks of the Brno Batholith mantle with dykes of granodiorite composition. Chemical influence of these rocks was substantially higher comparing that of Palaeozoic limestones forming the bedrock of the Jurassic rocks on the Handy Hill. In any case it would be possible on the basis of REE to distinguish a chert from the Stránská skála Hill from the Bile hora Hill (see below information about a Palaeolithic chipped industry found at the Bile hora Hill but prevalently made of the Stránská skála cherts).

Determination of microhardness represents another analysis suitable for characterization of cherts. As is the Stránská skála cherts concerned, it varies in a broad interval 840–1220 VHN (Vicker's Hardness Number) with the calculated medium value 1003 VHN (Přichystal 1975). For comparison the microhardness of quartz varies in the range of 1103–1260 VHN according to the published data. The lost of ignition reaches 0.71–0.92% with the medium value 0.79 %.

Prehistoric Use: The Stránská skála Hill was settled as one of a few places in Central Europe already in the Lower Palaeolithic before more than 600 000 years as is evidenced by finds of worked local cherts and animal bones (Valoch 1995, Musil ed. 1995), some of bones were burned (Přichystal & Strnad 1995). An intensive settlement during the Upper Palaeolithic (the Bohunician and Aurignacian; for the last time see Svoboda & Bar-Yosef, eds. 2003) was ascertained just on the hill plain. The connection of the Bohunician with the Stránská skála cherts is evident from an observation (Svoboda et al. 2002, 131) that the settlement sites of the culture are in fact identical with the Stránská skála chert distribution. The chert was transported especially along the Drahany Highland foot about 80 km to the NE up to the Prostějov area, on the other hand it has been found at Mohelno in the Bohemian-Moravian Highland (some 35 km to the west of the source). The Stránská skála chert was chipped also at the Szeletian sites above the valley of the Bobrava (SW of Brno). The mentioned shape of the cuesta caused the Stránská skála Hill served as a specialized place for horse hunting in the Epigravettian (locality Stránská skála IV – Svoboda et al. 2002). In that time the local cherts were used only partly because besides them there are substantially present such exotic raw materials as is radiolarite, obsidian, rock crystal and porcellanite.

The Stránská skála cherts were not largely distributed in the Neolithic because of the decisive influence of cherts from the Krumlovský les Highland in the Brno area as well. Hundreds of non-patinated chipped artefacts lying on the field between the eastern margin of local gardens and the spot height 298.65 m can be connected with a big workshop and supposed prehistoric mining in the

Eneolithic, especially in the period of Funnel Beaker culture (Svoboda & Šmíd 1996). A ceramic pot with hoard of 44 blades was found in a feature of the Funnel Beaker culture during excavations in 1982 (Fig. 55) when only less than half of the hoard is chipped from the Stránská skála cherts and the prevalent remaining part of blades is made of the Krumlovský les type cherts (but in this case coming probably from Tertiary gravels in the vicinity of the Stránská skála Hill).

Prehistoric mines at the Stránská skála Hill have not been discovered yet but with a high probability the main concentration of chert artefacts and limestone fragments in the field just behind the gardens represents a levelled tip after the mining and some pits in the SE corner of the garden around the waterworks could have prehistoric origin. Chipped industry at a nearby fortified settlement Staré Zámky in Brno-Líšeň (prevalently connected with the Funnel Beaker culture) is also mostly prepared from the Stránská skála chert, variety A.

II.2.3.5. Jurassic cherts of the Bílá hora Hill (Brno-Židenice)

Location: The Bílá hora Hill (299.6 m; formerly also Nová hora or Hybešova hora) is again situated in the eastern part of Brno called Židenice. From viewpoint of geomorphology the Bílá hora Hill is a point of the Šlapanice Hills and the vicinity of its hilltop with an area of 0.65 hectare is a nature reserve since 1991. A valley with the Zetor factory and Brno Incinerator of Municipal Waste divides the hill from the Stránská skála Hill. The valley is filled with the Tertiary and Quaternary sedimentary rocks. During building of the tram line No. 8 in 1984 there was unearthed the crystalline basement below the Jurassic limestones and from it follows a geological normal slip-fault must be between the Bílá hora and Stránská skála Hills. The Stránská skála Hill represents a sunken part because the bedrock of local limestone has not been catched up neither a few ten metres deep boreholes.

Geological Setting: Comparing the Jurassic limestones at the Stránská skála Hill, the rocks at the Bílá hora Hill represent a lower (basal) part of the Jurassic; in spite of it they both are of the same age (Upper Jurassic, stage Oxfordian). A lot of small quarries with mining of limestones probably since the Middle Ages occur on the southern and western slopes of the Bílá hora Hill but with no chert concretions. There is only one place on the gentle SE slope under the topic plain where the author was successful to find natural chert both in the slope sediments and in the limestone massif. From these data it follows the limestones of the Bílá hora Hill (and similarly the Hády Hill) are substantially poorer in cherts comparing the Stránská skála and Švédské valy Hills.

Macroscopic Appearance: The chert concretions are prevalently small, the size does not exceed 5 to 8 cm. In addition they often have irregular bizarre shapes (Supplement/Photo 51), they are not spherical or loaf-like. The colour is dark grey or olive grey (5Y 4/1), possibly up to light olive grey (5Y 6/1) and partly is similar to that of Hády cherts. Rectangular cavities imitating dissolved calcite crinoidal segments or prints of sea urchin spines represent common paleontological finds.

Stereomicroscopic Appearance: In the olive grey to yellowish grey siliceous mass there are parts of crinoidal segments with the size up to 1 mm, the translucent siliceous mass is sometimes clouded by a yellow-brown pigmentation. The translucent siliceous mass blends into a whitish non-translucent one with numerous transparent phantoms after sponge spicules.

Thin Section: In places the cryptocrystalline siliceous mass contains as an admixture clayey substance or iron oxides pigmentation that causes the yellowish or olive-grey shade. Frequent fossil relics are conspicuous because of filling by bigger fibres of chalcedony often arranged in spheroidal aggregates. Sponge spicules, relics of foraminiferal tests, parts of brachiopode valves are common; there were found also cross-sections of gastropods or bryozoan parts. The chalcedony can by recrystallized to quartz forming than euhedral crystals.

Other Analyses: Chemical composition of a chert from the Bílá hora Hill is shown again in the Table 1. The analysed chert has besides a high presence of SiO_2 the second highest content of Al_2O_3 from the whole studied collection of Moravian Jurassic cherts. On the other hand the lowest occurrence of Fe_2O_3 is surprising taking into consideration the data from the study of thin section. If the main oxide contents are similar to those from other Jurassic cherts in the Brno area, there is an important difference in the substantially higher presence of light rare earth elements (Table 1) as is the chert from the Bílá hora Hill concerned. It can be connected very probably with a higher contribution of fine detrital material in the basal Jurassic layers because a similar increase has been also ascertained for the chert from the Hády Hill.

Prehistoric Use: An Upper Palaeolithic station has been described from the eastern slope of the Bílá hora Hill; on the basis of typological signs of chipped industry it is assigned to the Bohunician. As the raw material there were used homogenous and banded cherts from the close Stránská skála Hill but we cannot exclude also partial using of the local Bílá hora cherts. Chipped pebbles of the honey-brown Cretaceous spongolites and the Krumlovský les type cherts, both coming probably from the Pleistocene river gravels lying on the Jurassic limestones just at the finding place, appeared in the industry also. Erratic flint representing an imported raw material (Valoch 1987) was found rarely similarly as radiolarite and brown silicite.

Generally it can be summarized the cherts from the Bílá hora Hill have not such quality and quantity as those from the Stránská skála Hill and hence according to the recent knowledge their use was only sporadic in prehistoric times.

II.2.3.6. Jurassic cherts of the Švédské valy Hill (Brno-Slatina)

Location: A small occurrence of Jurassic limestones situated in the cadastral area of Brno-Slatina about 2.5 km to the south of the Stránská skála Hill is called the

Švédské valy or Švédské šance Hill (254.5 m). Although it is about 55 m lesser than the Stránská skála Hill, the locality is morphologically very conspicuous because of its flat surroundings (the Tuřany Pleistocene sandy-gravel river terrace covered by loess) and rises above it about 15 m. Originally it could be about 10 m more because the limestone was intensively quarried during the Middle Ages. The devastation was finished in the second half of the 20th century as a consequence of the locality change for a waste dump. In that time it was very difficult to find at Švédské valy a piece of limestone or chert because the whole area became overgrown by high weeds. Thanks to building of an industrial zone in the years 2002–2006 the Jurassic limestones with plenty of cherts were unearthed in numerous excavations.

Geological Setting: It is a small denudation relic of the Upper Jurassic (Oxfordian) limestones of the same character as those at the Stránská skála Hill. The limestones built an isolated outcrop in the area of Miocene and Quaternary sedimentary rocks of the Carpathian Foredeep.

Macroscopic Appearance: The cherts form spherical or loaf-like concretions with a diameter up to 15 cm, the colour of siliceous mass has a distinct bluish-grey shade (5PB 7/2), somewhere they are intensively cracked (probably in the vicinity of tectonic faults), at some other places they are without any tectonic breaking. They have a conspicuous whitish cortex with a thickness up to 1–2 cm (Supplement/Photo 51).

Stereomicroscopic Appearance: The cherts are not banded but they can have an almost pseudobrecciated structure because of high content of microfossil fragments. Some of them can be identified as crinoidal segments. The prevalent part of siliceous mass has a very fine whitish clouding; veinlets of bluish chalcedony appear in the margin of concretions.

Thin Section: Studied thin sections showed an evident non-homogenous structure, it means by the presence of many patches with bigger chalcedony fibrous spheroids or grains in cryptocrystalline siliceous groundmass. Chalcedony spheroids usually more or less replace micrite carbonate. The higher presence of carbonate seems to be a characteristic sign for the cherts from Švédské valy comparing cherts from the other occurrences. Relics of microfossils represented especially by sponge spicules, well preserved foraminiferans, parts of moss animals, brachiopod valves or bigger crinoidal segments with typical latticed texture are common.

Other Analyses: Chemical composition of the cherts including determination of trace and rare earth elements is introduced in Table 1.

Prehistoric Use: The locality had to represent an important orientation point in prehistoric landscape what is testified by finds of artefacts believed to be of Lower Palaeolithic (Cromerian) Age and partly prepared from local cherts (Valoch & Seitl 1994). During large archaeological rescue excavations in 2005–2006 carried out by the Institute of Archaeological Heritage Preservation in Brno it was found in the vicinity of Švédské valy more than 2000 archaeological features of various ages. A settlement and burial ground of the Únětice culture found on the gentle slope to the S and E of Švédské valy belong to the most important. Stone chipped artefacts made of local cherts were found in the area of settlement and in the nearest vicinity there were ascertained relics of a few mining pits with chips of prehistoric pottery at the bottom of a modern small quarry. The mining pits could be evidence on mining of cherts in the Old Bronze Age (Kos & Parma 2007). In any case, the Jurassic cherts from Brno occurrences (especially both from Stránská skála and Švédské valy) represented an important part of the raw material basis in the older phase of the Únětice culture as we know from a former petrographic investigation of the Bronze Age stone artefacts in Moravia (Přichystal, Šebela & Kopacz 2004). In some cases it is impossible to distinguish cherts among themselves from the mentioned localities of the same Jurassic age and in addition forming in the geological prehistory an integral whole.

II.2.3.7. Jurassic cherts of the Hády Plateau (Brno-Maloměřice)

Location: The southern slope of the Hády Plateau (424 m) is limited by fault and represents both southernmost extension of the Moravian Karst and the highest elevation above Brno. It lies in the cadastral area of Brno-Maloměřice. In the course of the 20th century the whole southern part of the plateau has been transformed by mining of the Palaeozoic limestones in a huge quarry when originally three big quarries (Růženin, V džungli and Klajdovka or Maloměřice quarries) were united in the gigantic one having the length almost 1 km and total height of all benches about 100 m.

Geological Setting: The Devonian to Lower Carboniferous black limestone builds the prevalent part of Hády Plateau but just near the top a small relic of yellowish Jurassic limestones with a thickness of about 4 m has been preserved. The Jurassic rocks are well accessible in the uppermost bench of the Klajdovka quarry.

Macroscopic Appearance: Concretional, rarely layered cherts are a part of the Jurassic limestones. The concretional cherts are not of good quality having often pitted appearance. The colour is usually yellowish grey or yellowish brown (Supplement/Photo 51). The layered chert is similar to the chert of Olomučany type and the author found it in silicified limestones to the north of a small ridge connecting the bottom of the uppermost bench with the topical plateau.

Stereomicroscopic Appearance: The concretional cherts have siliceous groundmass irregularly clouded by lumpy clayey substance that is coloured in various intensities (usually in the gentle ochre colour). Among the clayey clouds there are thin well translucent veinlets or schliers of chalcedony. Bigger white inclusions are formed by relics of microfossils, especially by fragments of bryozoans, sea urchin spines or parts of brachiopod valves. Small sponge spicules are sometime accumulated in the vicinity of bigger microfossil relics, at another time they are spread in translucent parts of siliceous groundmass.

Thin Section: A thin section was prepared from the most occurring chert variety with macroscopically distinct moderate olive-brown (5Y 4/4) to dark yellowish brown hue (10YR 4/2). Spheroids of chalcedony filling oval cross sections probably of sponge spicules are conspicuous in the cryptocrystalline siliceous groundmass; there were also found brachiopod parts. The investigation using polarizing microscope is in accordance with the study under a stereomicroscope – cloudy parts with clayey substance have a very fine-grained siliceous groundmass and bigger fibres of chalcedony fill space among them. A carbonate forms numerous rhombohedral crystals in a part of the thin section.

The above-mentioned dark layered chert yields another picture similar to that of the Olomučany type chert. Investigating thin section with only the polarizer (in plane-polarized light), one can see conspicuous quantity of microfossils that are coloured by a brown pigmentation in different intensity. Bryozoan parts, foraminiferans and sponge spicules represent the microfossils. Isometric grains of green glauconite (potassium-iron-alumino-silicate clay mineral) with characteristic pockmarked surface occur in places and rare quartz grains or lamellae of biotite represent clastic admixture. A high presence of coarse-fibrous chalcedony is conspicuous when we use crossed polars.

Other Analyses: Chemical composition of the chert is introduced in Table 1. A higher content of Al_2O_3 is evident what can be surely connected with a contribution of clayey substance to the sedimentation basin as a consequence of the geological position – the Jurassic limestones at Hády represent a basal formation lying on older weathered rocks. The special ochre colour of the Hády cherts has been caused by oxides and hydroxides of iron gave on also by weathering of bedrocks.

Prehistoric Use: Valoch (1977) described a small Palaeolithic station with probable use of the local chert from the plateau partly destroyed by the highest quarry bench. It is possible to find non-patinated chipped artefacts on the topical plateau also in recent time but they are usually made of the brought Stránská skála cherts. From it follows the Hády cherts were use only exceptionally (especially in the Neolithic and Eneolithic) because of their low quality and close occurrences of the better cherts from Stránská skála and Švédské valy Hills.

II.2.3.8. Jurassic chert from Olomučany (Moravian Karst)

Background: Bosák (1978) has mentioned an occurrence of layered chert in the Jurassic relic at the village of Olomučany from the geological point of view. Přichystal (1981, 1984) recognized it as a raw material for prehistoric flaking for the first time among artefacts of the Moravian Painted Ware culture at localities Brno-Bystrc and Těšetice-Kyjovice. The researches in the years to follow have shown this was a significant raw material that was distributed also out of the territory of Moravia.

Location: The raw material source is a small Jurassic limestone relic near the village of Olomučany in the central part of the Moravian Karst, 3 km southeast of the town of Blansko. Chert outcrops can be seen at the upper winding of the road from Olomučany to Josefov, its natural chips occur in slope deposits of the Hloubatý Hill, or in the field beyond the gardens at the road to the abandoned Hrubých quarry at Olomučany (Fig 56). But chert does not crop out in the quarry.

Fig. 56. Aerial view on the workshop for chipped artefacts in the area of prehistoric mining at Olomučany, central part of the Moravian Karst. Photo by M. Přichystal.

Geological Setting: The chert forms stratified layers from several dozens of cm to 2 m thick in the Upper Jurassic (Oxfordian) limestones. The author registered also a small attitude of macroscopically similar chert at the Hády Plateau in Brno-Maloměřice (see above).

Macroscopic Appearance: The chert raw material has dark grey to greyish black colour, almost always with a distinct layering. Plentiful whitish grey or yellowish grey nearly non-translucent smudges appear at the marginal layer parts, or as the case may be, this variety prevails and, conversely, dark, more translucent smudges and lenses are visible in it. Siliceous geodes of various sizes (from 5 mm to several cm), sometimes even with their central cavities filled with crystalline quartz or chalcedony coatings, are ascertained in the chert quite often (Supplement/Photo 54).

Stereomicroscopic Appearance: Black parts of the chert are built of glass-like translucent siliceous groundmass containing a lot of whitish inclusions with diameter up to 0.5 mm (Supplement/Photo 55). They can be prevalently interpreted as non-dissolved clasts of original sedimentary rock (fine-grained sandstone to siltstone). They have usually a distinct preferential arrangement that corresponds to former layering. Some of them have yellowish or gently ochre colour. Small clusters of yellow-brown or red pigment are substantially lesser (under 0.1 mm). As microfossils there are numerous sponge spicules with dominating monoaxons, moreaxon shapes are also present. They look like parts of white thin thread. The black chert changes by the increasing of whitish inclusions to the lighter smudges or attitudes forming usually marginal parts of chert layer. In contrary, the circular cross sections of sponge spicules are bigger and translucent in such smudges.

Thin Section: The chert has unambiguously character of a spongolite because in places it is full of sponge spicules with brown pigmentation and preserved axial canal (Supplement/Photo 56). Fibrous chalcedony fills their longitudinal and cross-sections, the parts with brown pigmentation have usually only cryptocrystalline siliceous mass. Grains of greenish glauconite with a high relief occur only rarely.

Prehistoric Use: The Olomučany chert has been ascertained in small quantities as early as in older periods of the Upper Palaeolithic (for example at the Szeletian stations Drysice 1 and Ondratice 1 in the Prostějov region), artefacts made of it have been found also in the area of the Szeletian or Micoquian site Bořitov-Horky (about 10 km from the source). It has begun to be used in a systematic manner in the Late Palaeolithic at the cave stations of the Magdalenian and Epimagdalenian in the Moravian Karst (the Býčí skála, Barová, Kolíbky, Pekárna, Srnčí and other caves). In the Late Palaeolithic and Mesolithic this raw material was also distributed through the Boskovice Furrow to the north, to the present eastern Bohemia (the Tatenice and Krasíkov Pre-Neolithic sites 13 km to the north of Moravská Třebová). In the Mesolithic it is distinctly represented even in Mikulčice, southern Moravia (4.5%), it sporadically appears as far as the Mesolithic stations in the surroundings of Kłodzko in southern Poland (collections of J. Bronowicki from Wrocław).

During the Neolithic the Olomučany chert remained an important raw material for the territory to the north of Brno. It was ascertained e.g. in Kuřim, at the settlement with Linear Pottery, in Určice near Prostějov (Stroked Pottery culture), and in smaller quantities at more localities with the Moravian Painted Ware. It is the dominating raw material at the Eneolithic hilltop settlement in Brno-Maloměřice, part Občiny (Valoch & Šebela 1995), where 90 % of chipped artefacts are made of it (i.e. 1,093 out of 1,225 items). More details on the distribution of Olomučany type chert in prehistoric times may be found in papers by A. Přichystal, Z. Čižmář, and I. Mateiciucová.

Prehistoric Mining: From all the data mentioned above it is evident the Olomučany-type chert was a significant primeval raw material and therefore obtaining by mining could be assumed. During a field survey in the outcrop area near the village of Olomučany in 1999 the author found a large workshop that processed this chert, with the maximal artefact concentration about 75 m west of the abandoned Hrubých quarry, 350 m northeast of the chapel in Olomučany (cadastral part Na kopaninách). Besides numerous artefacts he found a few pebble percussion implements (Supplement/Photo 53). The workshop is situated in a farmed field and no significant morphological depressions are visible within its area that would prove remnants after prehistoric mining. Occurrences of the artefacts do not continue on the slope aside the Hrubých quarry, which complies with old photos of the quarry showing that chert layer was never recorded just in it, and thus it has to be situated in the bedrock of silicified limestones cropping out in the quarry.

Two stages of a geophysical survey were carried out at this locality in cooperation with V. Hašek and J. Tomešek, for which the DEMP (Dipole Electro-Magnetic Profiling) method was applied (Hašek, Přichystal & Tomešek 2003). We used the GEM-2 multi-frequency conductivity meter made by Geophex (USA) with the depth range of 4 to 6 m. From the processing of an isoline map of virtual conductivity and magnetic susceptibility the occurrence of four circular anomalies with an increased conductivity has emerged from the area of the workshop; these were interpreted as depression structures (probably pits) with a different filling as compared to the surroundings. In 2003 we made a survey trench 8 x 1 m in area and 1 m deep within the place of the largest anomaly (Přichystal & Přichystal 2004). The trench was situated on the 410 m contour line, which is about 1 m lower than the present bottom of the Hrubých quarry (its eastern part is filled with stones collected in the surrounding field and its north and south walls are covered with a talus pile). Several hundred chipped artefacts and pieces of raw material were acquired from the 20 cm thick arable land. In the bedrock of the arable land an edge of a vast pit has really outlined, which was filled with fragments of fresh silicified limestones with the sizes of up to 20 cm and with chipped artefacts. In one place a slightly recessed small pit was found filled with chipped artefacts and chert raw material. The archaeological survey was continued in 2004 and has confirmed the existence of a vast depression, which was filled with sharp angular and relatively fresh fragments of silica limestones (Supplement/Photo 52) as compared to the neighbouring, more than 2.5 m thick clayey layer originated by weathering of Jurassic limestones. In comparison with its surroundings the filling of the depression is less consolidated and considerably porous. The artefacts of Olomučany-type chert have only appeared in its upper section, to the depth of about 60 cm; in lower part there were only limestone fragments with one exception – two small chert splinters. Unfortunately no artefact (e.g. pottery, characteristic tool) was found in the pit filling that could specify the time of its emergence but we suppose it is highly probable we have detected an edge of a primeval (Eneolithic?) extraction pit.

II.2.3.9. Jurassic cherts of the Rudice Formation (Moravian Karst)

Background: When J. Wankel (1882, 376) evaluated his finds from a Palaeolithic (Magdalenian) station in the famous Býčí skála Cave in central part of the Moravian Karst he mentioned also big quantity of local chert or quartzite used as a raw material, cores and tools. On another page (p. 302) he has described in detail a cross section of the „Jurassic Formation in Rudice“ (recently we believe the formation is of Lower Cretaceous or Cenomanian age) on the basis of deep mines sinking in the second half of the 19th century for iron ores exploitation. One layer in the cross section he has called „Flint Layer“ (it means a gravel layer full of shortly transported chert concretions). Later, the raw material from the Býčí skála Cave had been designated as a quartzite for

a long time because of K. Absolon's opinion about the so-called quartzite Pre-Aurignacian. Recently we know it is imperfectly silicified chert from the Rudice Formation (Přichystal 1994, 44).

Location: As for area, the Rudice Formation represents a small occurrence of continental clastic sediments spread among the municipalities Rudice, Olomučany and Babice in the central part of the Moravian Karst, roughly 20 km to the NNE of Brno. In the geological past its surface distribution was much more large because rocks from the Rudice Formation are substantially represented in the Pleistocene terrace gravels of the Svitava river, e.g. at the SE margin of Brno. It means a part of the Rudice Formation including the cherts has been moved to the south.

Geological Setting: According to the present prevailing opinion, the Rudice Formation is believed to be a complex of continental sedimentary rocks originated by weathering of older surrounding rocks in the Lower Cretaceous period, some authors think about their origin a little later at the beginning of the Upper Cretaceous – in the Cenomanian (Pelouškova, Peloušek & Frejková 1985).

The deposits of Rudice Formation have been preserved prevalently only in the central part of the Moravian Karst because of their subsidence in the Blansko Graben. Jurassic marls to limestones with cherts cropping out in a small relic around the village of Olomučany were one of their mother rocks. The weathered out cherts are concentrated in chert gravels forming the upper part of the Rudice Formation and due to this they rise to the surface in the fields east of Olomučany, in the direction of the Pokojná spot height, or west of Rudice. Although their age is the Lower Cretaceous, they surprisingly are non-lithified sediments, in which, apart from the dominating fragments of cherts or only slightly transported chert concretions, quartz pebbles (whitish, dark, pinkish to rose quartz), and limonite concretions are plentifully represented. The presence of silica geodes (small globular formations with central cavity filled by quartz crystals or chalcedony) is characteristic; it is rarely possible to find whole silicified sponges or fragments of silicified wood.

Fig. 57. Abandoned sandpit at Rudice-Seč is the most spectacular locality in the Rudice Formation. Photo by the author, 2008.

Macroscopical Appearance: As a rarity, chert concretions from the Rudice Formation may reach the size of around 1 m. However, they are usually their parts up to 15 to 20 cm. A majority of cherts are of a pale grey to whitish grey colour and, usually even their thin edges are not translucent (for example in the Rudice-Seč sandpit). These varieties may be even banded; they often are only a few centimetre, sharply angular fragments without any relics of the concretion cortex (Supplement/Photo 57). Higher quality brownish grey or bluish grey types featuring a higher content of chalcedony, and therefore translucent either in their edges or in the whole fragment, are less frequently represented. From among fossils echinoid spines, prints of brachiopod valves, or conic holes left after fallen out belemnites are common. Even complete prints of ammonites or cherts with a shape of sea sponges have been found.

Stereomicroscopic Appearance: A special type is represented by the chert prevailing in the gravels in the plain above the Býčí skála Cave. A number of its pieces fell down through limestone sinkholes directly into the cave where they were used for chipped artefacts at the Palaeolithic station ascertained inside. Absolon (1944–1945) has designated this raw material as a quartzite but in reality it is a layered chert with plentiful relics of imperfectly diluted quartz grains and with fine spicules of siliceous sponges.

Thin Section: The chert under polarizing microscope is partly similar to the Olomučany chert: one can see relics of microfossils with brown pigmentation (but the pigmentation is not so intensive comparing the Olomučany chert), strongly silicified sponge spicules and bryozoan parts are common. The sponge spicules are filled by fibrous chalcedony. The presence of glauconite has not been detected; in contrary they are numerous grains of imperfectly diluted clastic quartz.

Prehistoric Use: The quality of cherts from the Rudice Formation is rather low; that is why they were chipped especially in the area of natural occurrence and the close vicinity. Their use was concentrated to the caves of the Moravian Karst (the Býčí skála, Barová, Pekárna and Ochoz Caves or the horseshoe-shaped rock wall Kolíbky near Rudice) in the end of the Palaeolithic. The same conclusion we can state as is the younger prehistoric periods concerned.

II.2.3.10. Cherts of the Krumlovský les type (SW Moravia)

Background: Investigations in the second half of the 20th century showed the cherts from the Krumlovský les Highland represented the most important raw material for chipped artefacts in southern Moravia since the Palaeolithic. Results of a long-lasted excavation of prehistoric mines and general review of our recent knowledge have been published in a monograph written by M. Oliva and twelve co-authors. A written history on these cherts has been evaluated minutely in the book (Oliva et al.

Fig. 58. Excavations of M. Oliva in prehistoric exploitation area in the Krumlovský les Highland. Trench I-3-1 from the year 1996. Photo by the author.

2010, 25–28) where as perhaps the first written report on the cherts of the Krumlovský les type is considered a mention on "Flindenstein" in the field between Jevišovice and Trstěnice in the work Tartaro-mastix Moraviae by J. Hertod in 1669 but most probably it concerns to chalcedonic weathering products of serpentinites and not to cherts. Undoubtedly the chert (Hornstein) is introduced from the surroundings of Moravský Krumlov in a paper of K. André in 1821.

From the geological viewpoint, Knies (1908) and later Dvořák (1956) have called attention to faired cobbles and rolled chert nodules in the Tertiary sediments in the wider surroundings of Moravský Krumlov, and deduced they originated from the totally denuded Jurassic limestones widespread in the area prior to the Tertiary deposits. When investigating the Palaeolithic stations in the Krumlovský les, Valoch (1975) has also recorded this raw material as important for the Palaeolithic man. Přichystal (1980, 1984) has established the term Krumlovský les type chert and defined two (later three) basic varieties. Lech (1981) during his studies of Neolithic chipped artefacts in Central Europe registered also numerous chipped collections made of an important local raw material deposited in the Museum of Moravský Krumlov and proposed to call it the Moravský Krumlov hornstone. Oliva (1997, 2005) highlighted an extraordinary extensive prehistoric mining of the cherts in the Krumlovský les Highland and for a long time has excavated the mining field (Fig. 58).

Location: The Krumlovský les Highland is situated roughly 18–28 km to the SSW from the Moravian capital Brno. It forms a flat highland bordered by an expressive fault slope facing the depression of Boskovice Furrow in the west and by the margin of the Bohemian Massif against the Dyje – Svratka Graben in the east. The valley of Jihlava River between Ivančice and Moravské Bránice forms the northern boundary against the Lipovská Highland, in the south it is separated from the Bohutický les Highland by a valley filled by Neogene deposits between Lesonice and Vedrovice.

Geological Setting: The basement of the Krumlovský les Highland is built by Proterozoic biotite and amphibolbiotite granodiorites of the Brno Batholith. In spite of no recent outcrops of Jurassic sediments in the area we have to suppose their presence before Tertiary because of occurrences of Tertiary deposits rich in Jurassic cherts there. Firstly, during the Lower Tertiary (especially in the Oligocene) the Jurassic limestones were denudated and accumulations of loosened resistant chert concretions were formed. They supported rise of a special form of duricrust (a breccia made of Jurassic chert chips and cemented by silica) originated in situ. Recently they are only relics of the duricrust represented by boulders. Sporadic rivers under desert weather conditions transported substantial part of the chert concretions and that is why their pebbles or rounded natural chips are covered by thin dark or black coating (desert warnish) with many traces after impacts of other pebbles during the transport. In the Upper Tertiary (Miocene, Eggenburgian to Ottnangian) the area was flooded by a shallow sea of the Carpathian Foredeep and the residual cherts were washed in the marginal sea deposits. Similar chert pebbles or natural chips with black desert warnish originated also around other Jurassic occurrences in Brno or in the central part of the Moravian Karst and they were washed in the Carpathian Foredeep deposits later (Lower Badenian gravels in Brno-Vinohrady or Brno-Líšeň). In addition to it, the Svitava River retransported them in the Pleistocene gravel terraces especially in the Brno area. The Eggenburgian to Ottnangian sandy gravels in the Krumlovský les Highland (Supplement/Photos 60, 61) represent undoubtedly the oldest and the most extensive deposits with such type of cherts because from psephite sedimentary rocks of the so called autochthonous Paleogene (polymict conglomerates of the Těšany Formation in the Nesvačilka Graben) these cherts have not been described (Brzobohatý 1994).

Macroscopic Appearance: The Krumlovský les type cherts are pebbles or only partly rolled fragmental cherts with a characteristic black or lacquer dark brown surface (desert varnish). A great quantity of nail-like scratches that have probably originated from the mutual strokes of the pebbles among themselves is characteristic for the pebble surface of the raw material. These strokes often resulted not only in the scratch record on the pebble surface but lead to the chipping of a natural flake- or even blade-like shape and than to the origin of conspicuous

pseudoartefacts. On such cherts it is possible to observe a significantly thicker desert varnish on the original pebble surface than on the negatives after the chipped parts. Consequently, this dark to black desert varnish was formed at the time when the natural chipping of the pebbles occurred. According to data in the geological literature (e.g. Bates & Jackson, eds. 1987) the desert varnish represents a thin, glossy film or coating consisting of ferric oxides that are accompanied by manganese oxides and SiO_2 (Supplement/Photo 61). It emerges on the surface of pebbles, cobbles, or rocky fragments after their long-term exposition to the desert climate. It is supposed the desert varnish originates by "sweating out" (due to marked temperature differences between days and nights) of slightly mineralised solutions from inside of a rocky fragment and their precipitation on its surface. These desert varnishes is known not only on pebbles and fragments of Jurassic cherts but also on indubitable Upper Cretaceous spongolites, for example in the surroundings of Bořitov, which enables us to date its genesis to the period after the Upper Cretaceous and prior to the Neogene, i.e. to the Palaeogene. As regards climate under which the desert varnish is formed, the geological literature (e.g. Kukal 1986, 371) states we do not know much about its emergence yet and, according to some authors, it may originate even under humid conditions.

Stereomicroscopic Appearance:

Krumlovský les I type chert

In the mining area it represents an entirely dominating variety that meets the above definition from the occurrence form viewpoint. Its specific feature is a light or medium bluish grey colour of the siliceous substance (5B 7/1–5B 5/1) that may, however, alternate a very light grey (N8) within one sample. Chert is almost never homogenous as for colour; on the other hand, the alternation of streaks or irregular bands of the specified colour shades (Fig. 59) is more common. Sometimes even a distinct pink hue may be observed (5 YR 8/1). The colour shades are related to the dimming of the chalcedony substance either by a quantity of animal sponge spicules (*Porifera*), or by prevailingly isometric cloudy formations of the 0.1 to 0.3 mm size that undoubtedly represent poorly silicified relics of the original clastic rock, in which chert was originating (Fig. 60). In terms of the fossil content, the Krumlovský les I variety represents a spongolite (Supplement/Photo 63) that bears a comparison with standard Cretaceous spongolites in respect of the animal sponge spicules content. A number of Upper Cretaceous (Turonian) spongolites also have the bluish grey shade (for example the Ústí nad Orlicí type spongolite described by Vencl 1990). Due to these reasons it cannot be excluded that the prevailing Krumlovský les I variety has originated by weathering of the Upper Cretaceous clastic sediments (supposedly calcareous sandstones – siltstones) with spongolites rather than of Jurassic limestones with cherts as has been generally stated by all authors up to now. An unambiguous proof of this conception would, however, be only enabled by special studying of fossils preserved in the Krumlovský les I type chert.

Fig. 59. Chert of the Krumlovský les I type can have banded structure. Jezeřany–Maršovice. Dimensions of the left sample: 6 x 4.9 cm. Photo by the author.

Another characteristic feature is the presence of fine cracks in the chert that are healed by fine crystals of rock crystal; entire cavities with rock-crystal "cellars" occur as a rarity. It is also possible to observe light coffee inclusions in the chert (Polish authors coin the term petrosilexes for them, although according to both geological dictionaries and Czech authors this term is usually used for extremely fine-grained acidic volcanic rocks). The above inclusions usually feature the 1 to 2 cm size (smaller than with the Krumlovský les 2 type to follow) and represent the most silicified chert parts as far as to the quartz stage.

Krumlovský les II type chert

From the macroscopic viewpoint it is a quality chert of the brownish grey to brown colours (10YR 6/2 pale yellowish brown to 5YR 5/2 pale brown) with a sporadic reddish tint (Supplement/Photo 66). In typical cases the siliceous substance only rarely contains sponge spicules, phantoms of partly dissolved clastic mineral grains are missing (as we know them from the Krumlovský les I variety), on the other hand larger light cloudlet-like dimming of otherwise clear siliceous substance occurs

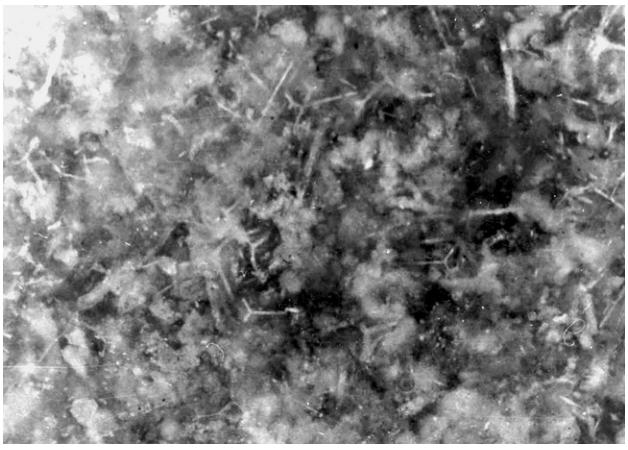

Fig. 60. Chert of the Krumlovský les I type with relics of clastic texture and numerous spicules of *Porifera*. Length of the sponge spicules varies between 1–1.5 mm. A Neolithic artefact in water immersion under the stereomicroscope. Photo by the author.

(Supplement/Photo 67). Even with this variety we are aware of hair-thin cracks, sporadically widening, than healed by fine rock crystals. Big coffee-brown or whitish-grey inclusions (petrosilexes) built of quartz can reach dimensions up to 3–5 cm and they are often bordered by a dark stripe. Origin of the Krumlovský les II type variety from the Jurassic limestones (as it has been supposed e.g. by Dvořák 1956) is evident. During M. Oliva's excavations in the Krumlovský les Highland in the test trench I-1–1 we found the Krumlovský les II type chert enclosing a typical silica geode that is known only from the Upper Jurassic deposits. No geodes have been found in the Upper Cretaceous sedimentary rocks in the whole area of the Bohemian Massif.

Krumlovský les III type chert

This variety again occurs in the form of pebbles or partially rolled fragments with black surface. Unlike the previous varieties, the colour of the siliceous substance is dark grey to black-grey – N3, N4, N5 according to the Munsell colour system (Supplement/Photos 68, 69). The variety has been defined, based on the study of the Late Aurignacian station in Alberndorf (Lower Austria) where it represented the dominating material (Přichystal 1997a) and where it was transported probably from the NE part of Brno area. Natural accumulations of such cherts are connected with the Lower Badenian or Pleistocene sandy gravels in Brno-Líšeň (upper part of the Jedovnická street), Brno-Vinohrady, the western slope or eastern part of topical plateau at the Stránská skála Hill. According to recent experience it appears only sporadically in the classic territory of occurrence, i.e. in the Krumlovský les Highland.

Thin Section: An interesting picture is provided by the chert of the Krumlovský les I type in the basic chalcedony substance of which a number of sponge spicules appear; their oval cross-sections are often highlighted by a dark organic pigment when observed with only the lower polar. With crossed polars the majority of only slightly pigmented microfossils are filled with fibrous chalcedony (Supplement/Photos 64, 65). A high content of chalcedony causes a good translucency of this variety.

Prehistoric Use: Cherts of the Krumlovský les type represent the most significant Moravian raw material for chipped artefacts in the prehistory. They are found already in the Middle Palaeolithic industries, in the area of Krumlovský les they are amply represented in the Upper Palaeolithic collections, especially of the Szeletian and Aurignacian, in the surroundings of Vedrovice, Maršovice, Kupařovice but also in the Brno vicinity (Rozdrojovice, Želešice I). Gravettian hunters from the big stations at the hillside of Pavlovské vrchy Highland or from Přerov-Předmostí have practically ignored this raw material (if it occurred, it has originated from the Dyje river gravels); during the Magdalenien its role also appears to be wholly inferior. A new interest in the cherts of the Krumlovský les has begun during the Mesolithic (Smolín, Přibice, Mikulčice), and according to the latest findings of M. Oliva (Oliva et al. 2010, 355) as early as in this period an extraction of cherts has commenced (according to the GrA-34410 dating: 9410 ± 50 BP). The importance of cherts is hugely augmented during the Neolithic: the Krumlovský les I variety has then become the dominat material at the Linear Pottery Culture settlement in Vedrovice, and Ondruš (1975–1976) has described workshops for their processing from this site. The peasants of the older period of the Moravian Painted Ware culture fancied the Krumlovský les II variety (e.g. settlement at Těšetice near Znojmo) albeit its sources are not located in the classic area among Vedrovice, Moravský Krumlov and Jezeřany-Maršovice in the Krumlovský les Upland but to the north of the Jihlava River where the settlements in the surroundings of Němčičky, Pravlov and Mělčany have been processing this raw material. A detailed description of the Krumlovský les type cherts utilization and distribution from the Neolithic through to the Lusatian Urnfield cultures may be found in the paper by Oliva, Neruda & Přichystal (1999).

An entirely special issue is constituted by a large mining field at the topical plateau and eastern slopes of Krumlovský les that has been explored by M. Oliva since 1994. To a great surprise, the majority of the hitherto excavated mining pits have been dated back mainly to the Early Bronze Age, but there has been an intense presence of people of the Lusatian Urnfield Cultures in the Late Bronze Age and of the Horákov culture in the Early Iron Age in this extraction area. The disproportion between the quantity of the extracted raw material and its utilization at the temporally corresponding settlements in Moravia is conspicuous at first sight. This has made M. Oliva reflect the social aspects of this activity (the consumption of social energy), and the interference of the inhabitants when acquiring these endowments of the earth (e.g. Oliva 2000, Oliva et al. 2010). Boulder granodiorite outcrops modified by people that are found within the extraction field are probably related to this activity as well (Supplement/Photo 58, 59).

II.2.3.11. Cretaceous spongolites of the West-Moravian origin and their secondary southward occurrences

Background: In the geological publications the first references to cherts near Březová nad Svitavou have appeared already in the work by Reusse (1854, 60). In the first half of the 20th century the Cretaceous sediments with cherts in this part of Moravia have been addressed in detail in a number of works by B. Zahálka and F. Zvejška. As the sponge spicules are present not only in cherts but also in sandstones and silty marls, the previous authors have referred to all these rocks as spongilites. However the Encyclopaedic Dictionary of the Geological Sciences (J. Petránek and Z. Kukal in J. Svoboda, ed. 1983) has rightly separated the terms spongilite (a light, sandy marlite rich in sponge spicules called opoka among stonecutters) and spongolite (a kind of silicite, which contains siliceous sponge spicules or is genetically related to them).

As a raw material of Palaeolithic artefacts in Moravia the Cretaceous spongolites have been noticed due to their

conspicuous yellowish brown (honey) colour as early as in the first quarter of the 20th century. In his descriptions of Palaeolithic tools from the Kůlna and Pekárna Caves Knies (1925, 98) informs about a "yellow chert". Valoch (1954, 6) has already termed this raw material, discovered e.g. in smaller quantities also at the Aurignacian station at Stránská skála, a "yellow Cretaceous chert".

Location: Relics of the Lower Turonian sediments with cherts crop out in the northern surroundings of Letovice (Březová nad Svitavou, Chrastavec, Brněnec, Moravská Chrastová), at Čížovka near Boskovice, Chlum, and the saddle between Skřib and Milenky Hills near Kunštát, in the eastern surroundings of Bořitov. The weathered ouf Cretaceous cherts are to be found in the vicinity of Velký a Malý Chlum Hills near Krhov (Fig. 61). The Svitava River has distributed them far to the south so that in the secondary position they plentifully appear in the Pleistocene sandy gravel terraces in the area of both Brno and its southern surroundings, and may be traced as far as below the Pavlovské vrchy Highland.

Geological Setting: From the viewpoint of regional geology this is the southernmost part of the Bohemian Cretaceous Basin called the Orlice-Žďár area. The bedded layers of spongolites are often present in denudation remnants (butte témoins) of the Lower Turonian sandstones to sandy marlites with the occurrence of the *Inoceramus labiatus* pelecypod, which are situated on the Permian sedimentary infilling of the Boskovice Furrow. Cherts also crop out in the valleys of Svitava or Křetínka Rivers, and other watercourses where the Lower Turonian sediments have been uncovered. Important sources have also been the already mentioned secondary occurrences in the Pleistocene sandy gravel terraces as the contents of Cretaceous spongolites are rather high in them. For example in the sandpit at Dolní Věstonice which is located over 60 km from the nearest primary occurrences, the honey-brown Cretaceous spongolites have been represented by as many as 7% in the 2 to 20 cm grain-size fraction.

Macroscopic Appearance: At outcrops the raw material forms layers, sometimes striped, usually patinated with white colour. The cherts are compact, very rigid, with a glassy lustre and a colour that varies from light grey to brownish. The cherts from secondary occurrences are nearly always honey-brown (their good translucency is also reminiscent of honey) to red-brown, often flat-shaped with remnants of silicified sandstone on the edges (Supplement/Photo 71).

Stereomicroscopic Appearance: Contrary to the Jurassic cherts, the brownish or yellowish siliceous matter features very good vitreous (gelatinous) translucence as a result of a high representation of chalcedony. The chalcedony matter contains conspicuous whitish, markedly elongated spicules of sponges reminiscent of shreds of white filaments, mostly single, sometimes branched (Supplement/Photo 72). There are also whitish, either sharply circumscribed or clot- to cloud-like isometric shapes present that may be interpreted as remnants of grains or fragments of fossils from the original rock. Some of them are ochre-coloured by iron compounds.

Fig. 61. Residual hills Velký (463.5 m) and Malý Chlum (488 m), relics of Cenomanian and Lower Turonian sediments in the Boskovice Furrow north of Bořitov. Natural chips of Cretaceous spongolites are scattered in their surroundings. Photo by the author.

Thin Section: Thin sections of cherts from the Čížovka rise near Boskovice and from Březová nad Svitavou have been described by Zahálka (1935), those from Kunštát and southeastern surroundings of Svojanov by Zvejška (1946, 1948). The totally prevailing mineral is chalcedony, which is present as fine-grain aggregates with small fan of chalcedony fibres scattered among them. Authigene quartz has not been ascertained; opal was only rare (Zvejška 1946). This author also reports a find of *Globigerina, Textularia* and *Nodosaria* genera of foraminiferans in a chert from the saddle between the Skřib and Milenky Hills near Kunštát. The sponge spicules are relatively few; some have dilated hollow axial canals, others are totally leached with only traces left behind. Fine grains of clastic quartz appear in cherts with a varying intensity; authigene glauconite may be rarely found, sponge spicules are often calcified and crushed.

Other Analyses: The loss on ignition assessed with a Cretaceous spongolite from the sandpit in Brno-Černovice is markedly higher (1.11–1.45%) than with the Jurassic cherts from Stránská skála (0.71– 0.92 %). Microhardness has reached relatively high values of 958–1220 VHN (Přichystal 1975). A simplified chemical analysis of a Cretaceous chert from Kunštát is in a paper by Zvejška (1946): SiO_2 = 97.40%, TiO_2 = 0.02%, Fe_2O_3 = 0.39%, loss on ignition = 1.50%. High losses on ignition may no doubt be related to the high representation of chalcedony that contains adsorbed water.

Prehistoric Use: These cherts have played an important role especially in the Palaeolithic and Mesolithic. In the Brno area Early Palaeolithic artefacts from Cretaceous spongolites have been described from soil complexes in a loess profile near Růženin dvůr (Valoch 1977); they are commonly represented within the Middle Palaeolithic industry in the Kůlna Cave, Moravian Karst. They represent the key raw materials in the vicinity of their natural occurrences, i.e. in the area of Bořitov and in the wider surroundings of Jevíčko (so called Little Haná). For example geologist and archaeologist H. Freising from the Technical University in Brno obtained just before the 2nd World War 196 kg chips of intensively patinated Cretaceous chert from the landscape part called Hradisko near Dlouhá

Loučka, about 5 km to the south of Moravská Třebová (Mackerle 1948, 5).

In the Upper Palaeolithic these cherts appear as a favourite raw material for flat retouched tools (leaf points) e.g. at a number of sites in the Prostějov and Olomouc region, surprisingly far from their geological occurrences. They were amply used also in the surroundings of Brno where they constitute an important part of the Pleistocene river gravels. Contrariwise, during the Neolithic and Eneolithic they have not belonged with the raw materials of supra-regional importance, and their chipping has practically concentrated only to the surroundings of their natural occurrences (primarily the Bořitov area).

II.2.3.12. Cretaceous spongolites of the Osoblaha (Czech Silesia) and Głubczyce (Polish Silesia) regions

Background: Skácel (1961) elaborated the Cretaceous sediments of the Osoblaha region from the geological viewpoint in the second half of the 20th century and he has also mentioned the presence of chert "nests" several times.

Location: Minor occurrences of the Cretaceous sediments were preserved on both sides of the Czech-Polish state border in the Osoblaha projection. On the Moravian side there are 9 relics to the south of Osoblaha, on a small territory among Karlov – Horní Povelice in the west and Matějovice – Hrozová in the east. In terms of area the Cretaceous sediments in the surroundings of Matějovice are the largest. The Polish part consists of two small "isles" of Cretaceous age to the north of Głubczyce (Królowe, Zawiszyce), and another two to the south of this town (Buguchwalów, Włodzienin).

Geological Setting: Skácel (1961) considers the surface Cretaceous sediments (kaolinite sandstones, non-lithified sands, sandstones with cherts, sporadically conglomerates) of the total thickness of up to 40 m as deposits of a sea bay that has reached the Osoblaha area from Opole, Poland. His temporal classification of the rocks is to the Cenomanian. However in a borehole north of Osoblaha marlites and calcareous siltstones of the Turonian and Coniacian age have been captured as well. J. Skácel has classified the mother rocks of cherts as quartzose, slightly glauconite sandstones with kaolinite rock cement. On the grounds of geological mapping he presumes that cherts are quite common in the western part of the Cretaceous rock occurrences, i.e. between Horní and Dolní Povelice, and they give out towards the east although they may be found even near Matějovice.

A surface investigation of the author has proven that spongolites have not been too widespread in the Osoblaha area. Silicified sandstones appear more often; e.g. in the sandpit opened in glacigene deposits near Bohušov (surrounded by Cretaceous relics) where a number of fragments and pebbles of weathered and limonitized Cretaceous sediments are present. The northern erratic silicites (flints) formed 90 % of the collected silicites in the sandpit when the Cretaceous spongolites occur under 10 %. Similar conclusions also follow from the silicite collections near Osoblaha and Vysoká.

Macroscopic Appearance: A documentation sample of spongolite from Dolní Povelice-Grundek deposited in the Moravian Museum of Brno is a layered chalcedony chert, grey-coloured, hyaline, forming a layer in sandstone. Spongolites from the sandpit near Bohušov have the character of brownish grey lens-shaped forms several centimetres thick, closed in whitish silicified sandstone. It is obvious from the samples of yellowish brown spongolites from the sandpits near Osoblaha and Vysoké that, prior to their integration into glacigene sediments, they laid on the surface for a long period of time during the Tertiary because a dark desert warnish has developed on them similar to that we know with the cherts of the Krumlovský les type.

Stereomicroscopic Appearance: In the hyaline translucent light grey siliceous mass there are very numerous simple spicules of sponges (monoaxons) of white colour, mostly with both ends pointed. Their length reaches up to 2 mm. More complex types of spicules (tetraxones) are present only exceptionally. On the edge of spongolite, small isometric brown speckles appear that may sometimes be deciphered as relics of decomposed glauconite. In places it is preserved in the green colour. The spongolites have a characteristic mat, finely pimpled patina as the sponge spicules have a brown colouring, apparently by limonite, on the white patinated surface.

Prehistoric Use: It has not been described yet, and could most likely be only expected in the area of natural occurrences.

Silicites of the Western Carpathians in Moravia and Czech Silesia

II.2.3.13. Jurassic cherts of the Pavlovské vrchy Highland

Background and Geological Setting: Geological literature contains only brief references on the presence of grey layers and chert nodules in the Ernstbrunn limestone, without a more exact localization. Apparently the most extensive information may be found in a paper by Pícha & Stráník (1963, 109–110), who mention chert limestone also from the highest part of the Klentnice Formation, together with oolitic and crinoidal limestones. They characterize the cherts of the superposed Ernstbrunn limestone as honey-brown nodules, and describe them from its lower part where this limestone tends to be somewhat darker. It is therefore obvious that the silicification processes are concentrated around the boundary of the Klentnice Formation and Ernstbrunn limestone; in the higher parts of limestones uncovered e.g. in the Mariánský mlýn quarry in Mikulov there are no traces of cherts at all.

Location: The author of this monograph has succeeded in finding the cherts in a cutting of a road with the red tourist mark on the southern slope of the Stolová hora Hill. Deluviofluvial stone-loamy sediments on the Ernstbrunn limestone occur there according to the geological map 1: 25 000 (Čtyroký et al. 1995).

Macroscopic Appearance: The cherts form concretions of a maximum 6–7 cm size, confined by a conspicuous whitish cortex up to 5 mm thick and containing calcite

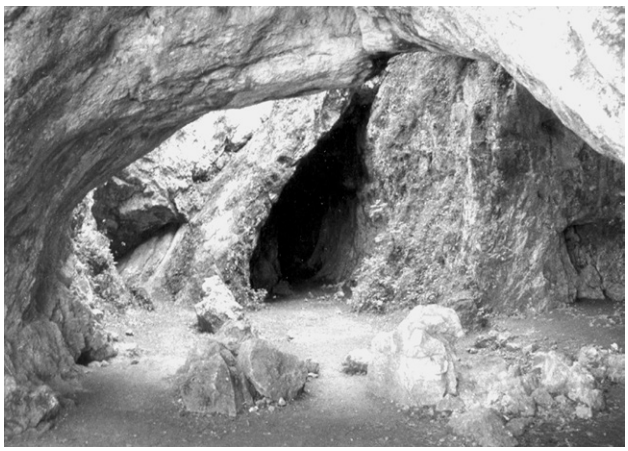

Fig. 62. Šipka cave at Štramberk, northern Moravia. Baška chert coming from the Carpathian Flysch Belt in the surroundings was chipped during the Middle Palaeolithic in the cave. Archives of the author.

(the cortex reacts with diluted HCl). The silicite mass is deeply yellowish brown coloured (10YR 2/2) and distinctly delimited against the cortex. Jointly with cherts it is possible to find silicified stems of crinoids or rostra of belemnites up to several centimetres long, shells of brachiopods without silicification were also ascertained.

Stereomicroscopic Appearance: The silicite matter is evenly tarnished by a very fine ochre pigment that causes the resulting dark brown colour. Under the stereomicroscope it is obvious that silicification reaches into the enclosing cortex. In some cases remnants of silicified corals were noticed at the cortex/silicite groundmass boundary.

Prehistoric Use: Close to the chert outcrops towards the slopes of Stolová hora Hill the author has discovered two chipped artefacts (so called segments) but both were made of imported raw materials (chert of the Krumlovský les I and erratic flint). Although with some fragments of local cherts it cannot be excluded they bear traces of chipping, hitherto a distinct artefact has not been found. So far it is unclear whether the huge collections of Gravettian chipped artefacts at Dolní Věstonice and Pavlov contain this raw material.

II.2.3.14. Cherts of Mesozoic limestones at the head of the Magura Group flysch nappes

Background: At the front of the Magura Group flysch nappes, namely the Rača Nappe, tectonic slices and fragments of Mesozoic limestones, clayey limestones or marlites crop out at more places; some of them containing concretions or chert layers. As examples it is possible to mention the occurrences near Cetechovice, Zdounky, Kurovice, Lukaveček and Vigantice.

Cetechovice (18 km SW of Kroměříž)

Chmelík (1957, 543–545) has mentioned cherts contained in the slices of Jurassic limestone near Cetechovice. He indicated them from a flooded pit quarry to the east of the village (the so-called eastern klippe) on the one hand, and from a shelf quarry to the SE of Cetechovice ("the big quarry") on the other. In the first case these are honey yellow to dark brown cherts comprising sponge spicules that are closed in a bank-shaped, off-greenish grey limestone with an ample admixture of clastic quartz. In the "big quarry" the massive greyish brown limestone contains greenish grey ellipsoidal cherts, which show numerous organic relics of mainly sponge spicules under the stereomicroscope.

Zdounky (10 km SW of Kroměříž)

The local tectonic unit is situated at the front of the Magura Group nappes in the Chřiby Mts. It was also exhaustively elaborated by Chmelík (1971). Apart from sandstones and conglomerates he also reports whitish and bluish grey marlites to clayey limestones with dark freckles, with a temporal classification to the end of Lower Cretaceous. They contain numerous sponge spicules, foraminiferans, and algae but cherts have not been ascertained.

Kurovice (8 km ESE of Kroměříž)

Upper Jurassic, whitish grey massive limestone sometimes contains elongated concretions of cherts up to 5 cm thick and 8–10 cm long. The cherts are sharply circumscribed against the limestone, they have a markedly darker colour (light olive grey, 5Y 6/1), they are not translucent even at their edges; sometimes they are intersected by younger calcite or chalcedony veinlets. Ample darker round cross-sections of 0.1–0.5 mm diameters are apparently relics of radiolarians. The quality of cherts has enabled their utilization for chipped artefacts.

Lukaveček (2 km NW of Fryšták)

Cherts are not recorded in the dark grey, prevailingly crinoidal limestone with numerous relics of other fauna.

Vigantice (4 km SE of Rožnov pod Radhoštěm)

Elongated concretions of light grey (N 7) cherts around 2 to 3 cm thick and up to 8 cm long occur in a tectonic relic formed by white-grey marly limestone. The cherts are considerably fissured and the prevailing microfossils are represented by sponge spicules.

II.2.3.15. Baška chert

Background: Přichystal (1997, 353) introduced the term Baška chert into the archaeological literature in relation to ample occurrences of this raw material among the Mousterian artefacts in the Šipka Cave at Štramberk (north Moravia). It is a simplification of the name chert of the Baška Formation. Already Maška (1886, 78) highlighted the utilization of the local "quartzite"; J. Uhrová (in Valoch 1965, 19) has designated this raw material as sandstone and compact chert from the immediate environment without a further stratigraphic qualification.

Location: Occurrences of the Baška Formation with cherts may be demarcated by a triangular territory with the apexes formed by the Libhošťská hůrka Hill in the west; in the north it is the village of Staříč near Frýdek-Místek, and Baška or Janovice in the east. The cherts crop out e.g. in the N part of the Bílá hora Hill near Štramberk, between Lichnov and Kopřivnice, to the NE of Lichnov, in the slope of the hill with the Hukvaldy fortified castle, in the fields around the height Strážnice near Staříč.

Geological Setting: The chert usually forms only 2 to 8 cm thick layers in the sandstones of the Baška Formation (the Godula development of the Silesian Unit). This is a part of the outer Krosno-Silesian (menilite) Group of the Carpathian Flysch Belt. The Baška Formation is 250 to 350 m thick and is dated to the turn of the Lower and Upper Cretaceous (the Albian to Lower Cenomanian).

Macroscopic Appearance: Conspicuous layers of bluish grey or brownish albescent chert are limited on both sides by a rough brown cortex, distinctly grained and up to several mm thick (Supplement/Photo 76). The thickness of chert beds usually varies around 5 to 8 cm. Sometimes even the chert itself features a perceptible relic clastic structure as a result of silicification of the original biodetrital calcareous sandstone.

Stereomicroscopic Appearance: In the silicite matter there are alternating laminae containing the relics of clastic texture sometimes pigmented by iron hydroxides in brown colour, and parts of prevalently bluish-grey chalcedony (usually in the central part of a chert layer). Some of light clasts represent chips of fossils rich in calcite because they react with the diluted HCl. In visible clastic laminae we may note greenish glauconites or just clots of iron hydroxides after their disintegration. Small fragments of black coal up to 1 mm size are typical (Supplement/Photo 77). Glauconite and tiny fragments of black coal are also mentioned for the surrounding sandstones (Menčík et al. 1983, 65).

Thin Section: The chert contains numerous fragments of microfossils (bioclasts) formed by calcite; they can fill up to 50 % of the rock in places. It is possible to determine sponge spicules, parts of crinoids, moss animals and molluscs among them. Rarely it is possible to find clasts of quartz, opaque organic matter (black coal) and relics of limonitized glauconite. The space among them is filled by small aggregates of chalcedony, sometimes having bigger dimensions with radial fibrous texture.

Prehistoric Use: In prehistory the Baška chert has been used in the surroundings of its natural occurrences despite the fact that these sites were usually situated in the vicinity of higher-quality silicites (flints) from glacigene sediments. Artefacts chipped from the Baška chert are known from as early as the Middle Palaeolithic in the Šipka Cave near Štramberk. During the implementation of the Czech-Polish project "The research of prehistoric hilltop settlements in the Beskydy piedmont region between the Bečva River (the Czech Republic) and Biała River (the Polish Republic)" chipped Baška cherts have been discovered at more sites, all of which were situated within the territory between Nový Jičín, Frenštát pod Radhoštěm, and Frýdek-Místek (Přichystal in Janák et al. 2004): Lichnov S of Kopřivnice, Lubina NE of Kopřivnice, Dolní Sklenov near Hukvaldy, Lysůvky W of Frýdek-Místek. The locality of Lichnov was most interesting from this point of view as 8 artefact made of the Baška chert have been discovered there, and a workshop processing this raw material could possibly be unearthed there by a detailed research.

II.2.3.16. Menilite cherts

Background: The menilite designates a dark, bituminous opal the name of which – after Ménilmontant at the suburbs of Paris, France – dates back to 1795. In 1843 E. F. Glocker has designated the rocks containing stripes and layers of such opal in the outer group of the Western Carpathian flysch nappes as menilite layers. The use of menilite opals from the Carpathian flysch for chipped artefacts has been recorded for the first time by Skutil (1934–1935) after his consultation with geologist K. Zapletal. It was namely related to the Palaeolithic station Věžky 8 km WSW of Kroměříž (central Moravia).

Location: Menilite layers stretch in a band not exceeding 1 km width from Pouzdřany in south Moravia through Velké Němčice, Křepice, Moutnice, and Nesvačilka, to the N surroundings of Otnice (18 km SE of Brno), then through Kobeřice to the S surroundings of Němčany (E of Slavkov). Further on it is possible to observe the more northern band of occasional occurrences from the NE surroundings of Bučovice to Litenčice and Hoštice; the more southern band stretches from Mouchnice to Nemotice and further on as far as Roštín.

At the NE side of Hornomoravský úval Graben the layers with menilite chert continue from Čechy and Pavlovice near Přerov towards Dolní and Horní Netčice; a great accumulation of menilites is in the rectangular territory delimited by the villages Oprostovice and Mrlínek in the west, than Opatovice near Hranice and Rouské in the east (the whole territory lies to the south of the Maleník Block). Other occurrences of menilite cherts are found in the surroundings of Špičky near Hranice, Kelč and Kladeruby. In northern Moravia they are concentrated near Ženklava south of Štramberk, among Palkovice, Baška, Frýdek-Místek, and through Bystřice they continue to the last occurrences in the Czech territory near Jablunkov.

Geological Setting: The menilite layers are a part of the outer Krosno-Silesian (menilite) Group of the Carpathian Flysch Belt. In Moravia these include the Pouzdřany, Ždánice, Sub-Silesian, and Silesian Units but in the Pouzdřany Unit we know only disintegrated diatomites in the Uherčice Formation. Thickness of the menilite layers is not too great varying from 5 to 17 m. The cherts form stripes or lenses from several mm up to tens of centimetres thick. Temporally they are classified as the Lower to Upper Oligocene (Lower Tertiary).

Macroscopic Appearance: Markedly layered cherts, often interchanging in several millimetres thick laminae with silicified light shales. The colour is usually brown to black-brown; brown-yellow or brown-red appear less often (Supplement/Photo 75). The cherts are sharply limited against the surrounding rock but there is no cortex on them. They may contain pyrite visible to the naked eye. The cherts have a characteristic waxy (greasy) lustre. Steel needle scrapes against them.

Stereomicroscopic Appearance: The cherts are non-translucent even on their edges. In the alternating laminae the deposition of clastic parts parallel with the bedding is sometimes obvious. Numerous small tectonic failures and laminae shifts alongside with them are typical.

Thin Section: The menilite cherts are usually non-fossil opals; according to Hanzlíková (1981) radiolarians, spines of radiolarians, carbonised vegetable pulp, and small fish teeth have been ascertained in some thin sections. Tiny globigerinas have been discovered at the Hůrka and Kozinec sites. A menilite chert from the Kelč Hilly land shows stripes formed by isotropic opal and stripes recrystallized into chalcedony and quartz were alternating. Moreover, in the recrystallized stripes shorter contorted schliers enriched with iron oxides and hydroxides were appearing. Accumulations of tiny opaque crystals of pyrite were quite conspicuous.

Prehistoric Use: In the territory of Moravia we are only aware of the use of menilite cherts from several Upper Palaeolithic stations in the central part. Besides the Věžky near Kroměříž station mentioned in the introduction the menilite raw material has been recorded in small quantities at three other sites, namely Křepice N of Hustopeče (Klíma 1968/69), Pavlovice near Přerov (Přichystal 1980), and Hranice-Velká Kobylanka (Neruda & Kostrhun 2002). In all these cases the sites are located near the source of the raw material. The occurrence of artefacts made of menilite chert in the Gravettian layers of the Dzeravá skála Cave near Plavecký Mikuláš, on the western foothills of the Lesser Carpathians, is therefore surprising (Kaminská, Kozłowski & Svoboda 2005, 17). Theoretically speaking, the closest possible resources for this site are located in Moravia, in the Litenčice Hilly land in approximately 80 km distance (although we are not aware of black menilites occurring there), or even the black menilite cherts in NE Slovakia/ SE Poland in a distance exceeding 300 km.

Hitherto the use of menilite cherts in more recent primeval periods has not been described.

II.2.3.17. Cherts of the Krumlovský les type and other cherts in the Vienna Basin (southern Moravia)

Background: From the viewpoint of cognition of this raw material it should be noted that Skutil (1940, 56) already mentioned the presence of cherts in the Uherské Hradiště area when he published the finds of V. Hrubý from the Sušice-Kocovy polycultural locality. Somewhat later Hrubý (1951, 48) himself has reported on the raw material in his list of Palaeolithic localities advising that he was collecting a "pebble-like flint stone material". A mineralogist Tomáš Kruťa has recorded the occurrence of cherts in gravels of the Morava river in the paper "Mineralogical investigation of Moravian Slovakia" where he has published photo of a chert with agate appearance that was obtained during dredging of gravels near Staré Město at Uherské Hradiště (Kruťa 1947, 48). In the course of a systematic field prospecting in the Uherské Hradiště area, P. Škrdla has found pebbles or rolled chert concretions with black surface that may also be designated as a variety of the Krumlovský les type cherts, based on the original definition (Škrdla & Přichystal 2003). If they are not patinated it is possible to distinguish them from the cherts of the classic occurrences in the Krumlovský les Highland. Because of special importance, one variety of the cherts with black surface from gravels in the Vienna Basin has been described separately as the chert of Boršice type.

Location: During a detailed survey of the region, the source area of these cherts was determined in the area between Spytihněv and Jalubí (to the north of Uherské Hradiště). Sporadically they are present even farther to the south, particularly in the cadastral areas of Modrá and Buchlovice. The main occurrence area was recorded in three ridges running to the southeast from the main ridge of the Chřiby Highland, in particular in the cadastral areas of Kudlovice and Traplice. The cherts occur on high, possibly Lower Pleistocene gravel terraces the relics of which are preserved in the uphill edging the southeast foot of the Chřiby Highland, prevalently in the 250 to 330 m altitude. Single chert pebbles have been found even in the 380 m altitude (Buchlovice-Chrastě). On the other hand, some pebbles may sporadically appear in wider surroundings, where the mentioned gravels were eroded or transported on the lower terrace scarps. Generally such transported cherts can be collected in a vast territory up to the state border with Austria (for example in the surroundings of Valtice or at Břeclav-Poštorná).

Chert pebbles or only rounded chert concretions are to be found also in other parts of the Vienna Basin. M. Goldmann collected partly rolled chert concretions of a good quality with diameter up to 10–15 cm in Cenozoic gravels in the wider surroundings of Kyjov and Svatobořice-Mistřín. Limestones with lenses and layers of grey cherts weathered out from conglomerates of the Ždánice-Hustopeče Formation in the area of the Babí lom (or Babylon, 418 m) NE of Strážovice (Gába 1969, 41).

Macroscopic Appearance: The cherts mostly evoke the worse variety I from the Krumlovský les Highland, usually it is possible to distinguish them using the stereomicroscope. Pebbles found on the surface of fields are usually considerably cracked, thus appearing rather unsuitable for processing. They can reach quite big dimensions, e.g. in a sandpit at Břeclav-Poštorná the author found a half of loaf-shaped chert with the diameter 26 cm and weighting 8.6 kg. The chert pebbles have a dark or black warnish on its surface and abundant traces after strikes of other pebbles during their natural transport (Supplement/Photo 70).

Stereomicroscopic Appearance: It is very difficult to describe these cherts consistently because of their big variability. Some of the best pieces resemble the variety I of cherts from the Krumlovský les Highland because they have also a bluish-grey colour of the siliceous mass with reddish parts in places and occurrence of sponge spicules. But translucence of the groundmass is not so good and there has not been ascertained any layering or banding. The cherts have prevalently a very bad translucence and contain a lot of cracks without their healing by younger silica veinlets. There are also missing cavities with small rock crystals or agates being characteristic for the chert from Krumlovský les Highland, variety I. High quality cherts corresponding to the variety II from Krumlovský les were not found.

Thin Section: There are similarities to the cherts from Krumlovský les in thin section as well, for example by plentiful presence of fibrous chalcedony clusters. Using only lower polar it is possible also to note a lot of isometric features probably of organic origin with a pale brown pigmentation. In contrary to the cherts from the Krumlovský les Highland there is important presence of clastic quartz grains, rarely of mica or feldspar as well.

Prehistoric Use: In spite of their low quality, these cherts were undoubtedly used in the Upper Palaeolithic and especially at some Aurignacian sites around the Morava River in southern Moravia (Boršice near Buchlovice in the Uherské Hradiště area, Kvasice in the Kroměříž area) they represent an important or even prevalent raw material.

II.2.3.18. Chert of the Boršice type in the Vienna Basin

Background: The raw material was described for first time from the Upper Palaeolithic station at Boršice near Buchlovice and according to the locality it has received a preliminary designation as the Boršice type chert (Škrdla & Přichystal 2003).

Location: The Palaeolithic site Boršice near Buchlovice is situated about 2.5 km NW of the village on a rise to the south of the storage reservoir Dlouhá řeka (Smraďavka) at the SE edge of the Chřiby Highland. Archaeological finds are collected on a plateau with the high spot 331 m, around the boundary between cadastral areas of Boršice and Buchlovice.

Geological Setting: With respect to the preserved relics of the pebble surface these cherts undoubtedly originate from gravels; however they have not been recorded in the known surveyed local terrace scarps so far. Thus the source area of this raw material is uncertain, although we do not suppose transportation from greater distances and are inclined to an unknown source within wider surroundings of the locality. It may be hidden under younger deposits of loess. In relation to the identification of the source area an important fact seems to be that the highest percentage of this raw material has been recorded at the Palaeolithic site Traplice-Kopaniny, not very rich in finds; at other Palaeolithic localities, except for the Boršice-Buchlovice site, this raw material was represented only by individual artefacts. In another locality in the Traplice cadastral area, particularly at the Palaeolithic site Traplice-Bukáčová, even pebbles of this raw material have been found, featuring no signs of working, which supports the assumption that the source area of these cherts could have been situated somewhere near.

Macroscopic Appearance: Macroscopically the above raw material evokes cherts from Olomučany in the Moravian Karst, although it does not contain glauconite and features a markedly semolina-like structure, which is still underlined by patination (Supplement/Photo 80). In the siliceous substance there are inclusions consisting of a brown material. In some cases there is a black cortex occurring on the preserved relics of the original surface, which corresponds with the Krumlovský les type cherts; in other cases a thin brown warnish appears.

Stereomicroscopic Appearance: The siliceous mass is well translucent and contains a lot of white or ochre (rarely even black) inclusions. The ochre inclusions are the most important because they are rhombohedrally limited, it means they represent newly formed crystals of a carbonate that has been confirmed by the study of thin section. Thin veinlets with agate texture are also interesting. As is microfossils concerned, the simple sponge spicules are present relatively frequently.

Thin Section: Using investigation of thin section it would be possible to distinguish the Boršice type chert in comparison with the Olomučany chert because there is missing an intensive dark pigmentation and bigger aggregates of fibrous chalcedony, the both being typical for the Olomučany chert. The thin section of the Boršice type chert has shown an epigranular cryptocrystalline siliceous mass almost without bigger fibres of chalcedony. A presence of carbonate (dolomite?) both filling relics of microfossils and forming numerous newly formed rhombohedral crystals (metacrystals) is absolutely specific.

Prehistoric Use: The Boršice type chert was processed especially at Aurignacian sites above the Morava river in southern Moravia; its knowledge can be supposed as well as in younger prehistory but only in the wider surroundings of the natural source.

II.2.3.19. Révaite (opalized silty claystone to chert)

Background: As an attractive raw material for jewellery the révaite has been firstly ascertained in a secondary deposition in a sandpit near Ostrožská Nová Ves by the student Révay, according to whose surname the stone has been given its trade name. It has gradually become the focus of attention of both geologists seeking non-traditional jewellery stones and a number of amateur collectors. In the few recent years it has started to be indicated among the raw materials of chipped artefacts; apparently the first to highlight révaite were Vokáč & Vokáč (2001) within the Palaeolithic localities of the Kroměříž region.

Location: Révaites are primarily known from the vast surface sandpit at Ostrožská Nová Ves (8 km south of Uherské Hradiště, southern Moravia). The sandpit also stretches to the cadastral areas of Chylice and Uherský Ostroh villages. The absolute altitude of the site varies between 173 and 176 m. Vokáč & Vokáč (2001) have described finds of natural révaite pebbles from the SW outskirts of Kroměříž. According to information by M. Goldmann (a technical worker of the Department of Geological Sciences at Masaryk University) révaites have been discovered also in the Hulín sandpit, it is along the Morava River more to the north.

Geological Setting: Mátl (2000) has tried to elucidate their origin. He has issued from the then knowledge that in the Hulín sandpit, more northern against the current of the Morava, the révaites were not found, contrariwise more to the south downstream of the Morava in the Moravská Nová Ves sandpit they have occurred. Therefore he assumed that they originated from the area between Ostrožská Nová Ves and Hulín, and has prospected for their origin in the Hluk Formation of Cretaceous age,

which is 7 to 10 km east of Ostrožská Nová Ves. This formation is a part of a homonymic development of the White Carpathian Unit of the Magura Group of nappes. The highest part of the Hluk Formation is supposed to be formed by marly limestones rarely containing chert concretions (Roth & Hanzlíková in Maheľ & Buday et al. 1968, 428). However according to an oral report by O. Krejčí (Czech Geological Survey, Branch Brno), during a new, reviewing survey cherts were not found in the Hluk Formation. Likewise, new discoveries of révaites from off Kroměříž and from the sandpit in Hulín are contradictory to this assumption. The resource of révaites in some of the units of the Krosno-Silesian (menilite) Group of the Carpathian Flysch Belt seems to be most probable.

Fluvial sandy gravel accumulations with révaites at Ostrožská Nová Ves reach up to 13.5 m thickness and are of the Pleistocene age; Tertiary sediments of the Vienna Basin form their bedrock while the Holocene flood loams are in their superposition.

Macroscopic Appearance: Révaites form half-rounded shapes of a prevailing size up to 6 to 8 cm, sometimes indicating their original bedding. Mátl (2000) describes pieces with the longest axes up to 12–18 cm. The surface of révaites is smooth, with characteristic bowl-shaped break-offs to depressions, and an unctuous lustre of the surface. As for colour they may be rather variable on a fresh fracture: tawny hues (medium yellow-brown 10YR 5/4 – dark yellow-orange 10YR 6/6) are most common, although dark grey, less often red to yellow-red (even reminiscent of radiolarites), exceptionally blue and green are known as well, with the surface of fragments always somewhat darker than the colour inside. Single-coloured types prevail but bi- and tricoloured are known as well. Light pastel shades make a very pleasant impression. Collectors value révaites with a zonal structure; this usually copies the outer form of half-rounded shapes. The raw material is compact, capable of perfect polishing that causes a glassy lustre; it does not crack even upon processing.

Stereomicroscopic Appearance: Révaites are not translucent even on the edges, they have a rare presence of thin veinlets. The silicite matter is homogenously tarnished by a fine-grain dust substance, there might be streaks with a mildly more coarse-grain admixture. Tiny limonite spots are also noticeable; relics of microfossils have not been discriminated. Steel needle leaves metallic traces.

Thin Section: Parts variously impregnated with iron oxides and hydroxides alternate in the rock. In the polarising microscope the groundmass of the rock shows an almost isotropic picture; only with great magnifications (200x and more) cryptocrystalline SiO_2 may be discriminated in less impregnated parts. A dust-like admixture comprising mainly flakes of mica (up to 0.1 mm long) with fewer sharp-edged grains of quartz is quite conspicuous. The presence of tiny circular shapes filled, according to the fibrous extinction by chalcedony that apparently represent relics of probably diatoms, is quite rare. The rock may be tentatively designated as silicified (opalized) silty claystone to chert impregnated by iron compounds (Supplement/Photo 230–231).

Other analyses: Chemical analyses of two specimens from Ostrožská Nová Ves (carried out by P. Kadlec, Institute of Geological Sciences, Masaryk University in Brno) showed: SiO_2 – 88.18 and 88.16 %; TiO_2 – 0.11 and 0.13 %; Al_2O_3 – 3.08 and 3.42 %; Fe_2O_3 – 3.40 and 3.73 %; FeO – 0.80 and 0.44 %; MnO – 0.03 and 0.04 %; CaO – 0.51 and 0.56 %; MgO – 0.34 and 0.20 %; K_2O – 0.30 and 0.35 %; Na_2O – 0.13 and 0.15 %; P_2O_5 – 0.04 and 0.09 %; CO_2 – traces; S – 0.00; Li_2O – 314 and 235 ppm; total – 99.59 and 100.10 %. The chemical composition is partly similar to the so called Ondava brown chert from eastern Slovakia (see below the chapter Silicites of Slovakia).

Prehistoric Use: Révaite is a high quality raw material, and the chipped artefacts made of it are most probably likely to occur at the Palaeolithic stations in the wider surroundings of Uherské Hradiště or within the Napajedla Hilly land area. It may be assumed that in older papers the révaites were designated as cherts without a more precise classification. As a raw material, révaite has been ascertained by Vokáč & Vokáč (2001, 160) at the Palaeolithic stations Kvasice and Karolín in the Kroměříž region, or Přestavlky near Přerov; according to information by M. Hložek it is rarely present at the Palaeolithic sites in the surroundings of Čejč. A discovery of a scraper made of révaite has been described from an Aurignacian station Boršice near Buchlovice (Škrdla & Přichystal 2003, 183).

II.2.3.20. Chert of the Troubky-Zdislavice type (the Carpathian Foredeep)

Background: An occasional occurrence of a bedded silicite with a rough brown cortex and a semolina-like tarnished white patina has gradually been noticed on a number of Palaeolithic stations in the Brno and Prostějov regions in the latter half of the 20th century, although the provenance of this raw material was unknown. Its dominant position has been ascertained by Valoch (1986) at the sites in the surroundings of Troubky-Zdislavice village (the Kroměříž district), which are situated directly at the raw material source. This author has originally assumed them to be menilite cherts but according to geological maps these emerge about 5 km further to the south. Study under the stereomicroscope has shown different properties from the menilite cherts, and the resource of cherts has been confirmed directly at the Palaeolithic stations in Miocene gravels. For this reason the raw material has been designated as chert of the Troubky-Zdislavice type (Svoboda & Přichystal 1987, Přichystal 1994).

Location: The Troubky-Zdislavice village is situated 12 km SW of Kroměříž, in the eastern part of the Litenčice Hilly land. Elevation above sea level of the Palaeolithic stations varies between 380–400 m.

Geological Setting: The Palaeolithic stations are situated to the north of the margin of the Ždánice nappe Unit in the area of Miocene sediments of the Carpathian Foredeep. The cherts are a part of coarse-grained gravels with only mildly rounded fragments of both limestones and cherts. Their position in front of the Ždánice Unit and

the occurrence of rocks from the Carpathian system ranks them among the Kroměříž Formation of the Karpatian age (Benada & Kokolusová 1987). On the grounds of pebble analyses these clastics contain 11 to 22.5 % of dark cherts.

Macroscopic Appearance: The raw material occurs as sharp angular or only slightly rounded fragments of bedded cherts the thickness of which varies between 1 and 6 cm. They are limited by a rough brown cortex from a few mm up to 1 cm thick, in some cases even with relics of limestone matter on the cortex. The siliceous matter has a dull lustre, and its colour is usually close to light yellowish brown (10YR 6/2). The chert patina is neither glossy nor continuously white, but also dull and covered with fine brown dots (Supplement/Photo 78).

Stereomicroscopic Appearance: The well translucent silicite matter contains a great number of small isometric enclosures of 0.1 to 0.2 mm size (sometimes it is overfilled with them). Bigger, light cloud-like shapes of several mm diameters appear by the side of the enclosures. Microfossils are few and represented by tiny sponge spicules, sometimes highlighted by brown iron hydroxides (Supplement/Photo 79).

Thin Section: Small "islands" of fan-shaped aggregates of fibrous chalcedony are spread in the cryptocrystalline siliceous groundmass; there are present also clasts of quartz (about 0.1–0.2 mm), sometimes with the intensive undulous extinction. Rarely also clasts of chloritized biotite can be found. Clusters of micrite carbonate with diameter up to 0.2–0.3 mm are common and within them it is possible to recognize organic relics – circular cross sections of sponge spicules even with the central pore canal or parts of crinoidal segments in addition marked with opaque pigmentation.

Prehistoric Use: The Palaeolithic stations in the surroundings of the Troubky-Zdislavice village are mostly placed to Aurignacian with a marked presence of Szeletian elements (Valoch 1986, Svoboda et al. 2002). The use of the Troubky-Zdislavice type chert is known from a number of other Aurignacian sites in the Brno, Kroměříž, and Prostějov regions; so far its presence in the Post-Palaeolithic industries has not been ascertained.

II.2.3.21. Jurassic radiolarites in Moravia

Background: Radiolarites at the Moravian prehistoric sites are usually (and essentially rightly) considered as imports from the Carpathian Klippen Belt at the Slovakian side of the White Carpathians Mts., from the surroundings of the Vršatské Podhradie village 8 km NE of the Vlára Pass (for more details see the chapter Silicites of Slovakia). However other resources in the Carpathian Klippen Belt (Podbranč 8 km SE of Skalice, Brodno in the Kysuca Gateway N of Žilina) or the site with a proven Neolithic extraction of radiolarite in Wien-Mauer cannot be totally excluded either. Nevertheless, it has transpired recently that small natural occurrences of Jurassic radiolarites exist also in the two areas in Moravia: a) in the Filipovské valley 5 km south of Velká nad Veličkou near the border with Slovakia; b) in more places of the Carpathian Foredeep in the form of pebbles in gravels.

Location: The Filipovské valley stretches on the Moravian side of the White Carpathians Mts., ca 5 km south of Velká nad Veličkou, 20 km SE of Uherský Brod. The valley traces the Hrubý Brook, and its southern end is in the mere 2 km distance from the border with Slovakia. The local occurrence of radiolarites has been highlighted to the author of this monograph by archaeologist M. Polák.

According to current knowledge pebbles of radiolarites may, from time to time, apparently occur in the entire southern part of the Carpathian Foredeep, from the border with Austria to the Hornomoravský úval Graben. The biggest concentration is found in the south, in the surroundings of Mušov, Dolní Dunajovice, on the road from Brod nad Dyjí, where the representation of radiolarites may be estimated up to 2–3 %. Scarce pebbles may probably be obtained in the entire area of the southern and central part of the Carpathian Foredeep, as proven by occasional finds in the Brno area (Brno-Líšeň), or as far as Stará Ves near Přerov.

Geological Setting: In the Carpathian Foredeep pebbles of radiolarites occur in the Lower Badenian gravels. The most probable explanation of their presence may be related to the Miocene predecessor of the Danube, which has then flown into the sea filling the Carpathian Foredeep, bringing a rugged material from the Alps. In northern Moravia and Silesia the origin of radiolarites appears as probable from the flysch layers, where radiolarites are sometimes mentioned in the Silesian nappe Unit ("radiolarian layers") or in the Magura Group of nappes (in the frame of "margle łąckie" = Łącko marls) in the Polish territory (Unrug et al. 1969, 115, 149).

Macroscopic Appearance: Radiolarites from the Filipovské valley feature a typical red-brown colour; they are closed within bigger limestone blocks and disturbed by numerous cracks that are healed by younger veinlets of calcite.

The size of radiolarite pebbles in the Lower Badenian sandy gravels of the Carpathian Foredeep is usually up to

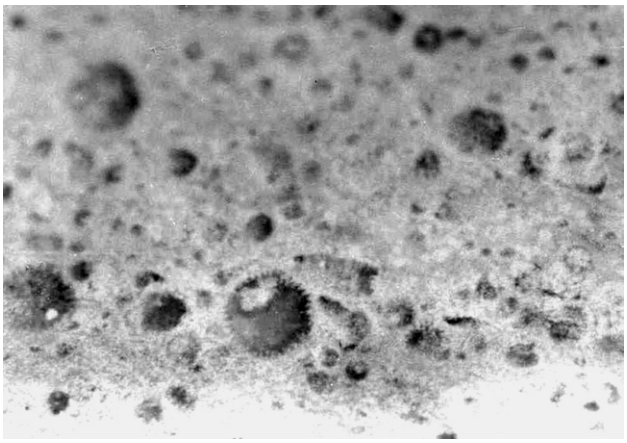

Fig. 63. Radiolarians with preserved sculpted tests in yellowish radiolarite from the Palaeolithic site of Albendorf in Lower Austria. Length of the picture is 2.5 mm. Appearance of artefact in water immersion under the stereomicroscope. Photo by the author.

5–6 cm, and they are also red-brown or greenish coloured. Similarly to radiolarites from the Pleistocene gravels of the Danube they are generally markedly tectonically disturbed, so that their utilization as a raw material for chipped artefacts has been greatly limited.

Stereomicroscopic Appearance: Upon a routine stereomicroscopic examination no distinctions from radiolarites of the Carpathian Klippen Belt in Slovakia have been observed excluding numerous hair-like thin cracks healed by calcite.

Prehistoric Use: Artefacts made of radiolarites with relics of pebble surface have been found at many Upper Palaeolithic sites in Moravia and Lower Austria (Fig.63), so it is probable a part of them has origin in the Miocene gravels of the Carpathian Foredeep.

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II.2.4. Silicites of Lower and Upper Austria

From the geological point of view, the prevalent part of Lower and Upper Austria consists of crystalline complexes composed from metamorphic and igneous rocks of the Bohemian Massif. It is represented by geological units called the Moldanubicum and Moravicum. In such strongly metamorphosed rocks no occurrences of sedimentary cherts can be found. In addition to it, the Austrian part of the Bohemian Massif lacks the Mesozoic platform cover, which is the source of the most significant silicites in the whole Central Europe including the Czech Republic. Palaeozoic limestones with cherts of lesser quality known from the Barrandian area are not evidenced there either; thus we may rightly state no primary sources of silicites may occur in the Austrian part of the Bohemian Massif, i. e. from the border with the Czech Republic up to the Danube. However silicites do occur in the geological units of the Eastern Alps (see for instance paper of Sauer 1999); as resistant rocks they have been partly transported, and have been occurring in gravel fluvial deposits of the Danube and its predecessors.

II.2.4.1. Radiolarites from Wien-Mauer

Background: Local limestone at the locality had been quarried at least since 1880; the first finds from the prehistoric times were introduced in 1924. J. Bayer, the director of Prehistoric department at the Natural History Museum in Wien, did archaeological excavation of prehistoric mines for radiolarites in 1929–1930. Further investigations had been carried out in 1938 and 1949. Ruttkay (1999, 405) described the locality for the Bochum catalogue of prehistoric mines in Europe. The last evaluation of the Neolithic mining in Wien-Mauer can be found in a paper of Trnka (2011).

Location: This most important Lower Austrian raw material for chipped artefacts has its source in Wien-Mauer (SW part of the city, 23rd district, Liesing), on a slight uphill bearing the name Antonshöhe (356 m). From the geomorphological point of view, this is the edge of the Wienerwald (a part of the Eastern Alps).

Geological Setting: As for geology, this is a Jurassic limestone klippe of the Penninicum, which is located on an edge of the Alpine Flysch Belt (Fuchs & Grill 1984), explicitly it is a part of the klippen belt called the Ober-St. Veit Klippen Belt.

Macroscopic Appearance: In comparison with radiolarites from another important mining locality in the surroundings of Vršatské Podhradie in Slovakia (Pieniny Klippen Belt) the radiolarites from Wien-Mauer have usually dull lustre (Supplement/Photo 82). Their colour shade seems to be also partly different: the greyish red (5R 4/2) prevails for the radiolarites from Wien-Mauer while for the radiolarites from the Chmeľová Hill at Vršatské Podhradie it is rather the dark reddish brown (10R 3/4). The radiolarites from Wien-Mauer make an impression to be more uniform as is their colour concerned; green or greyish-blue are rare. For comparison, in the surroundings of Vršatské Podhradie there are often two coloured varieties (dark reddish brown with green stripes) but it is possible to find also bluish-grey, wholly green or yellowish-brown. Generally it can be stated a part of the raw material spectrum from the Vršatské Podhradie area seems to be of better quality because of higher lustre and a lesser presence of tectonic cracks.

Stereomicroscopic Appearance: The siliceous mass is not translucent and a lot of circular relics after radiolarians of various diameters are present. The biggest of them can reach up to 0.2–0.5 mm (Supplement/Photo 83). They can contain both translucent chalcedony (usually lesser radiolarians) or whitish groundmass (bigger relics). On a fresh fracture the whitish relics react with diluted HCl, so they are filled by calcite. The artefacts lying for a long time at the surface have the calcite filling weathered out and one can find only small cavities with a secondary filling of limonite or clay minerals.

Thin Section: The radiolarite contains many cross sections of radiolarians filled by coarse-grained or fibrous chalcedony, in their central part a rhombohedral crystal of calcite can appear. Other cross sections of radiolarians, usually bigger, are fully formed by calcite and they have well preserved sculpted tests of the Spumellarian type, at some of them the projected thorns are visible. Foraminiferans and crinoidal parts, again with preserved calcite, represent other microfossils. The groundmass is

formed by a mixture of fine-grained chalcedony and calcite (Supplement/Photo 84, 85).

Other Analyses: Brandl et al. (in press) tried to distinguish radiolarite localities in Wien-Mauer and Wien-Gemeindeberg from the most important Slovakian (Carpathian) resources around Vršatské Podhradie. They have used LA-ICP-MS geochemical analyses for determination of trace elements Ba, Mg and to certain degree Sr, Rb and V. The authors showed possibility to determine the mentioned radiolarites in concentration plots Ba versus Mg, Ba versus Sr, and probably also others.

Prehistoric Use: The prehistoric mines were found in the area of about 0.5 ha as four narrow shafts with depths of 2–8 m and width of about 1–2 m. For example the shaft No III started with a funnel pithead and a 6 m long horizontal gallery had been run in the depth of about 8 m. All shafts were fully filled after their abandonment with extracted limestone with radiolarites. From archaeological finds there are important mining tools (used deer antlers, parts of hammer axes), bones of both wild and domestic animals and in the area of mines there were found 7 buried individuals (three women, two men and two children). Some graves were situated just at the bottom of a mine or within its filling. Based on the found pottery the mines are dated to the younger stage of the culture with Moravian Painted Ware (Ruttkay 1999). Thinschmidt and Trnka (2000) studied polished tools and percussion implements from the viewpoint of raw materials. According to the authors, the raw material spectrum is rather diverse: amphibolite, profyroide, diabase, diorite, serpentinite. They suppose for some of the rocks (diabase) a long distance transport from the Prague Basin of the Barrandian that seems to be rather surprising because there is no evidence on a wider prehistoric use of the Barrandian diabases till now.

II.2.4.2. Radiolarites and cherts from gravels of the Danube and its predecessors

General Overview: The Pleistocene gravel terraces of the Danube contain, apart from the prevailing quartz pebbles, also pebbles of the Alpine Mesozoic radiolarites and cherts (up to 1 %). In the gravels of the Thaya and the Morava Rivers the contents of silicites (in particular of cherts) are higher and reach up to 4.4 % (Minaříková & Havlíček 1990, 160). The radiolarites have besides typical reddish-brown and greyish-green colours very often yellowish hues. They are usually afflicted with a net of cracks filled by thin calcite veinlets, so as raw materials for chipped artefacts they were not very good (Supplement/Photo 124).

In the Alpine – Carpathian Foredeep it is possible to find also older fluvial gravels being deposited by a huge river (a predecessor of the Danube) that ran across the foredeep and the NW part of the Vienna Basin in the length of 86 km and emptied into a large brackish lake (see e. g. Nehyba & Roetzel 2004). The most extended gravels are a part of the Hollabrunn-Mistelbach Formation of Pannonian age. Quartz prevails in their pebble composition but chert pebbles are more or less present also at some localities (Supplement/Photo 87). The pebble size decreases from the west to the east. However from the viewpoint of suitability for chipping the pebbles are small, usually up to 3.5 cm in diameter (Batík 2000, 33). According to this author the cherts originate from the Jurassic deposits. They are considerably variable in colour (grey, black, with red spots), intensively cracked and having porous structure. Based on the study under the stereomicroscope, a part of them can be described as radiolarites.

Prehistoric Use: Chipping of radiolarites from the Danube gravels is mentioned for the Palaeolithic site at Willendorf (Leitmeier 1934). A preliminary study of chipped artefacts from the locality deposited at the Institut für Ur- und Frühgeschichte, Universität Wien, carried out by the author, showed the radiolarites as important raw material in this part of the Willendorf assemblage, some of them as pebbles or with relics of pebble surface on the artefacts. Erratic silicites from glacial sediments are also present. They had to be transported from the area of continental glaciations in northern Moravia and Silesia at a distance of about 250 km at least.

II.2.4.3. Menilite cherts of the Zellerndorf Formation (the Carpathian Foredeep)

Location: The most well-known occurrence of the cherts is a mining pit for diatomites 300 m NE of the castle in Limberg, some 4 km NE of Maissau or 8 km SE of Eggenburg in Lower Austria. The finding place is situated in the 1: 50 000 map sheet 22 Hollabrunn.

Geological Setting: The menilite cherts crop out within the Limberg Beds forming a part of the Zellerndorf Formation (Upper Eggenburgian – Ottnangian). The formation represents marine deposits of the Carpathian Foredeep. The beds with cherts can reach a thickness up 8 m (Roetzel, Řeháková & Rupp 1991).

Macroscopic Appearance: The chert is evidently layered with a thickness up to a few cm and forming elongated lenses. It has a typical wax lustre and light olive grey hue (5Y 6/1). The steel needle forms a metal trace on it. Its marginal parts have a whitish hue because of weathering (Supplement/Photo 86).

Stereomicroscopic Appearance: The alternation of various coloured (grey/olive grey/yellowish-grey) thin beds up to 1 mm is a typical sign of the chert groundmass. The beds are usually waved or they can cross themselves in a small angle. It is also possible to find black inclusions to small lenses of organic matter (parts of plants?) deposited in conformity with bedding and small whitish circular formations (up to 0.1 mm), probably relics after diatoms. Their palaeontological classification is introduced in a paper by Roetzel, Řeháková & Rupp (1991), in addition they have mentioned occurrence of small fish teeth and plant relics.

Prehistoric Use: Till the present time it has not been registered.

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II.2.5. Silicites of Thuringia, Saxony and Bavaria (Germany)

To a certain degree, Thuringia and Saxony have a similar raw material basis for chipped artefacts because their large parts were covered by a continental ice sheet in the Pleistocene. That is why the erratic silicites from glacial deposits (Fig. 42) became the key raw materials and they have been found as small specialized tools already at the Lower Palaeolithic site of Bilzingsleben (district of Sömmerda, Thuringia), they were chipped plentifully also in the Upper Palaeolithic and in the Neolithic. In Thuringia in addition to them there were used the Silurian silicified shales (Kieselschiefern) and Triassic cherts. Jurassic cherts from small occurrences at the Lusatian overthrust could be theoretically chipped in Saxony.

A different situation has been ascertained in the territory of Bavaria where vast sources of Jurassic limestones with cherts of the first-quality are to be found in the Frankische Alb Hilly land and in a few small Jurassic relics to the west of Passau (so called the Ortenburg Jurassic). Besides these important Jurassic sources there were chipped also the Triassic chert in Bavaria. A comprehensive study of siliceous raw materials in Bavaria can be found in a contribution of Böhner (2011).

II.2.5.1. Palaeozoic (prevalently Silurian) silicified shale (Kieselschiefern)

General Overview: According to the German authors, the term comprises various silicified shales that have the origin in the Thüringischen Schiefergebirge Mts. Artefacts made of the Palaeozoic silicified shales have very often preserved relics of the pebble surface (e.g. some of the Magdalenian artefacts in Teufelsbrücke), so it is evident as tough rocks they have appeared in the Pleistocene river gravels and than they were collected there by prehistoric man. Höck (2007, 57) has published these layered silicified shales can be of the Silurian, Devonian or Lower Carboniferous age. They are dark, grey brown, brown black to black hard rocks, it was described also a red variety. Data on their petrographic composition (that can be very variable) have been published by Kühn & Feustel (1980, 22) from a collection of Magdalenian artefacts in the Kniegrotte Cave near Döbritz (Saale-Orla district, Thuringia): cryptocrystalline quartz intensively coloured by clayish-coal or clayish-iron matter forms 85–95 %, small lenses of chalcedony are present as well. Detrital material (clasts of quartz, feldspars and muscovite with dimensions up to 0.03 mm) varies between 5–15 %. Relics of radiolarians are visible in some specimens.

Pfeiffer et al. (1985, 311) have introduced an average chemical analysis of ten Silurian silicified shales from Saxony and Thuringia: 92.3 % SiO_2; 0.1 % TiO_2; 1.4 % Al_2O_3; 1.6 % Fe_2O_3; – % FeO; – % MnO; 0.6 % MgO; 0.6 % CaO; 0.1 % Na_2O; 0.3 % K_2O; 0.3 % H_2O^+; 0.3 % H_2O^-; 2.1 % C, organic substance; – % S, SO_2; – % P_2O_5; 2.6 % loss of ignition; 100.2 % total sum.

Prehistoric Use: Chipping of the Palaeozoic silicified shales has been described especially at the Upper Palaeolithic sites in spite of close sources of erratic silicites; but the presence is very low, of course. In the assemblage of Magdalenian artefacts from the Kniegrotte Cave containing 13 881 items there were found only 53 pieces made of the Palaeozoic silicified shales, i.e. 0.4 % (Höck 2000, 55) when the raw material pebbles could be collected in close vicinity of the locality.

II.2.5.2. Triassic cherts (Karneol, Muschelkalkhornstein, Keuperhornstein)

General Overview: Occurrences of cherts of various quality and quantity are known from all parts of

the Triassic sedimentary rocks in northern Bavaria and Thuringia. A dusky red-brown non-translucent chert forming concretions and called among German collectors as "Karneol" (carnelian) comes from so called Buntsandstein (Bunter Sandstone Formation, Lower Triassic). Its correct stratigraphic position can be found for example in a paper of Weber (1955, 100): upper part of the Middle Buntsandstein. As is the Magdalenian settlement in the Kniegrotte Cave concerned, natural sources of the Triassic "Karneol" are supposed e.g. in the vicinity of Rudolstadt (Höck 2000, 58). Löhr & Schönweiß (1987) published a detail description of the Keuper chert including its geological occurrences and prehistoric use.

Another chert has been introduced from the Middle Triassic Muschelkalk in which it occurs especially in the Trochitenkalk (limestone built from parts of crinoid *Encrinus liliiformis*). The cherts have a medium to dark grey colour; they can be also greyish-brown, yellowish-grey and non-translucent, with greasy or dull lustre. The samples the author has to his disposal have evident laminae in mm thickness. Cryptocrystalline varieties of silica are the main building components, carbonates can be preserved in places. The cherts crop out in the southern part of the Thüringe Basin in the area of Saalfeld, Remda, Stadtilm or Bad Sulza. Various types of chert have been described also from the Upper Triassic (Keuper) deposits, e.g. light grey chalcedony chert having sources in the surroundings of Bayeruth and Kulmbach (northern Bavaria).

Prehistoric Use: The raw material was prevalently only of local importance and it was chipped in the surroundings of its natural occurrences. These cherts in the Kniegrotte Cave assemblage form only 0.5 % even when their natural sources lie relatively close to the locality, about 20 km to the west. Totally prevailing erratic flints were imported from the north where sources of the worse quality are in deposits of the Elster glaciation about 30 km far, or from younger Saale moraines at a distance of about 80–100 km (Höck 2000, 59). The cherts of Upper Triassic (Keuper) age are to be found periodically at sites of the Atzenhofer group of the Late Palaeolithic in Oberpfalz, northern Bavaria (Schönweiss 1992).

II.2.5.3. Cherts of the Jurassic limestones at the Lusatian overthrust in Saxony

General Overview: Similarly as in Bohemia, small tectonic lenses of Jurassic limestones crop out at the Lusatian overthrust also in Saxony. Pietzsch (1962, 358) has introduced from the border with the Czech Republic to the northern surroundings of Pirna these localities: Weissbachtal just at the state border, old quarries at Hinterhermsdorf in Heidelbachtal, after roughly 5 km there is another occurrence at Saupsdorf which is followed by an uncertain locality at Lichtenhainer-Mühle. The next Jurassic limestone appears after more than 10 km to the NW at Hohnstein and finally the westernmost again uncertain finding place lies at Dittersbach (8 km to the north of Pirna). According to old published data there should be silicified layers to cherts in the Jurassic limestones (analogically to the occurrences in Bohemia), unfortunately because of almost total destruction of limestones by former quarrying the author could not verify it.

Prehistoric Use: Till the present time the raw material has not been described in the frame of studied prehistoric chipped artefacts in Saxony but it can be hidden among undetermined raw materials. On the other hand it is a question if the Jurassic cherts could be used at all for their tectonic striking and small occurrences.

II.2.5.4. Jurassic cherts of the Fränkische Alb Hilly land to the west of Regensburg (the region between Donau and Altmühl)

Background: As is the geological viewpoint concerned, the first reports on the cherts in the limestones of Frankish Alb appeared in the second half of the 19th century. Deecke (1933) has registered them as a raw material for prehistoric chipped tools in his overview of Central European raw materials. Excavation of prehistoric mines at Lengfeld in the Kelheim District brought a modern evaluation of local Jurassic cherts (Reisch 1974). During the last quarter of the 20th century and in the beginning of the third millennium new discoveries and detailed characteristics of the mining centres at other localities (Arnhofen, Baiersdorf) increased and comprehensive papers were published on extensive distribution of the tabular cherts (Plattensilex) in Central Europe (Davis 1975, Engelhardt 1985, Binsteiner 2005).

Location: Fränkische Alb, Frankenalb (Franconian Alb) is a vast limestone hilly land to the north of the Danube elongated in the west – east direction between the Ries impact crater (in the west) and Regensburg (in the east). At Regensburg it changes its continuation towards NW up to Coburg in northern Bavaria (Oberfranken). Many chert sources have been described from this area. In the last comprehensive paper of Binsteiner (2005) he distinguished in the W – E part of the Fränkische Alb (i.e. between the Danube and Altmühl River) four source fields: in the surroundings of Eichstätt (the Eichstätt source field) with prehistoric mines at Schernfeld, in the surroundings of Painten (the Painten source field) with mining at Baiersdorf in the valley of Altmühl, the Kelheim source field with exploitation of cherts at Lengfeld and finally the Arnhofen source field with prehistoric mines at Arnhofen near Abensberg.

Geological Setting: The concretional and tabular cherts crop out in limestones of the Upper Jurassic (the Malm), from the viewpoint of detailed stratigraphy the rocks have the Upper Kimmeridgian and Lower Tithonian age. A close evaluation of facial development during the Malm north of the Alps (i.e. in the area of Bavaria) can be found in explanations to the geological map of Bavaria 1: 500 000 (Meyer 1981). The cherts appear firstly in the rocks of the Malm Epsilon 2 in so called Setuzone (according to leading ammonite *Virgatosphinctes setatus* SCHNEID). The superposed Geisental beds with a chert horizon "Dachhornstein" have the age of Malm Zeta 1. The third important position of platy cherts lies in the Mörnsheimer beds (the Malm Zeta 3). Geological description of the

above mentioned source fields can be found again in the comprehensive paper of Binsteiner (2005).

Macroscopical Appearance: There are more types of chert in such large area, some of them have characteristic signs and they were regularly used at many archaeological finding sites, so we can call them as the main varieties. In the prehistoric times there were very popular especially platy cherts of the Arnhofen and Baiersdorf type, both extensively exported also out of the Bavarian territory. In addition to the platy cherts there crop out a lot of concretional cherts as well.

The tabular chert of the Arnhofen type forms both beds (plates) and flat concretions. It represents a very attractive raw material because of very fine banding in grey colours: for the concretions it is characteristic a few mm thick banding parallel with the concretional surface, the platy cherts have very fine horizontal bands with thickness under 1 mm. The cortex is very thin, smooth, with a whitish or yellowish hue. A like hair thin dark band appears just under the cortex (Supplement/Photo 162).

The tabular chert of the Baiersdorf type has a light to medium light grey colour (N7–N6), sometimes greyish brown, pale yellowish brown (10YR 6/2) or bluish grey. A thickness of the plate varies usually between 0.5–2 cm. Its structure is prevalently homogenous but thin lenses or bands can appear. Relics of fossils are present in the marginal parts under the cortex. The cortex is thicker (up to 2–3 mm), usually rough with a various intensive brown or brownish red colour (Supplement/Photo 160). Transversal cracks to the layering can have also an intensive ochre hue.

The concretional cherts (for example from the Ries impact crater and its eastern surroundings) can reach up to 15–20 cm; they have a few mm thick white rough cortex and the siliceous groundmass is in grey hues. A banding can appear under the cortex; in the central part of concretions we see dark spots. A band thin like hair is possible again to find just under the cortex. Their macroscopical distinguishing contrary to the Moravian Jurassic cherts is probably impossible in some cases. The author of this book found also chert breccias in the Ries crater, at first sight similar to the Moravian ones. However their origin is different and has to be connected with the fall of a big extraterrestrial body some 14.7 million years ago. It is a difference in the composition: the Ries chert breccias contain besides chert clasts also chips of limestone.

Stereomicroscopic Appearance: The chert of Arnhofen variety has a conspicuous banded structure (Supplement/Photo 163) – in a chert with thickness of 13 mm it was found up to 22 thin bands. There is an alternation of clouded bends with translucent ones, the border among them is veil-like bended. Bigger relics of microfossils have not been ascertained but in some specimens a fine dark pigmentation is spread. The chert of Baiersdorf type is fully clouded and has schlieren (lentil-shaped) structure, some of the schliers have yellowish or light brown colour (Supplement/Photo 161).

Thin Section: The both varieties are built of microcrystalline quartz with size under 0.02 mm, only the filling of microfossils is composed of fibrous chalcedony. Conspicuous oval cross-sections with the size around 0.1 mm and filled by radial fibrous chalcedony occur in the Arnhofen variety. A light brown pigmentation is not spread uniformly but is concentrated in parallel bended schliers with a various length (0.1–1 mm). Bigger or lesser accumulation of the schliers causes the macroscopically evident banding. In the Baiersdorf variety the pigmentation is cloudlike spread within the whole chert, it often skirts transversal or longitudinal sections of sponge spicules or it impregnates fibrous chalcedony in the fillings after microfossils. The pigmentation is represented by oxides and hydroxides of iron.

Prehistoric Use: An extraordinary shape of the tabular cherts from the Fränkische Alb Hilly land caused their extensive use also out of the territory of Bavaria. Towards east they have been found especially in western and southern Bohemia, artefacts made of this raw material (e. g. sickles) have been ascertained in Moravia as well (for more details see Mateiciucová 2008). The transport followed especially the Danube as is proved by numerous finds in Lower Austria and single ones in SW Slovakia or northern Hungary. Towards west the raw materials are spread up to the Rhine valley and only exceptionally the Arnhofen variety crossed it during the Middle Neolithic (see comprehensive maps in the paper of Binsteiner 2005). Maximal distribution of the Baiersdorf variety seems to be a little later during the Late Neolithic (or the Eneolithic respectively) in the Altheim culture. The Arnhofen tabular chert was mined in open pits or shafts with a depth 4–8 m and diameter 0.7–2.2 m; the number of mines is estimated on 20 000 in the area of roughly 20 hectares (Binsteiner 2005). The extensive distribution of the Arnhofen tabular chert was in progress in the period of the Stroked Pottery, Rössen culture and Lengyel cultural complex.

II.2.5.5. Cherts from relics of Jurassic limestones between Regensburg and Passau (Ortenburger Kieselnieren-Kalke, Flintsbach-Hardt)

Background: The area to the east of Regensburg (SE Bavaria) is very rich in the Neolithic settlements but also numerous Palaeolithic sites have been ascertained there. This prehistoric occupation used important local sources of cherts connected with small denudation relics of Jurassic limestones on the SW margin of the Bohemian Massif. The older archaeological literature on prehistoric utilisation is summarised by Weißmüller (1995) and he correctly named the raw material as a chert. The prehistoric mining was proved at the locality of Flintsbach-Hardt in 1988–1989.

Location: The Ortenburger Kieselnieren-Kalke is represented by a few small denudation relics of Jurassic limestones between Passau and Regensburg in Lower Bavaria. In the western part of the area there are two isolated localities Münster-Buchberg and Flintsbach-Hardt, in the eastern part the Jurassic limestones crop out at Maierhof, Dötter and Obermühle close to Passau. The most popular occurrence at Flintsbach-Hardt (District of

Deggendorf) lies at the northern side of the Danube, so it was well accessible from southern Bohemia.

Geological Setting: From the geomorphological point of view, the area of Ortenburger Kieselnieren-Kalke is situated at southern margin of the Bayerische Wald. The limestone deposits originated in the Upper Jurassic (Malm Beta, Upper Oxfordian). They represent sediments of the shallow platform development with crystalline rocks of the Moldanubicum in their basement. Tertiary sedimentary filling of the Alpine Foredeep crops out to the south, partly covered by Pleistocene loess and fluvial sandy gravel.

Macroscopic Appearance: A wide spectrum of cherts (Supplement/Photos 156–157) is connected with individual localities of the Ortenburger Kieselnieren-Kalke and for example Weißmüller (1995) characterized them in detail. Probably the most important locality of Flintsbach-Hardt has yielded for collectors a range of various cherts from the whitish grey with suggestion of banding under the cortex (and with such appearance to be similar to the cherts from Stránská skála in Moravia) to the high quality types of brown colour – with prevalent pale yellowish brown (10YR 6/2) or dark yellowish brown (10YR 4/2). Almost all types have a characteristic spotted structure with darker spots of dimensions from 0.1 mm to 5 mm in the frame of homogenous non-translucent groundmass. The cortex has usually a thickness up to 1 mm, whitish or ochre colour and small hard outgrowths can be often seen on it.

Stereomicroscopic Appearance: The spotted structure attracts your attention at first sight also under the stereomicroscope (Supplement/Photos 158, 159). The lesser spots are usually more oval, comparing the surrounding groundmass more translucent and they contain finely spread ochre pigmentation. The bigger spots are more whitish or they have a whitish core bordered by a darker translucent bend. They usually represent parts of fossils. It is possible to distinguish polyaxon sponge spicules.

Thin Section: The cryptocrystalline groundmass is very homogenous from the viewpoint of size, there are missing bigger fibrous aggregates of chalcedony as we know from cherts of other localities. Thin veinlets filled by fine-grained quartz can be seen in places. Investigating with only one polar there are conspicuous oval cross-sections of sponge spicules and other parts of organic structures (e.g. corals) accentuated by brown pigmentation. Clasts of quartz can appear in the bigger organic parts. There were seen also small chips of fine-grained sedimentary rocks.

Prehistoric Use: Chipped artefacts of the Middle, Upper and Late Palaeolithic, Mesolithic, Neolithic, Eneolithic and probably also the Bronze Age were found in the area of Flintsbach-Hardt. Minig activities have been dated 4460 cal. BC (Weißmüller 1995, 292) that corresponds to the end of Middle Neolithic (younger Oberlauterbach Group). Taking into consideration the large utilization of Jurassic cherts of Flintsbach type during the Late Palaeolithic and Mesolithic in southern Bohemia (Přichystal 2006) it is possible to consider Flintsbach-Hardt to those central European localities where the mining started already before the Neolithic.

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II.2.6. Silicites of Poland (Fig. 64)

II.2.6.1. Ordovician chalcedony cherts, Góry Świętokrzyskie Mts.

General Overview: Occurrences of these cherts have been described for example from the surroundings of Wysoczka pod Bogorią in the southern part of Góry Świętokrzyskie, about 32 km to the west of Sandomierz. They represent the oldest Polish silicites with temporal classification to the lowest Ordovician stage, the Tremadocian. Above the basal conglomerates (developed only in places) there are glauconite sandstones with layered deposits of chalcedony cherts containing solitary fauna of primitive graptolites *Dendroidea* and brachiopods (Książkiewicz, Samsonowicz & Rühle 1965, 69).

Prehistoric Use: Prehistoric chipped artefacts made of this raw material have not been registered in papers till the present time.

II.2.6.2. Silurian siliceous shales with lydites (lupki krzemionkowe z lidytami), Góry Kaczawskie and Góry Świętokrzyskie Mts.

General Overview: Black siliceous shales of the Lower Silurian age (the Llandovery Epoch) rise out both in Silesia (Góry Kaczawskie Mts., surroundings of Javor and Sobótka) and in the northern section of the Góry Świętokrzyskie Mts. They contain layered deposits of dark silicites designated as lydites or radiolarites. According to Tomczyk (in Sokołowski, Cieśliński & Czerminski, eds. 1976) the shales with lydites are called the Lower Bardo Beds.

Prehistoric Use: Although the usage of these Silurian silicites has not been described in the Polish specialized literature yet, analogous raw materials were utilised in the Late Palaeolithic and in the Mesolithic in the Bohemian Karst area.

II.2.6.3. Devonian Kostomloty chert, Góry Świętokrzyskie Mts.

General Overview: Thin layers or lenses of chert crop out in the Upper Devonian (Frasnian) limestone within the Kostomloty Beds (warstwy kostomlockie) in the Łysica section of the Góry Świętokrzyskie Mts.

Prehistoric Use: No proofs of their use in the prehistory have been available for the time.

II.2.6.4. Devonian radiolarite of the Bardo type (rogowiec bardski in Polish)

Background: The raw material was found by a Polish archaeologist J. Bronowicki during his research of the Mesolithic stations in the Góry Bardzkie, about 7 km NNE of Kłodzko, in the Lower Silesia County (southern Poland). The founder called it originally as a quartz-lidyte shale (łupek kwarcowo-lidytowy) or flint of the Morzyszów type (krzemień typu Morzyszów).

Location: The raw material has natural occurrences in the northern part of the Góry Bardzkie, among the municipalities of Bardo Śląskie – Morzyszów – Ławica, about 8 km to the north (NNE) of Kłodsko.

Geological Setting: The radiolarites are a part of an allochthonous lithostratigraphic unit called the Zdanów Group being defined by Haydukiewicz (1979). This geological unit comprises rocks of the Upper Ordovician to Lower Carboniferous age and cropping out as tectonic lenses or olistoliths with length up to 200 m and thickness up to several ten of metres within flysch rocks of the Lower Carboniferous. The cherts have the Middle – Upper Devonian age. With no doubts, the raw material can be compared with the Devonian – Lower Carboniferous radiolarites of the Ponikev Formation we know from the basinal development of the Devonian in Moravia and Czech Silesia, more explicit in the scope of the Variscan Moravo-Silesian Klippen Belt (for more details see the chapter II.2.3.1.).

Macroscopic Appearance: According to the presence of microfossils, the cherts should be called radiolarite cherts to radiolarites. They are not of a too high quality, usually have a grey-green (but also pale grey or black) colour with an admixture of pelitic and aleuritic components and the radiolarites form several centimetre thick layers or almost 40 cm thick beds, often with a distinct layering consisting of alternating sub-millimetre laminae (Supplement/Photo 88). As a consequence of intensive tectonic influence the radiolarites naturally desintegrate into cubiform fragments of a several centimetre size.

Stereomicroscopic Appearance: On the fresh fracture the layering of silicite is only indicated by arrangement of black graphitic lamellae but radiolarians (up to 0.1 mm) are relatively well visible in a non-translucent dark grey green siliceous groundmass, in places it is possible to observe even projecting thorns from radiolarian tests (Supplement/Photo 89).

The weathered surface shows a very clear alternation of yellowish and green grey thin bands. In addition the green gray bands contain a lot of small whittish inclusions representing relics of clastic grains. Small cavities filled by limonite or clay minerals are rests after weathered out radiolarians.

Thin Section: According to published data, x-ray study and examination of thin sections, the Devonian radiolarites of Bardo type contain apart authigenic and detrital quartz also fine cummulations of chalcedony, illite, chlorite, mica flakes, pyrite, graphitic and carbonate substance. Better or worse preserved oval phantoms of radiolarians with conspicuously bigger grains or fibres of chalcedony may always be found within them. The surrounding groundmass has only cryptocrystalline appearance (Supplement/Photo 90).

Other Analyses: When measured by a portable kappameter they feature virtually zero magnetic susceptibility.

Prehistoric Use: The radiolarite of Bardo type was chipped at the Mesolithic sites in the vicinity of natural occurrences to the north of Kłodsko, for example at localities of Morzyszów 3 and 4, Ławica 8, Ścinawica 1 and 2 (Bronowicki & Bobak 1999, a letter of J. Bronowicki). It started to be use probably already at the end of the Palaeolithic in the Magdalénian (Ławica 8).

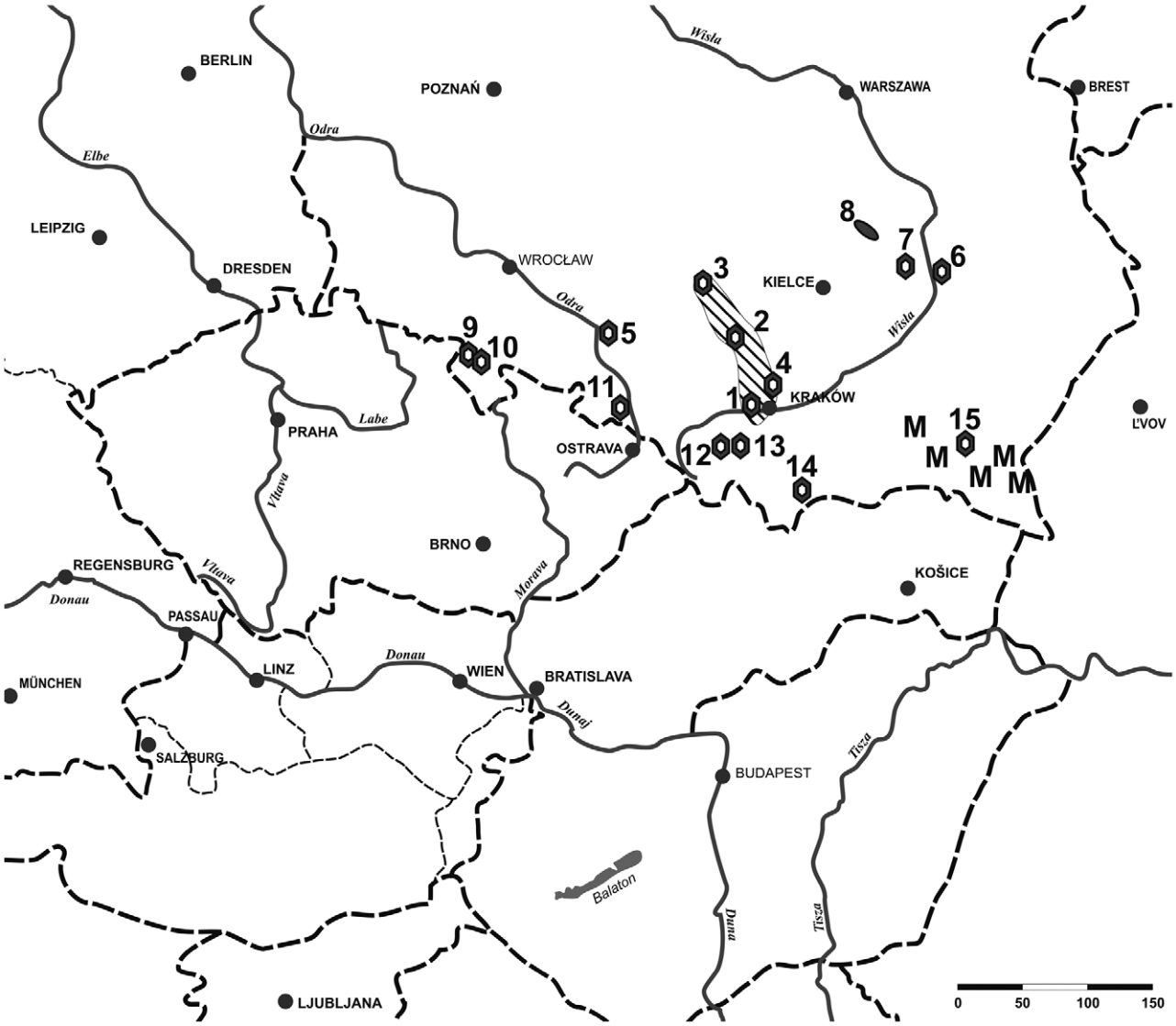

Fig. 64. Sources of silicites for chipped artefacts in Poland. Area of the Cracow-Częstochowa Upland (oblique hatch): 1 – Jurassic silicites around Cracow, 2 – Jurassic silicites (variety G) around the Krztynia river, 3 – Jurassic silicites (variety Gojść) around the Warta river, 4 – Cretaceous silicite of the Wielka Wieś type, 5 – silicites from Opole-Groszowice, 6 – spotted Świeciechów silicite, 7 – banded Krzemionki silicite, 8 – chocolate silicite, 9 – Permian limnic silicites in the Intra-Sudetic Basin, 10 – Devonian Bardo radiolarite, 11 – erratic silicites at Maków, 12 – cherts from limestones of the Andrychów klippes, 13 – Mikuszowice cherts and radiolarites in the Silesian Unit, 14 – radiolarites of the Pieniny Klippen Belt, 15 – Bircza silicite, M – menilite cherts.

II.2.6.5. Permian limnic silicites of the Intra-Sudetic Basin

General Overview: Thanks to a Polish archaeologist J. Bronowicki the author had a chance to study chipped artefacts and chert raw material from the locality of Ratno Dolne, 9 km to the SSW from Nowa Ruda in the Polish part of the Intra-Sudetic Basin. Layered, prevalently black or grey chert thick only a few cm and limited by rough brown cortex (Supplement/Photo 91) occurs there as natural chips in eluvial horizons of the Permian rocks. Sometimes the complete chert is represented by an alternation of thin black and brown laminae with a thickness of about 1mm. Macroscopically it resembles the chert chipped at the Mesolithic site of Hřibojedy near Dvůr Králové nad Labem in the Czech Republic, some 50 km far from Ratno Dolne. Similar cherts occur probably at more places in the Intra-Sudetic Basin.

In thin section the chert is built by cummulations of cryptocrystalline quartz with smudges of coarse-grained probably chalcedony in the space among them. Spots of iron oxides and hydroxides are irregularly spread in the siliceous mass. No microfossils have been found using both the stereomicroscope and polarizing microscope.

Prehistoric Use: The raw material was very probably only of local importance and its flaking can be supposed especially in the Mesolithic in the surroundings of natural sources.

II.2.6.6. Triassic cherts of the Górażdże Beds (warstwy górażdżanskie, Wyżyna Śląska, Góry Świętokrzyskie)

General Overview: As is the Triassis deposits concerned, there is a substantial difference between the Czech Republic and Poland. In Bohemia we know only small relics of continental clastic sediments (so called Buntsandstein) without cherts and in Moravia the Triassic rocks do not occur at all. But the area of Upper Silesia and Cracow region in southern Poland were flooded by the Middle Triassic sea which deposited the "Muschelkalk". The Górażdże Beds (warstwy górażdżanskie, named after the village of Górażdże about 15 km to the SSE of Opole) occur in the lower part of "Muschelkalk"and they are built by limestones partly oolitic. They represent the only Triassic limestones with concretional cherts (Książkiewicz, Samsonowicz & Rühle 1965, 125). The cherts often contain preserved relics of fossils that were destroyed in the surrounding limestones because of dolomitization. The Middle Triassic limestones with cherts analogical to those from the Górażdże Beds have been described also from the Góry Świętokrzyskie Mts.

J. Szulc and J. Bronowicki draw the author's attention to grey and brecciated cherts found in weathered parts of limestones in quarries at Górażdże. Triassic cherts are also known from the Karchowice limestone, for example at the locality of Strzelce Opolskie. They were found in old quarries at the village of Malnie that is introduced as the type locality of the Górażdże Beds (Senkowicz 1976, Sawicki 1997). But from all data mentioned above it is evident the Triassic chert represent only small occurrences.

Prehistoric Use: The possible using of Triassic cherts in assemblages of prehistoric chipped artefacts has not been inspected in the Polish archaeological literature till present time.

II.2.6.7. Silicites of the Cracow-Częstochowa Jurassic, southern part (the Cracow area)

Background: Silicites of the Cracow-Częstochowa Jurassic rank among the most important Central European raw materials for chipped artefacts. This is related to their excellent quality, sufficient size of concretions, vast area of occurrence, and a good availability. In the Polish literature this material is usually designated "krzemień jurajski" (Jurassic flint) or "krzemień jurajski podkrakowski" (Jurassic flint around Cracow). However, it has to be taken into consideration that the entire Cracow-Częstochowa Jurassic area has not been mapped in respect to the occurrence of individual silicite varieties till now; in any case somewhat different types of silicites occur in the central and northern parts of the unit; that is why they are characterized separately in chapters II.2.6.8. and II.2.6.9. Within the setting of the Cracow-Częstochowa Highland it is necessary to mention also presence of the Cretaceous sediments with cherts (NNE of Cracow, so called variety K) besides the Jurassic silicites.

Probably the first important mention of silicites (flints) from the surroundings of Cracow appeared in a classical paper of Krukowski (1920). He tried to classify them preliminary on the base of their occurrence in moraine deposits. He knew a primary source only at Ojców. The raw material was studied later by various researchers especially in the southern part of the highland in the surroundings of Cracow (Kaczanowska & Kozłowski 1976, Lech 1980). They differentiated six basic varieties of the Jurassic silicites (A, B, C, D, E, G), some of them are divided further in subvarieties. The source of variety G was found later in the central part of the Cracow-Częstochowa Jurassic.

Location: The Cracow-Częstochowa Jurassic is the name for a geological unit that is almost identical with the geomorphological unit Cracow-Częstochowa Highland (Wyżyna Krakowsko-Częstochowska in Polish). The highland forms a unique area elongated in the direction NW – SE with numerous karst phenomena between Cracow and Częstochowa. Silicite occurrences are concentrated in the vicinity of Cracow, than in the central part around the Krztynia River and also in the north along the upper part of the Warta River. A smaller part of the highland is built by Cretaceous marls.

Geological Setting: The silicites originated in the Upper Jurassic (Oxfordian) limestone, either of a massive, heavy-bedded, or of a thin platy nature. The characteristic fossils of these limestones are represented by ammonites of the *Perisphinctes* and *Peltoceras* genera. But because of weathering some silicites have created secondary resources already in the course of the geological past – towards the end of the Lower Cretaceous and at the beginning of Upper Cretaceous, in the Albian and Cenomanian, when conglomerates with plentiful pebbles of silicites have been formed, with the pebble diameters up to 12 cm (Lech 1980, 167); well rounded concretions of up to 20 cm are a part also of the Santonian conglomerates. The highest concentrations of silicites may be found in weathering products of the Tertiary (possibly Eocene) Age, represented mainly by karstic clays and red coloured loams lying directly on limestones, in the composition of which the silicites participate by as much as 50 %. We can find the redeposited Cracow-Częstochowa Jurassic silicites also in glacial deposits especially to the east of Cracow and in aluvial sediments of rivers and creeks.

Macroscopic Appearance: The diameters of big concretions usually vary around 10 to 20 cm, exceptionally exceeding 30 cm; obviously smaller nodules are common. On the other hand we are aware of layered silicites of up to several metres length. The concretion cortex can reach the thickness up to 10 mm; however, its variation between 1 and 3 mm is prevailing. The colour of the cortex is usually white-yellow or grey-white; the variety

A may have its cortex coloured by ferric oxides rust to dark brown. With the brown variety A and the black bluish variety E the transition between cortex and siliceous groundmass is sharp, with the others it is usually gradual, with transitions through various coloured layers, i.e. whitish, dark blue, brown-yellow (Kaczanowska & Kozlowski 1976, 206–207). The most significant distinguishing sign is the character of the siliceous substance as the cortex relics are only occasionally preserved on artefacts. The present knowledge shows that the most distributed variety A has various brown hues (for example greyish brown 5YR 3/2 in Brzoskwinia or dark yellowish brown 10YR 4/2 in Sąspów), in addition it is well translucent, with occasional coffee-brown inclusions (petrosilexes). Partly similar seems to be the variety C (Supplement/Photos 92, 93), also distributed. The siliceous groundmass of varieties B and D is not so well translucent and their colour varies between light brownish grey (5YR 6/1) and yellowish grey (5Y 8/1). To distinguish them from some Moravian Jurassic chert can be very difficult because they have very similar colour. The variety E is even greyish black, again almost non-translucent. It is necessary to take into consideration a very large variability of Jurassic silicites already in the area of Cracow where for example from a part called Sikornik we know flat concretions of grey silicites with a fine banding under the cortex. At the first sight they can resemble Jurassic tabular chert from Bavaria (plattensilex).

Stereomicroscopic Appearance: The variety A can be distinguished very well (Supplement/Photo 94). The silicite groundmass is translucent even if not completely transparent because it is cloudy by very fine pigmentation of orange, red or red brown colour. Sometimes the pigmentation is spread more or less uniformly but frequently it forms small accumulations filling original shapes of sponge spicules or other microfossils. The siliceous mass contains also bigger whitish enclosures (up to 2–3 mm) with many cavities resembling small potato chips. Most of them represent relics after fossil tests. The accumulations of orange pigment are well visible also in the variety C. In the variety D it has not been observed and to distinguish this raw material towards Moravian Jurassic chert could be very difficult.

Thin Section: A thin section prepared from the variety A (locality of Brzoskwinia) shows a picture partly similar to other high quality silicites. Cryptocrystalline groundmass contains in places small accumulations of bigger grains or fibres of chalcedony. These "islands"are conspicuous when investigating with one polar because they are without clouding by small brown inclusions or brown pigmentation. In the contrary the prevalent part of siliceous mass is full of the small inclusions in places forming even bigger irregular brown shapes. Using crossed polars they are almost isotropic.

Other Analyses: Bańdo (1992) did a mineralogical and geochemical investigation of silicites from the Cracow-Częstochowa Jurassic (more explicitly from the valley of the Visla River west of Cracow). He took nine different varieties from the region of Jeziorzany – Krzemień. On the base of petrographic thin sections he stated chalcedony as the prevalent mineral (93 %) of silicites, coarse-grained particles (> 5 μm; quartz, carbonates, opaque minerals) form the rest. The results of microscopic study on total prevalence of chalcedony were proved by x-ray investigation of two silicite samples from Wołowice and Kamień using a diffractometer Dron-3. As is the trace element presence concerned it can be mentioned contents of Pb (0.0022–0.0034 %), Zn (0.0003–0.0018 %) and Cr (0.0008–0.0019 %), from the main elements is interesting Fe (0.043–0.13 %) and Mn (0.0018–0.0038 %).

Prehistoric Use: Kaczanowska & Kozłowski (1976) in the scope of their overview have mentioned chipping of silicites from the southern part of the Cracow-Częstochowa Jurassic already in the Lower and Middle Palaeolithic (Piekary, Wawel). The Central European significance of the raw materials and their distribution outside the territory of natural occurrence may be observed since the Upper Palaeolithic; for example in the Pavlovian they were transported at a distance of about 300 km to settlements situated on the slopes of the Pavlovské vrchy Highland in southern Moravia. According to Oliva (1997) their presence at the Pavlovian site of Pavlov is about 25 %. Janák & Přichystal (2007) investigated in detail the occurrence of the Cracow-Częstochowa Jurassic silicites at various Neolithic sites in Moravia and Czech Silesia. It is necessary to point out the raw materials were significantly used in eastern to central Bohemia, for example at the Neolithic site of Bylany (Fig. 65).

Prehistoric mining in the southern part of the Cracow-Częstochowa Jurassic has been proved at a few places (see localities PL 14, 15, 16, 17 and 19 in Kobyliński & Lech, eds. 1995), in the Czech archaeological literature it was summarized by Oliva (1999). The extraction of silicites started already at the end of the Palaeolithic (Wołowice, probably also Brzoskwinia) and culminated during the Neolithic (Sąspów, Bęblo, and Jerzmanowice). Some of the mined raw materials have such characteristic appearance (shape of their concretions, cortex, and colour of the siliceous mass) that it is possible to recognize them in the Neolithic chipped assemblages in central Moravia (e.g. the Sąspów variety in the area of Velký Kosíř Hill near Prostějov).

II.2.6.8. Silicites of the Cracow-Częstochowa Jurassic, central part (variety G)

Background: Kowalski (1963) described the raw material already in the first half of the sixties of the 20th century as a white-grey non-translucent or only partly translucent "flint" that was used by the southern group of the Funnel Beaker culture. When studied assemblages of chipped artefacts in the southern part of the Cracow-Częstochowa Jurassic, Kaczanowska & Kozłowski (1976) did not find a source for the variety G in the surroundings of Cracow, so they could not exclude its origin in another part of the Cracow-Częstochowa Jurassic. Kopacz & Pelisiak (1992) confirmed it to find the raw material source area in the surroundings of the Krztynia River in

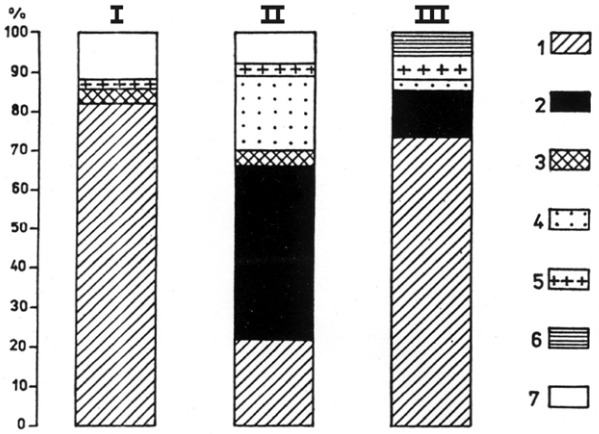

Fig. 65. Frequency of the Cracow-Częstochowa silicites in individual phases of development at the Neolithic site of Bylany, central Bohemia. According to I. Pavlů and A. Přichystal (Přichystal 1985, 483). I –Early phase of the Linear Pottery culture, II – Middle to Late phase of the Linear Pottery culture, III – Stroked Pottery culture. 1 – erratic silicites from glacial sediments, 2 – silicites of the Cracow-Częstochowa Jurassic provenance, 3 – quartzite of unknown provenance, 4 – quartzites mainly of NW-Bohemian provenance, 5 – cherts of the Krumlovský les type, 6 – Bavarian tabular chert (Plattensilex), 7 – other raw materials (radiolarite, porcellanite, siliceous weathering products of serpentinite, Cretaceous spongolite).

the highland central part. The last close study devoted to the variety G has been written by Pelisiak (2006) who distinguished three subvarieties (G1, G2 and G3).

Location: The Krztynia is a tributary of the Pilica River from the left side about 40 km SE of Częstochowa or 55 km NW of Cracow. Sources of the raw material (variety G) have been found in the southern surroundings of its valley together with workshops and probably with prehistoric mines (Huta Szklana). Next workshops occur also south of the Pilica flow among localities Strzegowa, Góry Barańskie and Kępie.

Macroscopic Appearance: The silicites of variety G form big loaf-like concretions with a size even more 20–30 cm and the weight can be a few kilograms. The cortex is usually smooth with many small hard outgrowths and its colour is yellowish, very pale orange (10YR 8/2) to greyish orange (10YR 7/4). The thickness of cortex does not exceed 2–3 mm. A banded structure often appears under the cortex and sometimes it can fill the whole nodule as several cm thick bands (Supplement/Photo 95). In another case its central part is formed by a non-translucent quartz core (petrosilex) and the translucent parts rich in chalcedony are preserved only at the concretional margin.

Stereomicroscopic Appearance: The concretional parts rich in chalcedony have usually a characteristic small spotted structure with spots up to 1–2 mm. Darker brown spots (close to the hue 10YR 6/2) are represented especially by chips of microfossils in a lighter brown white and worse translucent siliceous mass. The red or ochre pigmentation is not spread uniformly and it occurs only rarely cumulated around some microfossils (Supplement/Photo 96).

Prehistoric Use: According to Pelisiak (2006, 74) the variety G was used especially in the Eneolithic, as a matter of fact in the period of the Funnel Beaker culture, Baden culture and Corded Ware culture. Siliceous axes of the trapezoid shape (Supplement/Photo 99) and long blades are typical artefacts made of this raw material. The variety G1 (pale brown, partly similar to the variety A from the Cracow area) has its source near the Jasna Strzegowska Cave and blades up to 12 cm long were produced from it by the people of Lengyel-Polgár complex or with the Corded Ware culture. The light grey variety G2 again crops out in the surroundings of the Jasna Strzegowska Cave and in the Góry Barańskie Highland and for long blades or trapezoid siliceous axes was manufactured again by people with the late Funnel Beaker culture, Baden culture and Corded Ware culture. Finally, the variety G3 has light grey colour with darker spots and natural source at Strzegów, in the Barańskie Góry Highland and in the surroundings of the Krztynia River. It served for similar artefacts and in the same periods as the variety G2 (Pelisiak 2006).

II.2.6.9. Silicites of the Cracow-Częstochowa Jurassic, northern part (variety Gojść)

Background: According to the data in a paper by Ginter (1984) the first research in the territory around the confluence of the Warta and Liswarta Rivers were carried out already in the 1920s. In 1952 these were continued by M. and W. Chmielewski, and followed up since 1961 by B. Ginter, who has described large workshops from this territory and has called the attention of the European public to these occurrences. He has designated the raw material as a „Jurassic flint". As it is macroscopically different from the silicites in the central and southern parts of the Cracow-Częstochowa Jurassic, this monograph proposes to give this raw material off as a separate type under the name „Gojść variety".

Location: The occurrences of this variety are situated in the northernmost part of the Cracow-Częstochowa Highland (sometimes also termed the Cracow-Wieluń Highland), 42 km NW of Częstochowa, or 18 km SE of Wieluń. Large workshops processing the local raw material stretch out in the length of ca 30 km in the valley of the lower course of the Warta River, and especially in the area of the Liswarta River, its tributary. Three accumulations of sites may be differentiated here: the eastern localities of Gojść and Stoczki on the Warta River, and Kuźnica on the Kocinka tributary; the central group of finding sites around the confluence of the Liswarta and the Warta Rivers (Trzebca, Kule, Wąsosz, Patrzyków), and the western aggregation of workshops between the Działoszyn town and the Bobrowniki village. Very similar or almost the same variety of Jurassic silicite occurs also more to the south in the area of Złoty Potok Brook near Częstochowa.

Geological Setting: The bedrock of the territory under description is formed by limestones of Jurassic (Oxfordian) age with concretions of silicites. They are overlaid by products of an extensive karst weathering (red clays with concretions of silicites) that has occurred during the Cretaceous and Tertiary, and the clays are topped by fluvioglacial sediments of the Elster and Warta glaciation. In their highest part these fluvioglacial sediments feature a gravel layer with numerous shortly transported silicite concretions, fragments of silicified limestone and erratic rocks. The uppermost part of the profile consists of fluvial Pleistocene to Holocene sandy gravels and sands of the Warta River.

Macroscopic Appearance: The concretions of silicites reach the size from several cm up to 40 cm. For example J. Kopacz collected a concretion with dimensions 37 x 24 x 16 cm and weighting 17.1 kg in the area of Złoty Potok brook near Częstochowa. In comparison with silicites of the southern part of the Cracow-Częstochowa Jurassic the cortex is rougher, usually with a number of 2–3 mm sized outgrowths formed by fragments of fossils. The dimensions of some of these reach even more mm so that it is possible to determine spines of sea urchins or pelecypod impressions with the naked eye. In perpendicular sections the thickness of cortex does not exceed 2–3 mm. The transition into silicite matter is either sharp, or a lighter thin layer is developed. Sometimes even banded types are present. Many light patches representing prevalently fragments of fossils are conspicuous (Supplement/Photo 97).

Stereomicroscopic Appearance: The colour of the silicite matter is prevailingly in moderate yellowish brown (10YR 5/4), sometimes even rusty brown hues; even light brownish grey colouring (5YR 6/1) may occur. A typical characteristic is overfilling of the silicite matter with fragments of whitish microfossils (1– 3 mm), out of which spines of sea urchins, parts of moss animals, or fragments of crinoids may be discerned. It is possible to count between 5 and 12 of such fragments bigger than 1 mm per 1 cm^2 (Supplement/Photo 98). The majority of fragments is enclosed by a clear chalcedony mass in comparison to the dimmed surrounding silicite matter; oval shapes of clear chalcedony of the same size appear also without the whitish fragments in their centres.

Thin Section and Other Analyses: The results of infrared spectroscopy and the study of thin sections under the polarizing microscope performed by M. Pawlikowski (in Ginter 1984, 223) have proven that the prevailing material has been chalcedony, while quartz and opal as complementary components were represented variably, or even missing.

Prehistoric Use: According to Ginter (1984) the extraction pits and workshops on the lower course of the Warta River are primarily related to the Late Palaeolithic "Mazovian cycle" or in recent time more common used the Swiderian. The features of Tarnovian or Witowian have been ascertained by the side of the prevailing Swiderien at the sites near the confluence of the Warta and the Liswarta. Extraction pits sunken into the sandy gravels of fluvioglacial origin have been discovered near Gojść. The diameter of their upper part varied around 1.5–2 m, the depth was 1.5 m. Klimek (2006) studied in detail local specialized workshops and she has assumed the extraction of Gojść silicites was a seasonal job during the Final Palaeolithic.

In Moravia the author has found this raw material (silicite of the Cracow-Częstochowa Jurassic, Gojść variety) during a joint study with L. Šebela used for a silicite axe from Určice that is deposited in the museum in Prostějov under No 140 658, and is typologically related to the Corded Ware culture.

II.2.6.10. Silicites of the Opole-Groszowice type

Background: Geologist Z. Gába from Šumperk drew the author of this monograph attention to high representation of a silicite that did not correspond to the prevailing erratic types (i.e. flints of the Maastrichtian and Danian age) in the Opole-Groszowice sandpit. Following visits of the sandpit confirmed the Gába's piece of information. Reliable explanation of this silicite origin in the Polish geological literature has not been found; the Polish archaeological literature has not recorded this raw material used for artefacts yet.

Location: The raw material emerges mainly in the southern surroundings of Opole, where it is best accessible in a vast sandpit in the Opole-Groszowice end. Its occurrence in the glacigene sediments gradually diminishes southwards, in the direction towards the state border with the Czech Republic, although occasional pieces may appear as far as the Ostrava region.

Geological Setting: Silicites of the Opole-Groszowice type are a part of glacigene, especially glacifluvial sediments. Their primary origin remains a question. According to all their characteristics they conform very well to the silicites from the northern part of the Cracow-Częstochowa Jurassic (e.g. Gojść and its surroundings), and their original occurrence in the weathering products on the Jurrassic limestones has most probably been there. However their high percentage in the Opole-Groszowice sandpit does not allow for an exceedingly distant resource. In a fraction of around 5–10 cm they are estimated to about 30 % of the material. The most probable explanation is a closer occurrence of Jurassic limestones with silicites, in present time hidden under deposits of Pleistocene glacial sheets.

Macroscopic Appearance: Silicite nodules slightly rolled by transport often retain their original flat shape, and their pieces reach the size up to 60–70 cm and the weight of several kg (the author has in his collection a piece weighting 6 kg). The silicites usually have a dark brown colour (dark yellowish brown 10YR 4/2 to dusky yellowish brown 10YR 2/2) and enclose numerous relics of fossils, e.g. echinoids and their spines.

Stereomicroscopic Appearance: The brown silicite mass comprises ample whitish fragments of fossils of 1–3 mm size, mainly moss animals and spines of echinoids, in addition it is cloudily tarnished by a fine enclosed pigment, either whitish or orange-red. The

pigment may be evenly distributed or clustered into tiny accumulations, which is conspicuous especially with the red-coloured one (Supplement/Photo 101). In some cases this copies the outlines of sponge spicules or other microfossils. Out of other characteristics it is possible to observe oval spots of non-tarnished chalcedony matter (these are darker in comparison with the surrounding groundmass) with dimensions between 1–4 mm.

Thin Section: A cryptocrystalline silica groundmass with a number of tiny inclusions of light brown to reddish colour dominates. There is also a presence of small "islands" with large grains of chalcedony or quartz. These are usually without brownish inclusions; on the contrary, the inclusions in larger quantities line the outer edges of recrystallized parts.

Prehistoric Use: This raw material has not been recorded in the Polish archaeological literature yet but its probable chipping might be expected in the broad area between the Opole town and the state border with the Czech Republic. The author encountered it probably at the Upper Gravettian site in Ostrava-Petřkovice (Landek Hill) where 34 artefacts have been made of this raw material (Přichystal 2008).

II.2.6.11. Cretaceous chert of the Wielka Wieś type, the Cracow-Częstochowa Highland (Wyżyna Krakowsko-Częstochowska)

Background: The Cracow-Częstochowa Highland is built not only of the Jurassic limestones but to the north of Cracow, on an area exceeding 200 km^2, sediments of the Cretaceous age containing silicites crop out as well. From the geological point of view these were brought forward by Zaręczny (1953); upon the study of siliceous rocks from the southern part of the Cracow-Częstochowa Highland Kaczanowska & Kozłowski (1976, 208) have designated the raw material as the K variety.

Location: Outcrops of the Cretaceous cherts emerge in the surroundings of Bibice and Witkowice in the Garliczka valley, although they may be expected to occur at a number of other places in the Dłubnia River valley, and they are also known from the Cretaceous relics preserved on the Jurassic rocks near Wielka Wieś.

Geological Setting: The cherts are related to the Upper Cretaceous (Campanian) whitish marlites and marls (Gradziński 1972, 47). Santonian green glauconite marlites emerge below, while the Lower Maastrichtian marlite and opoka are placed above them.

Macroscopic Appearance: Chert concretions may reach the diameter up to 10–15 cm (Supplement/Photo 102), they feature a thin, smooth whitish cortex, and with artefacts the cortex secondarily acquires also a light brownish hue. The cortex is usually very thin, around 0.1 mm. The siliceous matter shows brown colour through only at the edges, it is smooth, its colour ranges from light olive grey (5Y 6/1), olive grey (5Y 4/1) to medium dark grey (N4). Bigger, differently silicified inclusions (petrosilexes) have not been noticed, whilst differently coloured parts elongated to several centimetres have been recorded quite often.

Stereomicroscopic Appearance: Poorly translucent silicite matter contains a number of enclosures of whitish, sometimes also black colour (Ujazd Gacki). The whitish enclosures are smaller, mostly up to 0.2 mm, a part of them are fragments of microfossils among which it is reliably possible to differentiate bigger simple sponge spicules. The remaining part probably comprises non-diluted clasts of the original sedimentary rock. The black shapes formed by a graphitic substance reach up to 0.5 mm. The most interesting are impregnations of some microfossils by a finely crystallized pyrite or, exceptionally, by a red hematite pigment (Supplement/Photo 103).

Thin Section: Numerous cross sections of sponge spicules with the diameter 0.1–0.2 mm and length usually about 1 mm can be seen in the siliceous groundmass built of microcrystalline quartz. The microfossil relics are well visible using one polar only because they are accentuated by a darker organic pigment in their vicinity.

Prehistoric Use: The Cretaceous chert of the Wielka Wieś type has been partly chipped by the people with the Funnel Beaker culture. It was also used for the manufacture of silicite axes, e.g. 12 such axes have been produced of it in Kopcowa Skala (Kaczanowska & Kozłowski 1976, 214).

II.2.6.12. Banded silicite of the Krzemionki type (krzemień pasiasty)

Background: The most famous Central European silicite, very attractive, in the Polish literature designated as „krzemień pasiasty" (in English it means banded flint). It is possible to determinate it usually macroscopically. The spectacular outlook of the silicite axes made of this raw material has caused that as early as between 1917–1918 first trials have been made to map out its occurrences. Budziszewski & Michniak (1984, 152) or Sałaciński & Zalewski (1987) described details of the research history. Archaeologist S. Krukowski (1920) has called attention to the approximate natural occurrences; his data were followed up by geologist J. Samsonowicz, who succeeded in discovering and a correct interpretation of prehistoric mines at Krzemionki Opatowskie in 1922 (Samsonowicz 1923). This was continued by a systematic research of a prehistoric extraction field under the guidance of S. Krukowski that has culminated in a monograph publication on this extremely important site (Krukowski 1939).

Location: The resource of Krzemionki banded silicite is located on the southern margin of central Poland, in the Kielce-Sandomierz Highland (Wyżyna Kielecko-Sandomierska), i.e. to the north of the Góry Świętokrzyskie Mts. and to the west of the Vistula River. The occurrences are concentrated into a 57 km long strip that begins in the north-west near Blaziny Górne at Iłża and continues through Sienne, Wodąca, Skarbka Dolna into the south-eastern part of the finding sites, e.g. Krzemionki and Ruda Kościelna. The centre of the primeval extraction is around the Krzemionki municipality, to the NE of Ostrowiec Świętokrzyski or to the north of Cmielów.

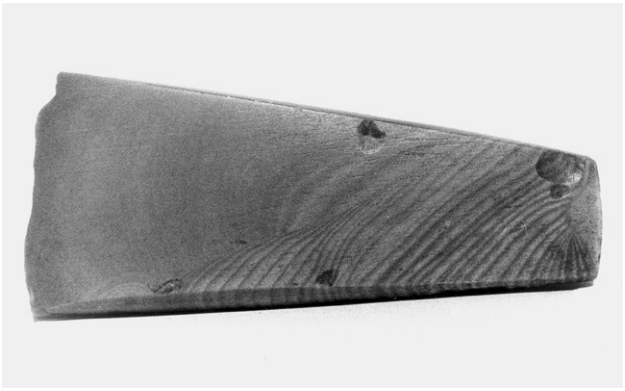

Fig. 66. Silicite axe, Prusinovice near Holešov, central Moravia. Length 12.8 cm. Banded silicite (krzemień pasiasty) coming from Krzemionki in central Poland. Photo by the author.

Geological Setting: Outcrops of the Upper Jurassic (Upper Oxfordian) limestones emerge in the southern wing of the Magoń-Folwarczysko Basin. Compact sponge limestones with nodular silicites contain interbeds of coral reef limestones with ample stromatoporoids. Banded silicites are characteristic for limestones with a more detailed temporal classification into the Lower Astartian (Malinowska & Dembowska in Sokołowski, Cieśliński & Czerminski, eds. 1976), now it corresponds the Kimmeridgian. In the uppermost Oxfordian the flat concretions elongated with the bedding cumulate into two horizons in the environment of fine micrite limestones. A layer of limestones, either oolitic or with ooliths, emerges above these; in some profiles layers of silicites appear even in these limestones (Budziszewski & Michniak 1984, 169).

Macroscopic Appearance: Dimensions of the concretions vary according to the place of prehistoric exploitation. The highest values are recorded just from the prehistoric mines in Krzemionki, where the length amounts up to 0.6–0.9 m and the thickness within 15 cm. The concretional shape has been described as discoid, flat, loaf-like sometimes even spherical (Supplement/Photo 104). In ideal cases the concretions have a zoned structure from the white zone under the surface, through the banded, darker peripheral part, the banded, light central part, and a homogenous non-banded core. The colour of dark bands is usually in conformity with brownish grey (5YR 4/1) or light brownish grey (5YR 6/1), the light bands are best compared to pale yellowish brown hue (10YR 6/2) – see Supplement/Photo 106.

Stereomicroscopic Appearance: The light bands are non-translucent, tarnished by a whitish cloud-like matter without a sharp delimitation. The dark bands are brownish-translucent, and especially in them the microfossils typical of banded silicite are present that either do not occur in other silicites at all, or only exceptionally. These are black tubular shapes that conically taper off towards one side. Their length may be up to 0.8 mm. Based on consultation with palaeontologists they could represent perhaps spores of mushrooms (Supplement/Photo 107, 109).

Thin Section: Thin section shows a homogenous structure formed by cryptocrystalline SiO_2; according to Budziszewski & Michniak (1984, 177), by an X-ray diffractographic record in this case it matches with the low temperature quartz. Clayey substance and carbonates are absent but with great magnifications under scanning microscope the siliceous matter has been found to contain small solution cavities, often of rhombohedral shape, which are most likely remnants of leached carbonate crystals. With fresh samples calcite is present in the white surface cortex (it reacts with diluted HCl). According to the authors above the macroscopically conspicuous banding is not manifested in the mineral composition or the structural differences, and is most likely related to the unsteady contents of Al_2O_3 (0.01–0.7 %) or Fe_2O_3.

Other Analyses: Budziszewski & Michniak (1984) have also performed differential thermal analyses and an X-ray diffractographic research. They have found neither any difference between the composition of the marginal and central parts of one concretion, nor between the silicite concretions from various parts of the source area. Cristobalite, which is often indicated, together with quartz, from other silicites in the northern foreland of the Góry Świętokrzyskie Mts., has not been ascertained. Differential thermal analyses have shown two minimums related to loss of water: moisture at the temperatures of 100–200 °C on the one hand, and water bound to defects in the SiO_2 crystal lattice (or in the remnants of opal) that has been releasing from 400 to 600 °C on the other hand. Very interesting results were obtained from microhardness measuring carried out on a profile of a concretion from Śródborz (Stawin 1970) that has, as opposed to the preceding methods, shown a great fluctuation of values from roughly 450 kg/mm^2 (just slightly more than the mean value for opal from Szklary) up to 1600 kg/mm^2, which exceeds the mean hardness of a crystal of Brazil quartz.

Prehistoric Use: The extraction field is around 5 km long and between 30 to 180 m wide; ca 3000 prehistoric shafts have been recorded on its extent (Sałacinski & Zalewski 1987). This number should be even higher as a part of the prehistoric workings has been destroyed upon extraction of limestone prior to World War I. The depth of the shafts is up to 8 m and there are underground chambers running out off their bottoms (Supplement/Photo 102). Charcoal drawings have been rarely found on the walls of the mines. The mining is dated (Budziszewski & Michniak 1984) from roughly 3730 BC (people of the Funnel Beaker culture) to the turn of 1750/1630 BC (Mierzanowice culture) but the most widespread distribution of axes made of the banded silicite falls within the Globular Amphora culture (Balcer & Kowalski 1978). Axes made of this raw material keep being found on a vast territory of the eastern part of Central Europe from the Baltic Sea coast to South Moravia (e.g. Přichystal & Šebela 2004) or to Eastern Slovakia (Trenčanová 1970).

II.2.6.13. Chocolate silicite (chocolate flint, krzemień czekoladowy)

Background: Also this remarkable silicite has drawn the attention of S. Krukowski after the end of World War I; according to the intensity of its distribution in the collections of Palaeolithic and Mesolithic chipped artefacts Krukowski (1920) has made a very precise forecast of its natural occurrences in the southern part of Central Poland. In the years to follow he has not only discovered the first outcrops but also prehistoric extraction places together with geologist J. Samsonowicz (Krukowski 1922, Samsonowicz 1923). Schild (1976) summarized the knowledge on chocolate silicite after World War II.

Location: Outcrops of the chocolate silicite emerge in a narrow stripe between the Radomka and Kamienna Rivers in the NE foreland of the Góry Świętokrzyskie Mts. The stripe runs from NW to SE, it is about 50 km long and 3 to 6 km wide. The most important localities with exploitation of the raw material include Wierzbica I (today's Polany Kolonie II), Orońsko II, Gliniany, Iłża-Krzemieniec, Guzów, and Chronów that have already been known to Krukowski (1939). After World War II the research was continued in Polany and Tomaszów.

Geological Setting: The host rocks of silicites are the Upper Jurassic (Oxfordian) oolitic and clayey limestones, then residual clayey weathering products preserved in karst depressions on limestones. However these rocks do not emerge on the surface as they are always covered by the Quaternary deposits of a varying thickness. In places where the prehistoric extraction was carried out a thin soil horizon is present.

Macroscopic Appearance: The chocolate silicite is such a remarkable raw material that it is usually no problem to make a macroscopic determination. The description below largely ensues from Schild's data (1976). The silicite forms spherical, oval, flat, and even irregular concretions mostly up to 20 cm long and 10 cm wide. The cortex of the concretions is light grey to brownish grey, slightly rough and limy. It is usually thin, up to 0.5 mm; sporadically it may be coarser, according to the above author up to 3 cm. The silicite groundmass has a characteristic waxy lustre. In terms of colour it may be rather variable, although the typical colours vary from dusky yellowish brown (10YR 2/2) to dark yellowish brown (10YR 4/2–10YR 4/4), more scarcely we are aware of transitions to black or red-brown. Schild (1976, 146), who indicates analogous colour hues, has been capable of hiving off 11 varieties of the chocolate silicite based on colour, structure, texture, lustre, translucency, shape, and cortex. However in prehistoric times only 3–4 varieties have been of importance (Supplement/Photo 112).

Stereomicroscopic Appearance: Chocolate silicite is mostly translucent only on the margins, lighter varieties have a better translucency; dark varieties (e.g. Wierzbica) are only slightly translucent. The characteristic feature is the presence of a dispersed, pimple-like clouding (Supplement/Photo 113) caused by altogether regularly dispersed authigene crystals of carbonate of the size up to 0.1 mm. By the side of these a much finer red pigment is present that sometimes highlights tiny simple sponge spicules (these may also be whitish). Relics of black tubular microfossils are present rarely.

Thin section: The study of raw material from outcrops or artefacts from both extraction sites and settlements were carried out in thin sections under the polarizing microscope by O. Juskowiak (in Balcer 1976, 149). However the results have not been so unambiguous as to enable an identification of the individual resources. The texture is cryptocrystalline or cryptocrystalline-spherulitic, more rarely patched. Chalcedony prevails, opal is present as well, pyrite, quartz, phosphate component, iron oxides and hydroxides have been ascertained in an accessory manner. Microcrystalline particles of the prevailing chalcedony are usually sized below 0.01 mm; more rarely they are bigger, from 0.05 to 0.1 mm. The size of microfossils varies between 0.03–0.1 mm, they have elongated or spherical shape, and apart from varieties of SiO_2 they are filled with collophanite (cryptocrystalline apatite), a bituminous substance, or iron hydroxides.

Prehistoric Use: Solitary chipped artefacts made of the chocolate silicite appear already in the Middle Palaeolithic (Mousterian) layers of the locality Piekary II near Cracow or in the Raj Cave in the Góry Świętokrzyskie Mts. The raw material is also rarely present at some Aurignacian sites in Moravia (Slatinice-Kobylí Hlava, district of Olomouc; Lhotka, district of Kroměříž). The maximum of its distribution is concentrated towards the end of the Palaeolithic and the Late Mesolithic periods. The chocolate silicite has also been popular during the Neolithic and the Early Bronze Age. The extraction activities in the prehistoric mines at the Polany II, Polany Kolonie II, and Tomaszów sites (all in the Radom district) are prevailingly dated to the turn of Eneolithic and the Early Bronze Age (for a summation on the prehistoric utilization see Schild 1976). Comprehensive contributions on the use of chocolate silicite in various prehistoric periods can be found in a volume from the conference "Chocolate flint in prehistory" held in Orońsk, 8–10 October 2003 (Borkowski et al., eds. 2008).

II.2.6.14. Dark Cretaceous Ożarów silicite (Ożarów flint, krzemień ożarowski)

Background: It was again S. Krukowski who found evidence on prehistoric mining at the locality of Ożarów in 1923. Than the finding place was out of attention up to 1960, later J. Budziszewski characterized the Ożarów "flint" in a few papers (e.g. Budziszewski 1997).

Location: The raw material crops out again in the Mesozoic rocks in the northern foothills of the Góry Świętokrzyskie Mts. about 21 km to the east of Ostrowiec Świętokrzyski. It lies roughly in the middle between the archaeologically famous silicite sources at Krzemionki and Świeciechów.

Geological Setting: Silicites ("flints") in the surroundings of Ożarów can be found in two levels of the Lower Turonian age (Michniak 1980); the lower horizon of irregularly distributed silicites is connected with opokas, a few horizons of concretional silicites appear in the upper detrital bryozoan limestone.

Macroscopic Appearance: The concretions can have elongated or isometric shapes with the dimensions up to 15–20 cm. A conspicuous whitish cortex of thickness up to 1 cm is typical. The boundary between the cortex and silicite mass is sharp, without any transitional zone. The colour of silicites is described in publications always as dark, usually black, greyish black or grey with brown hue (Supplement/Photo 114). The author has at his disposal samples with brownish grey (5YR 4/1) to brownish black (5YR 2/1) colour according to the Munsell colour chart. Light spots with a diameter of a few mm can appear in the dark siliceous groundmass.

Michniak (1980) has described two basic genetical types and within these he has defined a few varieties. The type A coming from opokas of the lower profile part he divided in the most common grey or black homogenous silicite (variety A1), sometimes with a brown hue and light or dark spots (A2), a black silicite with light grey oval spots or enclaves (A3) and another black variety with conspicuous big white patches (A4).

The type B is represented by concretions from the detrital bryozoan limestone. In its framework he has distinguished grey or grey brown markedly elongated silicite with light spots (B1) or grey light-spotted spherical variety (B2).

Stereomicroscopic Appearance: A grey well translucent chalcedony groundmass contains a lot of small (under 0.1 mm) isometric inclusions of whitish or ochre colour. Bigger white fossil relics (0.5–1 mm) are presented as well, it is possible to determine sponge spicules among them (Supplement/Photo 115). Occurrence of red pigmentation is visible in some parts using a high magnification. Black lumpy to spherical accumulations of organic matter with the diameter of about 0.2 mm seem to be characteristic for the Ożarów silicite. A part of whitish inclusions does reaction with the diluted HCl.

Thin Section: In abundance presented carbonate usually fills fossil relics but it occurs also as small rhombohedral metacrystals in the microcrystalline siliceous groundmass. Some metacrystals are rich in organic matter, so they look like almost opaque. The organic matter forms also lumpy accumulations. Michniak (1980) studied in detail the mineralogical composition of the Ożarów silicite and based on the x-ray investigation he described from the white cortex also cristobalite and calcite besides quartz. Using the scanning microscope he found rhombohedral cavities after dissolved idiomorphic crystals of probably calcite in the silicite mass.

Other Analyses: Six chemical analyses of the Ożarów silicite and two analyses of its cortex have been published by Michniak (1980). Besides the prevalent content of SiO_2 the silicite has also a higher content of CO_2 (0.73–4.44 %), CaO, Al_2O_3 and Fe_2O_3.

Prehistoric Use: A few radiometric ages between 3970 ± 70 to 3370 ± 80 BP (Budziszewski 1997) has been ascertained from the prehistoric mines at Ożarów-Za Garncarzami. According to J. Budziszewski the mining started already at about the middle of 3rd millenium BC when was connected with the Corded Ware culture and Złota culture. Other data based on C^{14} testify for a deforestification of the area and an extensive mining in the 21st century BC (early phase of the Mierzanowice culture). The mines were used up to the late phase of the Mierzanowice culture (18th – 17th century BC).

II.2.6.15. Spotted Świeciechów silicite (Świeciechów flint, krzemień nakrapiany, krzemień świeciechowski)

Background: This raw material has been hived off as separate one already in 1920 by an eminent Polish archaeologist S. Krukowski; its extraction places were discovered in 1923 by geologist Jan Samsonowicz. A detailed account on the cooperation between these two researchers and the issues of the detection of lithic raw materials in the northern surroundings of the Góry Świętokrzyskie Mts. are to be found in the work by Lech (1992).

Location: The raw material occurrences together with other silicites (banded silicite of the Krzemionki type, chocolate silicite, Ożarów silicite) form an important resource area in the northern foreland of the Góry Świętokrzyskie Mts. (southern margin of Central Poland). However the Świeciechów silicite is the only one situated on the right (eastern) bank of the Vistula River, and in the immediate vicinity of its valley as well. In a length around 50 km there the Vistula cuts into flat lying Mesozoic sediments, and separates the Lublin Highland with occurrences of spotted silicite in the east from the Kielce-Sandomierz Highland with the resources of banded and chocolate silicites in the west.

Geological Setting: From the viewpoint of regional geo-logy it is the filling of the southern (Radom – Lublin) part of the so-called marginal trough (S. Cieśliński and M. Jaskowiak in Sokołowski, Cieśliński & Czerminski, eds. 1976). Opokas of the Cretaceous age (Turonian, zone III) that emerge among Świeciechów, Annopol (formerly Rachów), and Gościeradów as the so-called Annopol (Rachów) anticline are the host rocks of silicites. The bedrock contains opokas with tabular cherts. As the

Fig. 67. Chipped artefacts made of the spotted silicite from Świeciechów, central Poland. Height of the artefacts: 6.9 and 6.6 cm. Photo by the author.

territory has undergone at least two continental glaciations, accumulations of silicite fragments appear also in the Pleistocene glacial sediments.

Macroscopic Appearance: Concretions of the raw material are usually tabular. The classic Świeciechów silicite has an attractive appearance and can be well distinguished from other raw materials (Supplement/Photo 110). As its typical sign we can introduce whitish circular spots of the size around 1–2 mm with a quite regular distribution in the silicite matter (Fig. 67) the colour of which is generally closest to dark yellowish brown (10YR 4/2), sometimes passing to dark grey (N3). The cortex is most often thin, usually smooth. Besides the spotted variety B. Balcer has also described a coexistence of a dark grey to black silicite, although this is not suitable for the production of chipped industry because of an irregular fracture. Additionally, B. Krukowski, the discoverer of spotted silicite, has differentiated yet another grey-spotted silicite, which he termed "Gościeradów flint". Nevertheless, according to the current knowledge it is just one of the varieties of the Świeciechów silicite, as both form jointly the same concretions.

Stereomicroscopic Appearance: Although the silicite groundmass is translucent, it contains so many enclosures of various sizes, that when observed by the naked eye, it is only slightly translucent on the edges of artefacts. Out of inclusions whitish clot-like shapes prevail, simple sponge spicules are quite frequent, apparently crystals of carbonate are present as well, and the specific feature is the presence of a greenish mineral glauconite. This has been described from the surrounding marls as well. Sometimes it is possible to find darker pigmented foraminiferans. Light spots may be delimited against the adjacent siliceous mass either sharply (especially the bigger ones), or may pass into it in a cloud-like manner. The spots are filled with a totally non-translucent whitish matter; the bigger of them sometimes show a kind of centre that is more liable to weathering (Supplement/Photo 111).

Thin Section: In conformity with the petrographic research carried out by O. Juskowiak (in Balcer, 1976, 180) the spottiness of the Świeciechów silicite relates to the presence of calcite and opal in the chalcedony matter. The increased contents of volatile compounds (CO_2, water) have also been corroborated by loss on ignition performed within the research of A. Přichystal. Its value with two samples has been ascertained within the range of 1.94–2.14 %; this is more than what is commonly found with other high quality silicites if parts of concretions are analysed without cortex as it was in this case.

Our investigation of thin section has shown microfossil relics filled by fibrous chalcedony or even big quartz crystal spread in the cryptocrystalline siliceous groundmass. Small islands of a carbonate or accumulations of its crystals are present also. Using only one polar the siliceous mass has the light brown colour and contains plenty of small microfossils, especially of foraminiferans and probably fragments of ostracods. Macroscopically seen light spots are surprisingly darker in the thin section because they have a substantial content of dark organic pigmentation.

Prehistoric Use: These issues have been digestedly summarized in more works by Balcer (1976, 2002). The far-reaching transport of the spotted silicite as early as in the Middle Palaeolithic during the Mousterian is very surprising. Kozłowski (1972–73, 6) recorded its sporadic representation among the artefacts in the 100 km distant Raj Cave near Kielce city in the Góry Świętokrzyskie Mts. Even more noteworthy is a finding of two tools made of the Świeciechów silicite in the Solyomkuti abri in the Bükk Mountains in northern Hungary, roughly 400 km to the south from the resource (Vértes 1960). During the Upper Palaeolithic the spotted silicite has been ascertained at a number of Polish sites, both to the north and south from the resource; also noteworthy are its far exports to the Slovak Aurignacian stations Barca and Tibava (around 300 km to the south), a blade from Miskolc in Hungary (Kozłowski 1963), or flakes among Magdalenian artefacts in the Pekárna Cave in the Moravian Karst (Valoch 1975). Its vast distribution comes about towards the end of Palaeolithic and in Mesolithic. It is also used in the Neolithic, e.g. in the period of the Linear Pottery culture isolated artefacts appear as far as in Mohelnice, Moravia, or in Lobeč, Bohemia, which in the latter case represented a transport around 500 km (Kozłowski 1958, 357). The importance of Świeciechów silicite has peaked in the Eneolithic, especially in the period of the Funnel Beaker culture, when silicite axes 15–17 cm long have been manufactured of it on the one hand, and blades up to 30 cm long on the other hand (Balcer 1976, 192). During the Globular Amphora culture its exports have been ascertained especially towards the east (up to 300 km) and north-west (around 500 km). Axes made of the spotted silicite appear among the tools of the people with the Corded Ware culture as far as in Moravia (Přichystal & Šebela 2004); the southernmost find comes from as far as Schiltingeramt near Krems in Lower Austria (Ruttkay 1999).

II.2.6.16. Silicified marls of the Opole Cretaceous

Background: Cretaceous sediments of the Cenomanian to Coniacian – Santonian (?) age emerge in the surroundings of Opole. The Cenomanian has started by conglomerates and the above greenish sandstones, the Turonian is in the limy development (marlites, marlite limestones), the Coniacian – Santonian (?) is built of marlite clays and quartz sands. As regards occurrences of silicites, the Turonian limestones and marlites which total thickness increases towards the west, and may amount up to 180 m, could be of interest. Although S. Cieśliński (in Sokołowski, Cieśliński & Czermiński, eds., 1976, 625–626) has not noted any silicites in the Opole Cretaceous, the Lower Turonian marlites with the occurrences of *Inoceramus lamarcki* and *Inoceramus labiatus* are supposed to be silicified (Książkiewicz, Samsonowicz & Rühle 1965, 169, Tab. 12). More details to the character of silicification have not been ascertained.

Prehistoric Use: There is no record of it as yet.

II.2.6.17. Cretaceous opoka from Zagaje Stradowskie (Świetokrzyskie Voivodeship)

Background: The Lengyel cultural complex can be characterized by a very varied spectrum of local raw materials used for chipped artefacts. This holds not only for the Moravian Painted Ware culture in Moravia, but a similar trend may be observed also in Poland, in the area famous for its high quality silicites. Burchard & Valde-Nowak (2004) have described, apart from the usage of Jurassic silicites from the Cracow-Częstochowa Jurassic and the chocolate silicite, also chipping of a hitherto unrecorded raw material from archaeological site at Zagaje Stradowskie (the Modlnica group of the Lengyel cultural complex) in the Czarnosin district, Świetokrzyskie Voivodeship). J. Tyszka and A. Łaptaś from the Institute of Geological Sciences PAN carried out petrographic determination based on thin sections and designated the raw material as a highly sandy opoka of the Cretaceous age. Surprisingly, this unusual raw material dominated there: out of 136 chipped artefacts it was used for 83 pieces (i.e. 61 % of the entire collection). Although it should have been – because of its petrographic designation (it is not a silicite) – included into the chapter „Other raw materials", with regard to its close relation to the Cretaceous cherts (spongolites) and for transparency reasons it was left in the chapter on Polish silicites.

According to the description by the authors and the published photographs it is a grey coloured rock, non-translucent, with a low surface lustre on the artefact faces. The outcrops of a corresponding opoka in the surroundings of archaeological locality have not been found.

Prehistoric Use: So far utilization of this rock for chipped artefacts has only been known for the Lengyel culture complex.

Silicites of the Carpathians in Poland

II.2.6.18. Jurassic radiolarites of the Pieniny Klippen Belt

Background: The first references on a specific, reddish brown coloured non-translucent silicite at the prehistoric stations around Cracow have been noted by B. Czapkiewicz already in 1936; in the years to follow other researchers have started to designate it radiolarian jasper and have looked for its origin in Slovakia. Even though in relation to the increasing finds of radiolarite artefacts at the Upper Palaeolithic stations around Cracow a potential chipping of this raw material from the Polish Pieniny Mts. and the Tatry Mts. has been considered as early as towards the end of the 1950s, at that time an opinion has prevailed that it was a poor quality raw material and addition heavily cracked. In the 1970s A. Dagnan and R. Schild (in detail see Rydlewski 1989, 25) brought attention to the possibility of acquiring the Pieniny radiolarites again. The cognition of the Pieniny radiolarites was enhanced by the work of Rydlevski & Valde-Nowak (1979), in which the authors have identified the outcrops of radiolarites in the Dunajec River valley and have pointed out their importance. Kozłowski et al. (1981) and Rydlewski (1989) summarized comprehensive data on Polish radiolarites of the Pieniny Klippen Belt.

Location: The Pieniny section of the Carpathian Klippen Belt (the Pieniny Mts.) may be found in the part of southern Poland called „Podhale", about 20 km to the north of the highest Carpathian mountains – High Tatras. The absolutely prevailing part of the Pieniny Klippen Belt is indeed situated in Slovakia but in the Orava Basin it crosses the border to Poland, where it stretches from Stara Bystra in the length of almost 50 km to Jaworki and Biała Woda south-east of Szczawnice to return to Slovakia again as the eastern part of the Pieniny Mts. The altitude above sea level varies between 700–982 m.

Geological Setting: The Pieniny Klippen Belt ("pieniński pas skałkowy" in Polish) is a part of the Western Carpathians, where it is located at the boundary between the Central and External Western Carpathians. Within the Pieniny Klippen Belt nine geological units tend to be differentiated that are collectively called the Oravicum. Radiolarites are bound to limestones of Jurassic age (Callovian – Oxfordian) especially in the deep-water Kysuca-Pieniny Unit; they are not known from the shallow-water Czorsztyn Unit, but they can also occur in the transitional units. The thickness of the formation with radiolarites may reach up to 40 m (K. Birkenmajer in Sokołowski, Cieśliński & Czermiński, eds., 1976, table 30). They have been secondarily displaced into the gravel sediments of the local water streams.

Macroscopic Appearance: In the Kysuca-Pieniny Unit radiolarites form homogenous layers or lentils, and the boundaries between them and the surrounding limestones are sharp. On the fracture surfaces they are smooth with greasy or vitreous lustre. The prevailing colours are reddish brown bluish, green, in places even black. According to Kozłowski et al. (1981) they have suitable qualities for the manufacture of chipped artefacts. Radiolarites from the transitional units are very variable, their average thickness is around 10 cm, but they are heavily cracked, and healed by numerous carbonate veins. The colour is prevalently red or speckled.

Stereomicroscopic Appearance: Radiolarians of the size around 0.1 mm are sometimes poorly visible in the radiola-rites from Niedzica. They tend to be filled either with clear or milky chalcedony; in the latter case they are more conspicuous in the enveloping silicite matter. Sometimes they again have red coloured cores. In several cases a clastic admixture (volcanic quartz?) was noticed. The samples from Szczawnica are heavily cracked and healed by calcite veinlets. Totally black radiolarites from Falsztyn have again not too well discernible radiolarians.

Thin Section: Under polarizing microscope the radiola-rites of the Kysuca-Pieniny unit show a homogenous structure of groundmass formed by recrystallized SiO_2. According to Kozłowski et al. (1981, 187) these radiolarites are supposed to contain tiny idiomorphic crystals of calcite and some samples should have parts resembling opal with big spheroidal shapes of chalcedony. Calcite also sometimes secondarily fills radiolarians and sponge spicules.

Other Analyses: The above paper also mentions the result of semiquantitative spectral analysis that has shown

increased contents of some elements (mainly Mn, Co, Ni, Ti, Al, and apparently also V) in the radiolarites of the Kysuca-Pieniny Unit as compared with the radiolarites of the transitional units. The authors relate the increased contents of Mn and Al with the presence of clay minerals. Blue and green radiolarites comprise a higher presence of U as against the red and speckled radiolarites, which are enriched by hematite pigmentation.

Prehistoric Use: The highly probable exploitation of the local radiolarites as early as in the Palaeolithic (Pavlovian) is exemplified by two miner's wedges made of horns that were discovered in the Obłazowa Cave (in limestone of the Pieniny Klippen Belt 10 km SE of Nowy Targ) in layer VIII dated back to ca 30 000 BC (Valde-Nowak, Nadachowski & Madeyska, eds. 2003). The wedges mean the oldest miner's tools in Europe the analogies to which are known from silicite (flint) mines from the Neolithic and the Bronze Age. The finds of artefacts made of Central Polish silicites (chocolate and Świeciechów ones), Jurassic silicite from the area of Cracow, Volhynian flint from the Ukraine, and rock crystal testify to an enormous operating range of the Obłazowa hunters.

The presence of Pieniny radiolarites has to be assumed in a conspicuous accumulation of the occurrences of radiolarite artefacts in the area of Cracow and its surroundings, where this material appears at the Aurignacian, Pavlovian, as well as Magdalenian stations. In the vicinity of natural resources at the Podhale area another concentration of localities with radiolarite industry is found, ranging from the Upper Palaeolithic to the Lower Bronze Age. In the Upper Palaeolithic stations Sromowce Niżne and Sromowce Wyżne-Kąty the radiolarite accounts for a totally prevailing raw material represented by more than 90 %. Kozłowski et al. (1981) gathered data on the use of radiolarites in the territories of Poland and Slovakia in the prehistoric times.

II.2.6.19. Cretaceous Mikuszowice chert (rogowiec mikuszowicki) of the Silesian Unit, Carpathian Flysch Belt

Background: W. Szajnocha in 1884 introduced the name of chert after the Mikuszowice municipality near Bialsko-Biała (Andrusov & Samuel et al. 1985). In the Czech and Slovak geological literature the term Mikuszowice chert is often replaced by the name chert of the Lhotka Formation. As a raw material for chipped artefacts it was mentioned by Rydlewski (1989) in the archaeological literature.

Location: The occurrences are bound to the northern flysch Carpathians, namely the Pogórze Ślaskie and Pogórze Wielieckie Mts. up to the northern hillside of the Beskid Maly Mts. The eastern edge of the chert resource is situated in an airline distance of about 30 km SW of Cracow. Within the Silesian Unit, the Mikuszowice cherts may be observed in the Polish territory as a strip of occurrences from Bialsko-Biała (Straconka) to Lanckorona near Kalwaria Zebrzydowska (Unrug et al. 1969). Besides outcrops in the flysch belt the chert could be collected from the secondary deposition in river sediments in the southern and SW surroundings of Bialsko-Biała.

Geological Setting: Silicified sandstone to bedded chert form streaks and lenses in the upper part of the Lhotka Formation (the Godula development of the Silesian Unit, Carpathian Flysch Belt). The chert is of the Lower Cretaceous age (the Upper Albian stage).

Macroscopic Appearance: Layers of chert to silicified fine-grained sandstone may reach the thickness up to 15–20 cm. Their structure is distinctly bedded, which may be well observed especially on slightly weathered samples, and shows an alternation of 1–5 mm thick dark and light laminae. Fresh samples are characterized by greyish blue colour (5 PB 5/2).

Stereomicroscope Appearance: Raw material taken in the vicinity of P. Valde-Nowak's archaeological excavation near Swinna Poręba village south of Wadowice can be characterized by clear relics of clastic texture already with 20–30x magnifications. Besides the prevailing quartz also sporadic light mica – muscovite and an authigene bluish glauconite appear although the last one is limonitized with some samples. In this case the raw material should be classified rather as a silicified fine-grained sandstone to chert (Supplement/Photo 119).

Thin Section: The cherts are designated as chalcedony spongolites, e.g. in a textbook written by Bolewski & Parachoniak (1978, 138), it is "spongiolity chalcedonowe" in Polish. The groundmass is built of fine-grained aggregates of chalcedony. Occurrence of sponge spicules filled by chalcedony or their calcite pseudomorphoses have been described also by Foltyn, Foltyn & Jochemczyk (1998, 166). The calcite can appear as small rhombohedric crystals as well.

Other Analyses: As against other silicites, the chert magnetic susceptibility surprisingly shows slightly higher values amounting to 0.05–0.07 x 10^{-3} SI, which is most probably related to the presence of glauconite (a mineral containing Fe).

Prehistoric Use: According to P. Valde-Nowak's information, the chert has been ascertained at the Mucharz 12 site within chipped artefacts of the Funnel Beaker culture and in the Mesolithic inventories. Foltyn, Foltyn & Jochemczyk (1998) have mentioned the using from the Upper Palaeolithic up to the beginning of the Bronze Age; at some Mesolithic sites (for example at Jaworze 8 near Bielsko-Biała) it represents wholly prevailing raw material.

II.2.6.20. Palaeogene Bircza silicite (Bircza flint, krzemień z Birczy) of the Skole Unit (Carpathian Flysch Belt)

Background: The raw material has been noted at the beginning of the 1990s as a result of systematic surface gatherings at the contact of External Western and Eastern Carpathians in SE Poland. Initially the material has had various designations, since 1997 it has been obvious it was a new local raw material. The primary impulse for its identification has been a discovery of a Magdalenian settlement with a few hundreds of artefacts near Hłomcza village that were described by Valde-Nowak & Muzyczuk (2000). Further on the raw material has been characterized

in detail by a collective of authors, Łaptaś et al. (2002), according to its natural occurrence 20 km SE of Dynów as „krzemień z Birczy".

Location: The occurrences of finding sites with artefacts as well as the natural outcrops are concentrated in the territory roughly delimited by Rzeszów, Przemyśl, and Sanok towns; from the geomorphological point of view they are located in the Pogórze Dynowskie, Rzeszowskie, Przemyskie, and Strzyżowskie Highlands. The Magdalenian locality Hłomcza is situated above the San River, in the Sanok area, Podkarpackie Voivodeship. The majority of natural occurrences is found in the broader surroundings of Dynów; the heavily meandering San River flows roughly through the centre of the area to have a prevailing N – S course between Sanok and Dynów, and to turn towards the E – W direction downstream of Dynów towards Przemyśl. The raw material crops out on a vast area of the Pogórze Dynowskie Highland.; thus it is uneasy to locate the places of its exploitation. The type natural site Bircza is situated roughly half way between Sanok and Przemyśl.

Geological Setting: The Bircza silicite originates from the Skole Unit (Carpathian Flysch Belt) where they are a part of a detrital algal limestone that emerges at the base of the Palaeocene-Eocene variegated shale formation ("formacja pstrych łupków" in Polish). Slices (exotic rocks) of silicified algal limestone are also found in the upper part of this formation within lenses of the so-called Babice clays. The host rock of the chert has been characterized by Łaptaś et al. (2002) as a "silicified foraminifera-bryozooa-lithothamnium biocalcarenite rock".

Macroscopic Appearance: The silicite crops out in the form of small fragments or whole concretions on the weat-hered parts of the variegated shale formation. The concretions usually have an oval shape with a silicified centre and a clear, more calcareous periphery, the size of the concretions varies from a few up to 15–20 cm. The colour of the siliceous matter may be considerably variable, from light grey through grey, grey-green, grey-blue, to the most translucent grey-rose. The latter variety has been ascertained at the Slovak side, at the Toporec locality in the Spišská Magura Highland (Łaptaś et al. 2002, 331). According to the Polish authors the variability of colours is caused by chemical processes in the concretions during weathering; therefore they do not distinguish individual colour varieties. An important macroscopic feature is the presence of small whitish spots up to 3 mm sized with vague outlines so that this raw material may be reminiscent of the spotted Świeciechów silicite (Łanczont et al. 2002, 158).

Stereomicroscopic Appearance: The author studied the Bircza silicite from Skodów-Bunacz (a sample provided by P. Walde-Nowak). The siliceous nodule has a thick white cortex having characteristic organodetrital texture. It contains $CaCO_3$ and in places green isometric grains of glauconite. Numerous small white inclusions including monoaxon sponge spicules and other microfossils occur in the dark brown siliceous mass in the central part of the concretion.

Thin Section: According to Łaptaś et al. (2002, 322) thin sections have been prepared from artefacts at more finding sites. The raw material is represented by silicified organodetrital limestone of the calcarenite size (the average size of grains is around 0.3 mm). Remnants of microfossils are common apart from carbonates and chalcedony in a fibrous development. These are above all planktonic foraminifera of the *Globigerina* group, but also benthic foraminifera of the *Miliolina* type. Relics of green algae of the *Dasycladacea* group, sponge spicules, spines of sea urchins, parts of moss animals and red algae have been ascertained as well. Authigene grains of glauconite may appear sporadically.

Prehistoric Use: The Bircza silicite has been found at more than 80 archaeological stations (Łaptaś et al. 2002), which are situated mainly in the eastern part of the Pogórze Rzeszowskie Highland. Its utilization has commenced in the Palaeolithic (the above mentioned Magdalenian Hłomcza station), some artefacts correspond with the Late Palaeolithic (Handzlówka 11). The using during the Early Neolithic is documented by the Łańcut 3 station (the Linear Pottery culture); workshops producing quadrangular axes (Maćkowice 5) or sporadic finds accompanied by the Funnel Beaker culture pottery apparently fall within the Eneolithic. There were also finds of artefacts together with the Bronze Age pottery (the Tarnobrzeg group of the Lusatian culture). The authors even admit to extraction of this raw material in a mining manner. A more important role was played by the Bircza silicite primarily in the area of its natural occurrences; its export to the territory of the today's Slovakia and the Ukraine is also likely. From the probably Magdalenian locality Toporec (the Kežmarok district, Upper Spiš, Slovakia) several chipped artefacts just from this raw material are mentioned (Soják 2002, 274).

II.2.6.21. Palaeogene menilite chert of the Dukla Unit (Carpathian Flysch Belt)

Background: The name menilite is derived from the Menil Montan locality in the Paris Basin and according to data in the French geological literature it appeared already at the end of 18th century. In Moravia the using of brown menilite shales and cherts for Palaeolithic chipped artefacts has been known since the 1930s (see chapter „Silicites of Moravia and Silesia"), although these raw materials have never been widespread there. This makes an extensive processing of better quality black menilite cherts from the Dukla Unit in SE Poland and NE Slovakia even more interesting. The use of the above raw material at the Polish side has been pointed out by Valde-Nowak (1987).

Location: The main occurrences of menilite layers emerge in the eastern part of the Polish flysch Carpathians within the Dukla Unit. The unit is wedge-shaped, and in the territory of Poland its southern margin may be delimited by the state border with Slovakia from the Dukla Pass towards the east, to the Wołosanka River valley (a sinistral tributary of the San River), the northern margin runs from Wołosanka through Cisno as far as Nowy Żmigród

Fig. 68. Menilite chert, Carpathian Flysch Belt, SE Poland. Length of the sample 8.3 cm. Photo by the author.

20 km SW of Krosno. Menilite cherts are also a component of other nappe units in this part of the flysch belt: the Silesian Unit and especially the Skole Unit. In the Skole Unit geological maps indicate menilite cherts from the area between Przemyśl and Sanok, in the Sileasian Unit e.g. in the broader surroundings of Krosno.

Geological Setting: The Dukla Unit is a part of the Carpathian Flysch Belt, and represents the innermost nappe of the Silesian – Krosno (earlier Krosno – menilite) Group of nappes (for more detail see Chapter I.3). Its name derives from the little town Dukla in the foothill of the Beskid Niski Mts. near the Polish – Slovak border, in the vicinity of which one of important passages through the Carpathians (the Dukla Pass) is located. The main occurrence of this nappe unit is in SE Poland, it partly reaches NE Slovakia and the Transcarpathian Ukraine. In the Polish territory the Dukla Unit is located to the east of the Dunajec River, and it stretches in the NW – SE direction for the length over 100 km and the width around 10–12 km. By the side of the Dukla Unit proper analogous rocks emerge to the west of it in tectonic windows from below the inner Magura Group of nappes; one of the most important is the occurrence in the Ropa River valley.

The Menilite Formation of the Lower Tertiary (Oligocene) age is a part of the Dukla Unit. In the east its thickness varies around 200 m and comprises several layers: submenilitic layers, Kotów cherts layers, Jawornik marlites (a temporal analogy of Dynów marlites from the Skole Unit), Cergow layers and upper menilite layers that are replaced by Krosno layers in the southern part of the Dukla Unit (Kotlarczyk et al. 2006).

Macroscopic Appearance: Chert layers may reach the thickness up to 40 cm, they have greyish-black to black (N 1) colour, a characteristic waxy lustre, and a conchoidal fracture (Supplement/Photo 122). The layer surface and some cracks are often covered by thin encrustations or little speckles of rusty Fe hydroxides (limonite).

Stereomicroscopic Appearance: Under the stereomicroscope the rusty speckles on the cracks may be interpreted as tiny limonitized crystals of pyrite (under 0.1 mm). The silicite matter is non-translucent in bigger pieces, very thin little splinters show through with a brown colour. No fossils have been noted, only an irregular appearance of tiny black speckles (accumulations of organic matter) and non-weathered small crystals of pyrite with aureate lustre. Magnetic susceptibility is lower than 0.01 x 10^{-3} SI.

Thin section: See description of menilite cherts in Slovakia.

Prehistoric Use: In the area of Ropa tectonic window numerous prehistoric sites with chipped artefacts made of black non-translucent menilite chert of a local origin have been ascertained in the 1980s by surface gatherings. At the very southern margin of Ropa village (Nowy Sącz Voivodeship) an occurrence of not only plentiful natural fragments but also 341 artefacts has been discovered to be interpreted as a site of prehistoric exploitation (Valde-Nowak 1991). From the typological point of view, pieces of the raw material in an initial stage of processing (i.e. with scarce negatives after chipped-off flakes) and flakes prevail, cores and tools are present less often. Some of the artefacts may be interpreted as exploitation tools. According to Valde-Nowak (1991, 81) the decisive exploitation activities fall within the Lower Bronze Age.

A gradual recording of menilite artefacts not only in the Polish part of the Beskid Niski Mts. but also in adjoining Slovakia has pointed out towards the utilization of menilite chert in a scarce manner from as early as the Middle Palaeolithic, more often in the Upper Palaeolithic – the Gravettian settlement at Hrčel (Kaminská 1986), also in the Tiszapolgár, Baden, and East-Slovakian Barrow cultures. A unique find is a small axe from Bušovce (Kežmarok District, Spiš area, NE Slovakia) with 69 x 42.5 x 18 mm dimensions made of this raw material (Soják & Novák 2004). On the grounds of typology the authors consider it to be most probably connected with the Neolithic. Foltyn, Foltyn & Jochemczyk (1998, 170) mentioned two finished and one semi-finished axes made of menilite chert from the western part of the Carpathian Flysch Belt in Poland. Isolated finds of the menilite battle-axes or their fragments connected prevalently with the Funnel Beaker culture have been introduced by Foltyn & Foltyn (2001, 62), they were ascertained even in the Lusatian culture inventories (the Late Bronze Age). In the western part of the Polish flysch Carpathians the menilite chert was used for chipped artefacts only sporadically.

II.2.6.22. Palaeogene Jawornik silicified marlstone to chert of the Dukla Unit (Carpathian Flysch Belt)

Background: The first artefacts made of this raw material have been discovered by J. Ginalski and A. Muzyczuk in 1993, during a field survey of the Góra Cergowa Mt. massif situated in the Beskid Niski Mts. (a part of Polish External Carpathians). Further research within a joint Polish and Slovak project focused at the entire Beskid Niski Mts. has confirmed the importance of the raw material in the wider surroundings of Dukla town – actually

the site of its processing and probable exploitation has been found (Budziszewski & Skowronek 2001).

Location: The Góra Cergowa Mt. (716 m) is situated ca 3 km SE of Dukla town, in the vicinity of a marked north-southern valley of the Jasiołka River. It flows through the Beskid Niski Mts., and together with the Dukla Pass it constitutes a passage though the Carpathians and a junction between the lowlands of eastern Slovakia and the Jaslo-Krosno Basin (Kotlina Jasielsko-Krośnieńska in Polish) in SE Poland.

Geological Setting: Jawornik silicified marlstone is a part of the Menilite Formation in the Dukla unit, and therefore it is an analogy of the Dynów marlstone from the Skole Unit mentioned lower. Geological situation of the Góra Cergowa surroundings has been described in detail in the work by Koszarski (2001). The natural finding site is a part of the Dukla Unit close to its boundary with the Silesian Unit. As a result of two major overthrust faults analogous rocks of the Menilite Formation are repeated in an inverted order at the Góra Cergowa Mt. as well as the more westerly situated the Mała Góra Mt. Both sequences of rocks consist of menilite beds with cherts, in the bedrock of which the Cergowa sandstone emerges as a result of upturning of beds, followed by the Jawornik silicified marlstone with inferior layers of cherts and the bottommost deformed slices of the Menilite and Krosno Formations. The age of Jawornik silicified marlstone is the Oligocene.

Macroscopic Appearance: Fragments of marlstone from the environs of the probable exploitation site have the same surface (patina) as artefacts: light brown to brownish or greenish hue of whitish colour. If round pebbles from water courses were chipped, they have rich brown coloured surface that tends to be preserved in relics even on artefacts. Usually a red-brown layer appears under the light patina, the fresh rock is black-green in its central part, and reacts with diluted HCl.

Stereomicroscopic Appearance: Artefacts have even more millimetres thick beige decalcified patina, with which the original bedding is indicated by a parallel arrangement of thin dark inclusions. The same may also be noticed in the dark greyish-green marlite core of the artefact. A tiny pyrite crystal is preserved from time to time.

Thin Section: The black-green rock from the core of fragments or artefacts consists of up to 90 % of micrite limestone (Budiszewski & Skowronek 2001, 156), detritic and clay component parts probably account for a mere 5 %. Furthermore, somewhat bigger grains of quartz have been observed, and a presence of dispersed iron hydroxide and oxide pigments. SiO_2 is scattered in the form of opal, in places is recrystallized into chalcedony among a fine-grained calcite. Relics of diatoms and other siliceous organisms may be observed as is microfossils presence. Muscovite and green chlorite appear in an accessory manner. Weathered light surface parts are depleted of calcite.

Prehistoric Use: A prehistoric workshop has been ascertained in the massif of the Góra Cergowa Mt., on a subsidiary peak the Mała Góra Mt., where the Jawornik silicified marlstone underwent processing. A place of its extraction has been discovered about 750 m to the SE of the workshop. The temporal classification of the sites from the Góra Cergowa Mt. may hitherto be performed only in a tentative manner, and placed into an extensive period from the Funnel Beaker culture to the Lower Bronze Age (Budiszewski & Skowronek 2001). A relationship to the people with Corded Ware appears probable because of an analogous raw material used in Slovakia.

II.2.6.23. Palaeogene Dynów silicified marlstone of the Skole Unit (Carpathian Flysch Belt)

Background: This interesting raw material has been first pointed out by Dagnan-Ginter & Parczewski (1976) when they studied chipped industry from the sites Hłudno and Wesoła in the Pogórze Dynowskie Highland; they consulted its provenance with geologist J. Kotlarczyk. Further research has proven its important usage during the Eneolithic and in the Early Bronze Age.

Location: Municipality Dynów is located on the San River 40 km to the west of Przemyśl; a highland of the same name stretches between the San in the east and the Wisłok valley in the west. To the SE of the San valley it is the Pogórze Przemyskie Highland. In terms of geology the Pogórze Dynowskie Highland is formed mainly by the Skole Unit, in the northern surroundings of Krosno by the Silesian Unit.

Geological Setting: Dynów silicified marlite emerges within the Skole Unit, which represents an outer margin of the flysch belt in SE Poland. The Dynów marlite is a part of the Menilite Formation: its bedrock in the Skole unit is comprised of sub-chert layers formed by clayey, often marly shales first, then by Kotów chert layers where cherts were originally represented by diatomites. These are followed by the Dynów marlite the overlying stratum of which are the Rudawka beds with a layer of Tyława limestone and Nowy Bor beds (Kotlarczyk et al. 2006, 10).

Macroscopic Appearance: On a fresh fracture the Dynów silicified marlstone is black-green rock without a discernible graining; it reacts with diluted HCl. Nevertheless, archaeological artefacts are brownish or whitish coloured because of a several mm thick patina – the original appearance of the rock often tends to be preserved only in the central part. Both fresh and patinated parts cannot be scratched by the knife.

Prehistoric Use: The Dynów silicified marlstone was chipped throughout the Neolithic and Early Bronze Age (Jarnot-Kozłowska 1988). Apparently the same, or a very similar raw material is also „łupek dynowski“ (Dynów shale), out of which polished axes from the sites in the Wisłok River valley and its surroundings have been manufactured (Ligoda 2006).

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II.2.7. Silicites of Slovakia (Fig. 69)

In Slovakia, the most decisive role among local raw materials for chipped artefacts played Jurassic radiolarites from the Pieniny Klippen Belt, Miocene limnic silicites (in older Slovak geological literature having a misnomer limnic quartzites) and Palaeogene nummulite silicites (Mišík 1975, Bárta 1979). Relatively less there were used cherts from the Mesozoic limestones of cover units of the Tatricum and the Fatric, Hronic or Silicic superficial nappes. Kaminská (1991) described a use of local menilite chert in eastern Slovakia where the Carpathian Flysch Belt goes from SE Poland. Other Slovak raw materials have been placed in the correct genetic groups: quartz, opal, chalcedony and jasper having hydrotermal origin in Miocene volcanic rocks or connected with weathering processes are characterized within minerals of SiO_2, obsidian is classified as a volcanic glass and the group of other rocks is represented by chipped andesites, silicified tuffs, pebbles of silicifed sandstones and marlites coming from rivers of eastern Slovakia (the Torysa and Hornád Rivers). The so-called Ondava or brown cherts (Kaminská 2001, 84; Vizdal 2002, 120) represent probably heavily silicified claystones or marlstones (in essence lithological analogies of the Dynów or Jawornik silicified marlstones in the territory of Poland). In the following text there are also shortly mentioned Palaeozoic cherts in Slovakia because their prehistoric using has been described only exceptionally.

II.2.7.1. Lower Palaeozoic lydites (radiolarites) of the Gelnica Group (Gemericum) and of the Harmónia Group (Malé Karpaty Mts., Tatricum)

General Overview: They crop out as dark interlayers for example in the surroundings of Betliar or Smolník in more formations of the Gelnica Group (Gemericum). They have Lower Palaeozoic age (Silurian, Lower Devonian). Relics of radiolarians have been found in some of them, it was possible also to separate radiolarians with preserved surface texture. Timing is based on the presence of palynomorfs. Their dark colour is connected with a high presence of carbon (average content 0.5 %, maximally up to 1.46 %), V and Cu as the trace elements have a positive correlation with carbon. Mišík (1999) summarized the data concerning these silicites for the last time.

Probably a Devonian lydite (radiolarite) is also known from the Harmónia Group in the Malé Karpaty (Little Carpathians) Mts. (Tatricum). In addition, pebbles of the Palaeozoic lydites are to be found in some younger conglomerates (see Mišík 1999, 491–492).

Prehistoric Use: Mišík (1975) registered two pieces of the Paleozoic radiolarites (lydites) used for Palaeolithic chipped artefacts at Hlboké and Kunov I (district of Senica). He has considered their provenience more probably as pebbles from gravels of the Morava River or from the Cretaceous conglomerates in the Pieniny Klippen Belt.

II.2.7.2. Upper Carboniferous and Permian limnic silicites (geyserites)

General Overview: Similarly as in the limnic Permo-Carboniferous of the Bohemian Massif we know a few types of limnic silicites; there are mentioned red limnic silicites from the Nižná Boca Formation of the Upper Carboniferous age in the Little Carpathians Mts. or from the Permian Rožňava Formation (Vozárová & Vozár 1988). The authors have interpreted them as geyserites. They can be found also as pebbles in the Lower Triassic conglomerates, psephite fragments in Jurassic limestones of the Czorsztyn and Nižna Units or in the Cretaceous Upohlava conglomerates (general data on the secondary occurrences see in a paper of Mišík 1999, 491).

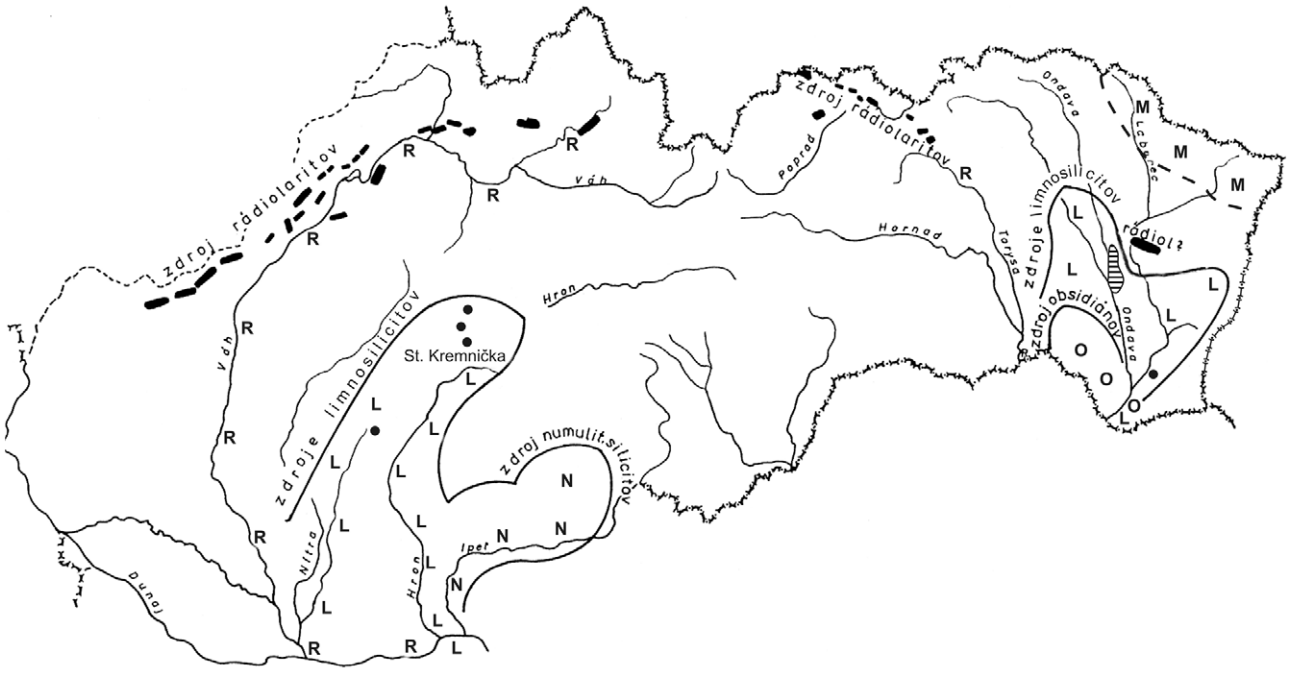

Fig. 69. Sources of silicites and obsidian in Slovakia. Adapted map after Mišík (1975). Black spots – occurrences of radiolarites in the Pieniny Klippen Belt; black small circles – the most important sources of limnosilicites; R – pebbles of radiolarite in gravels of the Váh and Orava Rivers; L – pebbles of limnosilicites in river gravels; N – pebbles of nummulite silicites in Lower Miocene gravels; M – menilite cherts in the Dukla Unit; O – occurrences of obsidian; horizontally hatched area around the Ondava River – gravels with abundant pebbles of the Ondava brown chert (silicified claystone).

Prehistoric Use: Chipping of these raw materials has not been described (if they are not hidden under the term jasper in the studied archaeological collections).

II.2.7.3. Triassic radiolarites of the Meliata Unit, SE Slovakia

General Overview: Radiolarites of the Triassic age (Ladinian to Carnian) have been mentioned only from the Meliata Unit in the Western Carpathians. They form big olistoliths in a mélange of the Jurassic age for example at the type locality Meliata or at Držkovce and Bohúňov. At Meliata, the red radiolarites are changed to red silicified limestones with a total thickness of about 20 m. In thin section they are built of microcrystalline quartz, in places with lamellae of hydromica, chlorite and silty particles of quartz; rutile, tourmaline and apatite occur as heavy minerals. Metacrystals of carbonates can reach up to 0.5 mm (Harman & Borza 1970). According to Mišík (1999, 492), the deposit of iron ores at Bradlo near Jelšava having probably the Triassic age is in fact a deposit of heavy hematitized radiolarites.

The Triassic radiolarites appear also as pebbles in the younger Cretaceous conglomerates near the Dobšiná Ice Cave or as fragments in the Jurassic limestones of the Pieniny Klippen Belt at Milpoš. Mišík (1999) has also published two chemical analyses of radiolarites from Meliata (including some trace elements – Cr, Cu, Mn, Ti, B, Ba, Sr).

Prehistoric Using: It has not been described yet.

II.2.7.4. Triassic and Lower Jurassic cherts from the core mountains of the Tatricum

General Overview: These cherts (if they were chipped at all) had very probably only a local significance because it was not registered their considerable occurrence among raw materials of chipped artefacts in Slovakia. Mišík (1969, 120) mentioned them briefly as potential raw materials but he did not find them in the Slovakian Palaeolithic chipped industries.

When surveying these potential raw materials, the oldest Middle Triassic cherts are represented by black cherts in the Reifling limestone that is a part of the Choč nappe and than they appear in some Triassic dolomites. Distinctly red cherts have been introduced from dolomites of the Upper Triassic ("Carpathian Keuper") in the High Tatras Mts.

A bigger significance could have the Lower Jurassic cherts cropping out as black or dark-grey spongolites or spicule-rich cherts in the Krížná nappe.

II.2.7.5. Jurassic radiolarites

Jurassic radiolarites of the Western Carpathians occur not only in the Pieniny Klippen Belt but also in other geological units (see an outline of Mišík 1999): in the Flysch Belt, in the so called Drietoma, Haligovce and Manín successions (interpreted as probably the Fatricum incorporated in the Pieniny Klippen Belt), in the Vahicum cropping out in the Považský Inovec Mts. (Lazy Formation).

As is the Upper Palaeozoic – Mesozoic cover units of the Tatricum concerned, the radiolarites appear only extraordinary in the Šiprúň succession in the Velká Fatra and Malá Fatra Mts. Jurassic radiolarites have been described also from limestones of the Krížná nappe (Fatricum), Silica nappe (Bohúňov, Bleskový spring near Drnava, Miglinc valley) and in the Meliata Group. They are not registered in the Choč nappe (Hronicum). There is no doubt about prehistoric using of the Jurassic radiolarites from the Pieniny Klippen Belt that is why the attention is paid to them below.

Middle- to Upper Jurassic radiolarites of the Pieniny Klippen Belt

General Overview: Radiolarite is a hardened silicite (chert) of an organogenic origin that consists of more than 50 % of siliceous shells of radiolarians. This is a large group of entirely marine protozoa having a shell with a perforated membranous capsule and a siliceous or strontium sulphate skeleton made up of spicules, bars and spines. They have been known since the Cambrian Period up to present. In the nowadays oceans the non-hardened radiolarian sediments are characteristic for the deep parts, between 3,600 and 8,100 m. Apart from the prevailing radiolarian shells the radiolarites contain argillaceous minerals and oxides or hydroxides of Mn and Fe. If the radiolarian content is less than 50 %, the raw material should be designated as radiolarian chert.

Radiolarites rank among the most important Central European raw materials the use of which is evidenced as early as from Middle Palaeolithic. Their overregional significance is evident since the Upper Palaeolithic when they were broadly transported towards Moravia and also Bohemia. In Slovakia, the radiolarites were extracted at more places within the Pieniny Klippen Belt, another region of intensive exploitation is connected with only 50 km long part in the Polish territory (see chapter Silicites of Poland).

Yet it is a great problem to distinguish the individual sources within the Pieniny Klippen Belt, in addition the radiolarites as resistant materials were moved into gravels of the Váh River and other water flows crossing the belt or running in its surroundings (the Vlára, Kysuca, Orava Rivers and others). Moreover, Jurassic radiolarites have been secondarily transferred not only to the Pleistocene gravels of the Váh and the Danube, but they may also be found in the gravels of the Tertiary (Lower Badenian) Age in the Carpathian Foredeep in southern and central Moravia. Another similar radiolarite source with evidenced prehistoric mining has been known from Wien-Mauer (see chapter Silicites of Lower and Upper Austria) and there are more radiolarite exploitation places in Hungary. In spite of application of modern analytical or micropaleontological methods (Kozłowski et al. 1981, Cheben 2005) for the time being we are unable to make a reliable differentiation of radiolarites from these geographically different sources, as they are basically of the same age, have emerged under analogous sedimentation conditions, and they feature a similar macroscopic and microscopic appearance, mineralogical and chemical composition. The best results gave a detailed investigation of radiolarians carried out by Ožvoldová (1987, 1988). On the basis of so called unit associations (U.A.) that characterize a certain time interval and are represented by a group of together occurring species it has been possible to distinguish the radiolarites from individual localities of the Pieniny Klippen Belt. The radiolarites from the Podhradská dolina valley near Pruské, the Keblie Hill near Púchov and Červený Kameň near Podbiel appeared to be the oldest ones (U.A. 5–U.A. 6, Upper Callovian – Lower Oxfordian). The famous radiolarite horizon from the surroundings of Vršatské Podhradie village has a long time interval, its sedimentation started in the Upper Callovian (U.A. 5) as well but the upper part of the horizon can be correlated with the Upper Oxfordian – Lower Kimmeridgian (U.A. 7–U.A. 8). These last mentioned U.A. correspond also to localities Brodno, Snežnica, Lopušné Pažite, Myjava-Turá Lúka, the lower part of these horizons has not been identified. The radiolarites from Lednica have shown the youngest time interval within the Upper Jurassic (U.A. 8 and U.A. 9, Lower and Upper Kimmeridgian).

The Pieniny Klippen Belt is a narrow (5–20 km) but long geological unit contains a number of klippes consisting of Jurassic limestones with radiolarites and cropping out in a length of about 320 km in the territory of Slovakia. It starts at Podbranč, 7 km to the NE of Senica in southwest Slovakia, then continues to the White Carpathians Mts. and in the west of Trenčín it goes very close to the Váh valley. It continues in parallel way with the Váh River to the famous occurrences in the vicinity of Horní Srnie and Vršatské Podhradie, only 3 to 4 km from the state border of the Czech Republic. At Bytča it turns to the almost W – E direction with an important source at Brodno in the Kysuca Gateway (north of Žilina). Concretions of the local high quality radiolarite can weigh about 6 kg. In addition of it, the locality lies at an old important way along the Kysuca River connecting the Váh valley in Slovakia with the area of Těšín and Ostrava in Czech Silesia. The Pieniny Klippen Belt than runs from the Kysuca Gateway north of the Malá Fatra Mts. and along the Orava River to the state border with Poland where it continues 50 km in the Polish Pieniny Mts. North of Stará Lubovňa it comes back to the Slovak territory and can be followed as a line of small occurrences to the SE where it is covered by neovolcanites of the Vihorlat Mts.

Radiolarite of the Vršatské Podhradie type (NE of the Vlára Pass)

Background: Moravian researchers registered the conspicuous reddish brown raw material among the Neolithic chipped artefacts already in the second half of the 19th century but up to fiftieth of the 20th century the raw material had been determined as jasper. Based on cooperation with an amateur collector A. Richter from Valašské Klobouky and other collectors from the area of Bojkovice, archaeologist J. Skutil introduced the radiolarite source to the specialized literature shortly after the 2nd World

Fig. 70. Pieniny Klippen Belt in the surroundings of Vršatské Podhradie. Postcard, 1936.

War. Large concentration of chipped radiolarite artefacts around the Vlára Pass caused he defined so called "Vlára Palaeolithic" that used especially the local raw material and formed an independent geographical region or even chronological group (Skutil 1947, 31). He ranked the artefacts to the Upper Palaeolithic and compared them with "an Upper Aurignacian phase from Předmostí". As the first J. Skutil highlighted the prehistoric mining of radiolarite on the Slovakian side south of Sidonia settlement at the limestone klippes Tri kopce and Vršatské Podhradie (Skutil 1947, 32; 1960, 10). He put the mining to the Palaeolithic and he believed to be the oldest evidence on raw material extraction in Central Europe. Vencl (1967) re-evaluated the Vlára Palaeolithic as workshop places situated in the source surroundings and originated during the whole Stone Age, not only in the Palaeolithic but also especially in the Neolithic and Eneolithic. Cheben et al. (1995) confirmed the prehistoric mining at the locality Tri kopce (Bolešov cadastral area) but they have regarded it as probably the Neolithic one. Another extraction field with more than 50 mining pits they found in the cadastral area of Borčice and Horné Srnie, six mining pits have been ascertained in the part Bukovina of the Krivoklát village cadastre and two pits at the Lysá Hill near Vršatské Podhradie (Cheben & Cheben 2005). The author of this book has collected chipped radiolarite artefacts (including rarely burnt) for about last 15 years in the vicinity of probably mining pits on the southern slope of the spot height 819 m (the area called Lysá), to the SW of the Chmeľová Hill (925 m).

Location: The village Vršatské Podhradie is located 4 km to the east of the border with the Czech Republic and 7 km as the crow flies to the SE of the Vlára Pass. So, occurrences of the Jurassic limestones with radiolarites are close to this important path being active since the prehistoric times but the Vlára Pass itself lies on clastic sedimentary rocks of the Carpathian Flysch Belt (the Magura Group of nappes). In geological maps there is no occurrence of limestone with radiolarite in the Vlára Pass area. That is why the Vlára Pass cannot be a source of radiolarite raw material because only workshops based on the radiolarite imported from a distance of about 8–10 km are situated there. The principal source of radiolarite crops out among the villages Vršatské Podhradie, Bolešov and Horné Srnie. From the geomorphological viewpoint, the area lies in the Bílé Karpaty (White Carpathians) Mts.

Geological Setting: Limestone klippes in the surroundings of Vršatské Podhradie (Fig. 70) are a part of the Pieniny Klippen Belt, i.e. the most important geological unit at the border between the Outer and Central West Carpathians. In the frame of the Pieniny Klippen Belt there has been distinguished a few lithofacial developments that were brought close together later tectonically. In the last geological map 1 : 50 000 of the Vršatské Podhradie area (Began et al. 1993) three units have been mapped: Czorsztyn, Kysuca and Drietoma ones. In the Kysuca Unit the Jurassic radiolarites form one belt cropping out in a few isolated slices arranged in the NE – SW direction: southern part of Červený Kameň village, west and north of the Chmeľová Hill, the area called Rychtárska, southern vicinity of the spot height 508 m near Vincúrova up to the part Dračica and Bolešov-Pri troch kopcoch. Two belts of radiolarites with analogical direction are within the Drietoma Unit: the first runs roughly between Vršatské Podhradie and Chotúč, the second one lies to the south of Krivoklát. The Csorsztyn Unit does not contain radiolarites. The formation with radiolarites form narrow but long belts, the dip of layers is very steep to almost vertical. According to data by Cheben (2005, 36), radiolarite layers up to 25 cm dominate in the Kysuca Unit while concretions with bigger diameters are present in the Drietoma Unit.

Macroscopic Appearance: Radiolarite can form both layers and concretions in the area of Vršatské Podhradie. The layered radiolarite is always strongly tectonically damaged and interwoven with a net of calcite veinlets. That is why the concretional radiolarite, usually of loaf- or disc-like shape, were looked for. The prevalent colour is dark reddish brown (10R 3/4) or greyish red (10R 4/2), commonly with green or pale olive (10Y 6/2) schliers or bands with thickness of about 1 cm or more. The green colour forms usually the concretional margin while the core is reddish brown with only green schliers (Supplement/Photos 125, 126). It is possible to find also greyish blue radiolarites (5PB 5/2) blending into almost black or moderate yellowish brown (10YR 5/4). All these mentioned colour types (even if the reddish brown and green hues prevail) are present at a well-known workshop Sidonie in the Vlára Pass. But the workshop is situated on the flysch rocks about 8 km far from the source. Lustre of radiolarite can be both glassy or matt, thin veinlets of pale olive colour in a reddish brown groundmass are common.

Stereomicroscopic Appearance: Radiolarian shells with diameter of about 0.1–0.2 mm and with transparent or whitish filling (Supplement/Photo 127) occur in brownish red, green grey or bluish grey siliceous groundmass. Some of them have preserved white spines (western slope of the Chmeľová Hill); polyaxon spicules are visible as well. In addition there are present semolina-like spheroidal or rhombohedral inclusions that have been determined

under the polarising microscope as carbonates. But they do not react with diluted HCl. A net of hair-like thin veinlets is possible to see usually only if you use the stereomicroscope.

Thin section: Many microfossil relics being filled by bigger and lighter aggregates of chalcedony occur in the cryptocrystalline siliceous groundmass (Supplement/Photo 128, 129). It is possible to distinguish radiolarians, sponge spicules, rarely foraminiferans or parts of crinoidal segments. In accordance with Mišík (1975, 97) there were found dark brown phosphatic fish scales or teeth with dimensions around 0.1–0.2 mm. Other minerals are represented especially by carbonates (commonly as calcite rhombohedral crystals), less by biotite, chlorite and clay minerals.

Radiolarians are the most important microfossils and after their separation it is possible to determine them into species (see a detailed investigation of L. Ožvoldová in Mišík 1975, 97). Using thin section we are able to classified radiolarians only generally to genus (L. Ožvoldová in Cheben 2005, 40).

Other Analyses: More researchers tried to characterize and distinguish radiolarites from different natural sources or archaeological finding places in Slovakia, Poland, Hungary and Austria using determination of principal oxides and trace elements. Kozłowski et al. (1981) have written an important contribution focussed on the topic. Two radiolarite artefacts from the Palaeolithic site at Pavlov and three comparative samples (two artefacts from the workshop at the Vlára Pass and one from the Pieniny Mts. source) were studied on the base of trace elements (Přichystal 1994). Comparing other silicites, the all five radiolarites has had higher contents of Mg, Fe, V, Ni and Ba. No differences have been found in composition of green and red brown radiolarites excluding higher contents of Ba in the green ones. The chemical composition of radiolarites from Pavlov is comparable with that of radiolarite from the Pieniny Klippen Belt.

M. Cheben under the guidance of the author carried out another comparative study in the framework of his master thesis (Cheben 2005). Besides 14 radiolarites from outcrops and workshops in the area of Vršatské Podhradie – Bolešov – Vlára there were analysed also samples from other parts of the Pieniny Klippen Belt (from west to east: Brodno, Nemšová, Falsztýn, Kyjov), from Vienna-Mauer and two radiolarites from Hungary (Szentgál, Gerecze). As the 14 samples from the studied area concerned, there is evident negative correlation between SiO_2 and CaO (but no such correlation between SiO_2 and MgO or between SiO_2 and Al_2O_3). It can be explained by occurrence of $CaCO_3$ in younger veinlets or connected with metacrystals. A detailed discussion of trace elements and rare earth elements in the studied radiolarites can be found in the master thesis of M. Cheben where he states impossibility to distinguish radiolarites from various sources based on their chemical composition.

Prehistoric Use: The high quality radiolarites of the Vršatské Podhradie type were evaluated already in the Palaeolithic. Valoch (2003) described two flat Levalloisian

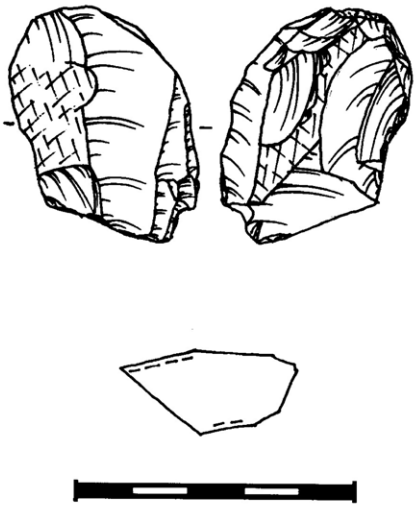

Fig. 71. A core made of red-brown radiolarite found near the top of Soláň Mt. (861 m) in the Moravskoslezské Beskydy Mts., Carpathian Flysch Belt. For details see Přichystal & Štěpánek (2004). Drawing by Z. Nerudová.

radiolarite cores from Brumov-Bylnice and Povláří (i.e. from the vicinity of the Vršatské Podhradie source) and he considers them as evidence on the source knowledge by the Middle Palaeolithic hunters. Really, in SE and central Moravia radiolarite artefacts appeared already in the Middle Palaeolithic, for example a handaxe at Karolín near Kroměříž (Supplement/Photo 130) or at Přerov-Předmostí. Radiolarite was the key raw material for the near Upper Palaeolithic sites in the Váh River area (western Slovakia), it occurs also in various quantities at many Upper Palaeolithic sites in Moravia. The most prominent one among them is the Aurignacian site Tvarožná east of Brno where radiolarite is the dominant raw material even if its source lies more than 100 km to the east in the Bílé Karpaty Mts. Colour spectrum of the used raw material and its stereomicroscopic appearance including numerous hair-like thin veinlets give evidence on the origin from the area between Vršatské Podhradie and Horné Srnie (Supplement/Photo 131). Besides the site at Tvarožná radiolarite is substantially present also at other Upper Palaeolithic stations just in Brno, for example in Brno-Jundrov or at the Stránská skála Hill (Brno-Slatina). The Carpathian radiolarite significantly occurs at some famous Gravettian (Pavlovian) settlements especially at Milovice or Pavlov. It has been found at the Magdalenian cave sites in the Moravian Karst or at Mesolithic camps in SE Moravia.

According to the prevalent part of researches, the large workshops found on the both (Slovakian and Moravian) sides of the natural source area (for example Sidonie in Moravia or Slavnica in Slovakia) testify for processing of radiolarite in the Post-Palaeolithic period. As is the Neolithic cultures concerned, radiolarite is present usually only in a small amount but its importance went

up at the end of the Eneolithic and in the Early Bronze Age. It represented one of the key raw materials in the period of Nitra group (Early Bronze Age), for example at the burial ground Holešov it was the second most important raw material with 25 % presence (Přichystal 1985). Individual radiolarite artefacts can be found at relatively high altitudes in mountains at the borderland between Moravia and Slovakia (Fig. 71).

II.2.7.6. Uppermost Jurassic to Lower Cretaceous cherts

General Overview: Mišík (1973) studied in detail these cherts from twenty Slovakian natural localities. They occur in the Pieniny Klippen Belt, cover units of the Tatricum and the Krížná nappe (Fatricum). Their host rocks are marly limestones with content of radiolarians, sponge spicules and other microfossils. Chert concretions are black, rarely light grey. Their dimensions vary up to 15 cm and they are usually elongated with bedding. A globular shape is exceptional. Remarkable transitional zones around the own chert were observed at some outcrops (for example at Brodno near Žilina). The concretions have usually numerous hair-like thin veinlets filled by calcite or chalcedony. The author mentioned above described both microfossils and mineral content including the assemblage of heavy minerals. He followed also their chemical composition using the semiquantitave spectral analysis.

Prehistoric Use: According to Mišík's studies of the Palaeolithic chipped artefacts in Slovakia, these cherts were used only a little because of their intensive tectonic afflicting as a consequence the Alpine orogenesis.

II.2.7.7. Palaeogene menilite cherts of the Dukla Unit (Carpathian Flysch Belt)

Background: In Slovakia, the menilite cherts were ascertained among the chipped raw materials substantially later than in Moravia. In the excellent paper of Mišík (1969, 120) they are mentioned as a potential raw material but he did not find them among artefacts from 35 Palaeolithic and Neolithic Slovakian localities. It was probably Kaminská (1986, 263) who as the first mentioned menilite artefacts from the Palaeolithic site at Hrčel in eastern Slovakia.

Geological Setting: The Dukla Unit is an independent structural zone of the Silesian – Krosno (or Krosno – menilite) Group of the Carpathian Flysch Belt. On the surface it appears south of Žmigród in Poland, than it continues through the NE edge of Slovakia and it is possible to follow it also in the territory of Transcarpathian Ukraine. In the south, the Slovakian part is bordered by the overthrusting of the Magura Group of flysch nappes that runs from the NW vicinity of Míková via Sukov, Zbudská Belá, southern margin of Papín, Kalná Roztoka and Ubľa up to the state border with Ukraine.

The cherts layers are present in the central part of the Menilite Formation where they form about 20 m thick deposits in the Revejka syncline, 40–50 m at Hostovice and Šterkovce and 90 m at Kalná Roztoka (Koráb & Ďurkovič 1978, 37). The own chert beds having thickness 5–20 cm are situated in brown or black silicified claystones. Chert lenses can appear sporadically in the uppermost part of the Menilite Formation as well.

Location: From geomorphological point of view the Dukla Unit crops out in the Bukovské vrchy Highland with the highest spot Kremenec (1121 m) and in the Laborec Highland. The Protected Land Area Východné Karpaty (Eastern Carpathians) is situated there. Black menilite cherts have been described for example from the NE surroundings of Snina (Prislop) or from the area SE of Medzilaborce (Čabalovce). In the Slovakian territory the cherts could be extracted also from their secondary gravel deposits of left tributaries running to the Laborec River (the Udava, Výrava and others), in gravels of the Laborec River and in gravels of so called Pozdišov Formation (Pannonian age). The last one crops out to the west and SW of Michalovce and the content of chert varies between 15 and 33.3 % (Vass & Eleško 1977, 44). From the description of the Pozdišov Formation it is not clear if in the chert content includes also silicified claystones of the Magura Group (see the next chapter II.2.7.8.) that have been called by some Slovakian researchers as brown cherts according to their brown pebble surface.

Macroscopic Appearance: Typical features of the Slovakian menilite cherts are bedding and pitch-like black colour. Their bordering against the host rock is sharp and they have no cortex. The fracture is conchoidal and the knife does not scratch them. Fine cracks are also present, in places with small pyrite crystals.

Stereomicroscopic Appearance: See the description of menilite cherts in Poland.

Thin Section: A detailed study of East Slovakian menilite cherts was done by Koráb & Ďurkovič (1978, 83–88). Based on their research, the absolutely dominant mineral is cryptocrystalline quartz, opal has not been found, and chalcedony appeared only as the filling of veinlets. Idiomorphic crystals of calcite in the siliceous groundmass or filling of veinlets can reach up to 30 %; the content of pyrite varies between 1.6–2.5 % (planimetric analyses of two samples). Detrital admixture up to 10 % is composed of quartz, muscovite, plagioclase and heavy minerals (zircon, rutile, apatite).

Other Analyses: A research based on the differential thermal analyses and x-ray investigation confirmed a presence of low-temperature well-crystallized quartz, there were also ascertained calcite, pyrite and marcasite. The authors also published seven chemical analyses of the cherts. In conformity with microscopic research some samples has shown a higher content of both CaO and CO_2, also TiO_2 – up to 0.22 % (occurrence of rutile), all cherts have had a relatively consi-derable prevalence of FeO above Fe_2O_3 indicating reduction environment of their origin. The presence of sulphur (up to 0.08 %) is also typical in connection with ascertained pyrite or marcasite and P_2O_5 (up to 0.08 %) having a relationship to a phosphate mineral without more precise microscopic specification. In view of some trace element higher contents it is supposed the volcanic origin of SiO_2, on the other

hand a higher presence of organic C and occurrence of diatoms testify for the organogenic influence (Leško & Samuel 1968, 114).

Prehistoric Use: Only small amounts of chipped menilite cherts have been described for example from Epigravettian sites Hrčel and Kašov (0.36 %, 0.04 %, Kaminská 2001) because high quality obsidians and limnic silicites represent the key raw materials. According to the mentioned author, the chipped menilite cherts have been ascertained also in west Slovakia (Moravany nad Váhom-Žakovská, again under 1 %). The question of provenance either from Slovakia or from Poland as is a small menilite axe found at Bušovce, district of Kežmarok (Soják & Novák 2004) has been still open.

II.2.7.8. Palaeogene silicified claystone to chert of the Magura Group flysch nappes (so called Ondava or brown chert)

General Overview: The raw material was registered during excavations carried out by a joint Polish – Slovak archaeological project in 1992 in the Ondava Highlands north of Humenné. It has usually grey green colour, it is not translucent and contains nodules of amorphic bluish SiO_2 (Valde-Nowak 2001, 72). The rock has been designated after consultations with specialists (A. Łaptaś, L. Illášová) as silicified claystone. P. Valde-Nowak starting out from the geological map 1: 200 000 sheet Košice (Matějka, ed. 1964) believes the claystone is a part of the Čerchov Unit (Magura Group flysch nappes). Recently the Oravská Magura (Krynica) Unit instead the Čerchov Unit is prefered (Kováč & Plašienka et al. 2002) and the silicified claystone is probably a member of the Malcov Beds. As flat and only partly rounded pebbles the raw material can be found in gravels in the vicinity of the Zeplínská šírava Dam or in gravel deposit of the Laborec River (Supplement/Photo 138, 139).

Prehistoric Use: The silicified claystones were used for example at Lubiša-Merava (1836 pieces) situated 10 km north of Humenné. The raw material was worked by people with the Corded Ware (Valde-Nowak 2001). Strakošová (2001) has introduced making of oblong axes from the Oligocene greenish claystone at archaeological locality Brestov-Dielňa (4 km NW of Humenné) including 1800 claystone chips, other raw materials were ascertained only as individual pieces. According to shards of pottery the claystone axe production can be connected with the Corded Ware culture. A source of the rock was found at close village Vyšné Ladičkovcie on the western slope of the Poloma Hill (401.2 m). Another place of the prehistoric claystone processing is represented by surface finds at the near village of Karná, 10 km NW of Humenné.

II.2.7.9. Palaeogene nummulitic cherts in southern Slovakia

General Overview: The nummulitic cherts crop out only in a small area of southern Slovakia, in particular south of Modrý Kameň up to the state border with Hungary. They have prevalently brown and grey colour, the nummulite tests are visible by naked eye (Supplement/Photo 133). The raw material is interpreted as a totally silicified nummulite limestone without sandy admixture and M. Váňová determined in it the species *Nummulites millecaput millecaput* Boubée, *N. anomalus* Harpe, *N. chavannesi* Harpe; as other foramini feras have appeared *Assilinas, Discocyclinas,* less *Rotalidas, Globigerinas* and *Textularias* (Mišík 1975, 99). Parts of moss animals, coralline algae, rarely gastropods are present as well. The organic relics are usually entirely replaced by SiO_2 and accentuated by brown pigmentation. The nummulitic cherts are reliable determined using the stereomicroscope (Supplement/Photo 136).

Prehistoric Use: In Slovakia, chipped artefacts made of this raw material were found at the Palaeolithic stations Malá Čajomija, Kiarov, Bátorová, Opatovská Nová Ves, the finding places lie close to the state border with Hungary and south of the Slovakian town Velký Krtíš. Pebbles of nummulitic cherts from the Neogene and Quaternary gravels were used for all artefacts. Their primary source has not been detected on the surface and it is supposed to be hidden under the Neogene sedimentary deposits and volcanic rocks north of Modrý Kameň municipality. The silicification of original limestones was very probably of hydrotermal origin in connection with Palayeogene volcanic activity because the pebbles have been found already in gravels of the oldest stage of the Miocene – the Egerian (Mišík 1975, 101).

According to the recent knowledge, this unusual raw material can be ascertained rarely also far away of the source. The author determined an artefact made of nummulitic chert pebble, very probably of the South-Slovakian provenance, at the Aurignacian site Kvasice near Kroměříž (central Moravia, more than 210 km from the natural source). The artefact No I/6–1244 (property of the Moravian Museum in Brno) has relics of black pebble cortex and its siliceous mass contains numerous nummulites with dimensions from 6 to 10 mm (Supplement/Photo 137). Another artefact prepared from the nummulitic chert was discovered in the Prepoštská Cave at Bojnice (about 100 km to the NW of the source) during a joint study of the Middle Palaeolithic chipped collection with P. Neruda.

II.2.7.10. Miocene limnic silicites

Background: From geological point of view it was already Dionys Štúr, the "father" of Slovakian geology, who was interested in relics of fossil plants in limnic silicites. Ciesarik (1967) mentioned using of limnic silicites from the Žiar valley for chipped tools in the Stone Age; Mišík (1969, 1975) proved their substantial presence among the Slovak Palaeolithic artefacts on the basis of petrographic and micropaleontological investigation. The thing is that the previous authors distinguished only "flint" (the term included also limnic silicites), obsidian, opal and jasper (radiolarite in reality). The former using of the term limnic quartzites is not correct because the limnic silicites are neither clastic sediments (orthoquartzites) nor metamorphic rocks (metaquartzites).

Location: The largest occurrences of limnic silicites are in the Žiar valley (central Slovakia). It is possible to mention their deposits at Bartošova Lehôtka, Stará Kremnička, Žiar-Podháj, Lutila, Slaská. Prestavlky, Trubín, the area between Sklené Teplice and Hliník nad Hronom represents other localities. One occurrence has been introduced 6 km SW of Nova Lehota in the Vtáčnik Mts., other limnic silicites occur at the lignite deposit Sejkov-Vyšné Nemecké or in the vicinity of Fekišovce village.

Eastern Slovakia represents the second region with limnic silicites. There the most important source lies at the village of Banské; boulders of limnic silicites have been described also at Drahlov.

Geological Setting: Slovak Miocene limnic silicites are generally considered as products of sedimentation from thermal springs rich in SiO_2 that precipitated in depressions filled by water (lacustrine environment). The deposited silica formed horizontal or only a little inclined beds. Genetically, the limnic silicites are connected with contemporary acid rhyolite volcanism and vitreous rhyolite tuffs form for the most part their underlayer. Thickness of limnic silicite deposits can reach up to 40–60 m as it follows from profiles constructed by M. Ciesarik for deposits at Stará Kremnička and Žiar-Podháj (published by Hruškovič 1967, 296). At the deposit basis it is possible to find usually small-silicified lignite seams or grey to black tuffaceous clays, inside the deposits there are beds of tuffites, tuffaceous clays, pumice tuffs and bentonites. The real layer of limnic silicite can reach thickness up to 6–10 m.

Macroscopic Appearance: Limnic silicites are very variable rocks. They can be massive or distinctly bedded, usually multicoloured but in places also in one colour, built of chalcedony or opal as well. Their colours vary from whi-tish, light grey or yellowish to brown, reddish brown even to dark grey and black (Supplement/Photo 132). Occurrence of plant relics is a characteristic feature, sometimes one can find a whole root system or reed stalks with a diameter of several cm (Fig. 72). Non-patinated Neolithic artefacts have visible irregular smudges of various colours (brown, yello-wish, light grey, black). The colouring is caused by presence of organic relics, graphitic pigmentation, iron or manganese compounds and clay substance. Some limnic silicites show a brecciate structure.

Stereomicroscopic Appearance: The rocks have also very variable signs observing them under the stereomicroscope. Varieties rich in chalcedony are well translucent, plant re-lics have been found only rarely but the siliceous matter is clouded in smudges or bands by black organic substance. The siliceous matter of most limnic silicites is non-translucent and contains numerous dark plant relics. Several mm big cavities filled up small quartz crystals or brecciate structures caused by penetrations of younger chalcedony into older milky-white or waxy-yellow opal matter are common signs for Slovakian limnic silicites. Plant relics are typical microfossils preserved in prevalent part of limnic silicites. These relics have usually dark or ochre pigmentation in lighter siliceous mass (Supplement/Photo 133). Besides the true microfossils there are visible dark formations looking like plant relics but these are only oxides – hydroxides of Mn and Fe called dendrites.

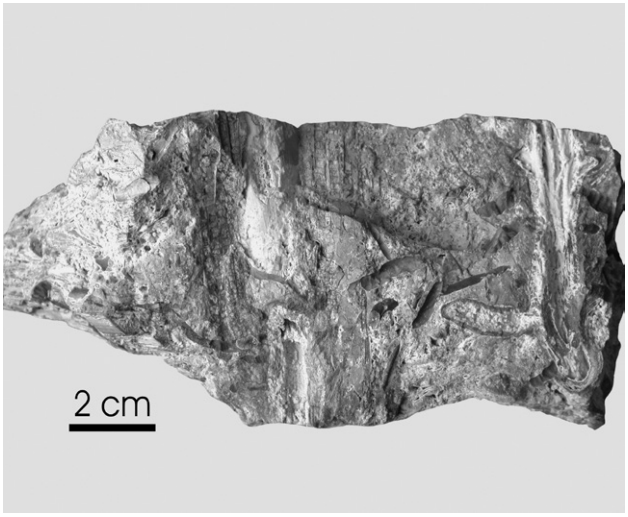

Fig. 72. Limnosilicite with relics of plant stalks. Stará Kremnička, central Slovakia. Photo by the author.

Thin section: The raw material is prevalently built of microcrystalline quartz; fibrous chalcedony in small sheaf or spherolithic aggregates is present less (Supplement/Photo 134, 135). The fibrous chalcedony appears especially in fil-ling of cavities often having zoned structure with different coloured bands, so it forms in fact small agates (with the dia-meter up to a few mm). Rutile, less anatase occur as accessory minerals (Mišík 1975, 94), calcite or siderite are spread as pigmentation. Opaque pyrite forms spheroidal aggregates or small grains with crystal shapes. The most important sign is already mentioned presence of plant relics, especially of grasses. It is possible to find also pollen grains, rarely ostracods or limnic gastropod (Mišík 1975, 94).

Prehistoric Use: According to Kaminská (2001, 90), Slovakian limnic silicites were used already in the Middle Palaeolithic for example at the Mousterian locality Prievidza-Mariánský vršok. They became the prevalent raw material at many Upper Palaeolithic finding places (Barca II, Kechnec I, Čečejovce, Seňa I). In the period of Gravettian the limnic silicites were transported even to the territory of SE Moravia (Milovice). They are substantially present in Slovakian Neolithic collections (for example in the Museum of Poprad) but they dwindled in importance because they were substituted by imported silicites from Poland (in the area of Spiš) or from Hungary (in SW Slovakia).

In the Middle Ages the limnic silicites were used for production of big millstones to crush gold-bearing ores in the area of Kremnica (central Slovakia). In some written reports the limnic silicite millstones are mentioned already in 1331 and Ciesarik (1967, 4) believes they were prepared even earlier during the 11th and 12th centuries.

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II.2.8. Silicites of Hungary

More than two third of Hungary are covered by unconsolidated Quaternary and Upper Tertiary sedimentary rocks (Holocene flood loam, Holocene and Pleistocene aeolian sand, Pleistocene loess and fluvial sandy gravel, Neogene sands and gravels) without outcrops of hard rocks. It concerns large eastern part of the country from the border with Romania including the area of Tisa River up to the Danube (Alföld). The south margin of hard rocks cropping out in northern and NW Hungary is delimited by an important geological line running in the NE – SW direction between Zemplín in Slovakia and Zagreb in Croatia. The Zemplín – Zagreb (or Mid-Hungarian) Lineament separates the Western Carpathians from the Pannonian Basin. South of this geological line there are durable rocks only in the Mecsek and Villany Mts. Sources of silicites and other raw materials suitable for chipping (Fig. 73) are connected with outcrops of hard rocks in northern and northwestern Hungary and the already mentioned two mountains in the south.

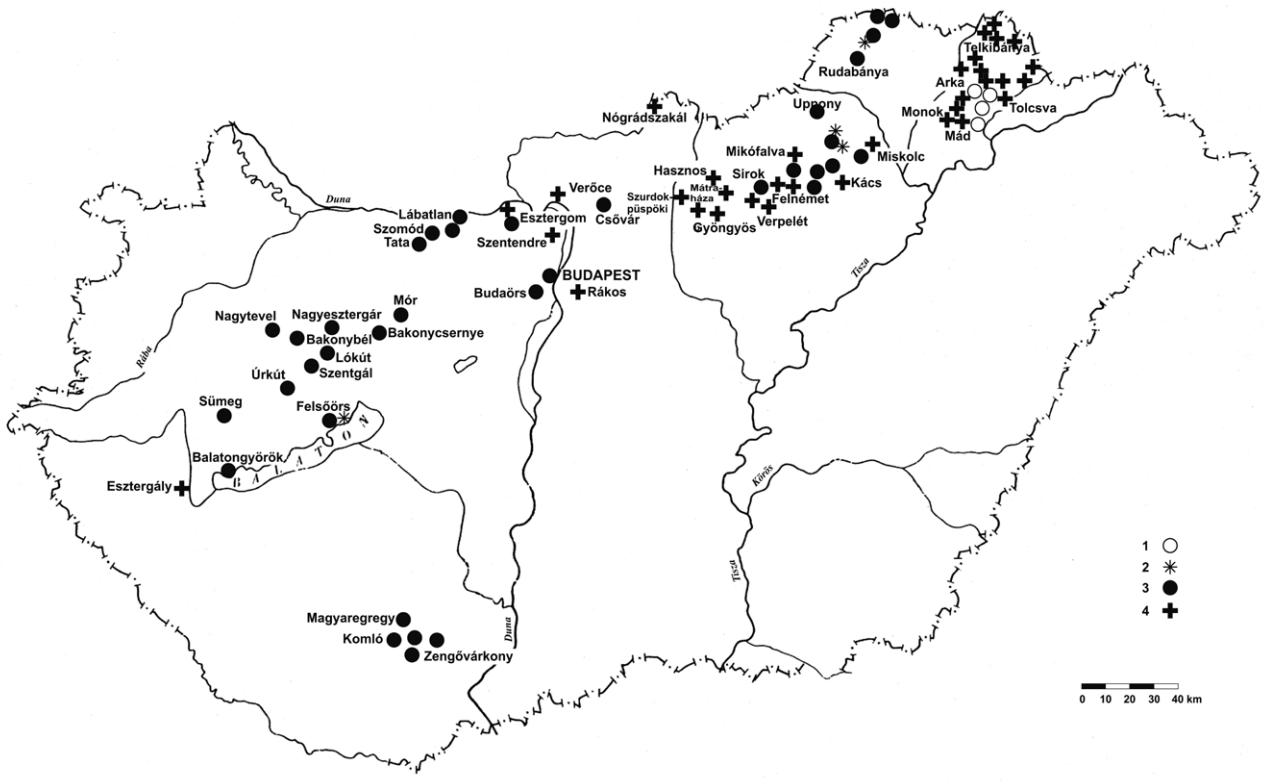

Fig. 73. Sources of chipped raw materials in Hungary. Adapted after Biró & Pálosi (1986). 1 – obsidian, 2 – Triassic felsitic metarhyolite („felsitic porphyry"), 3 – marine silicites (radiolarites, cherts, flint), 4 – prevalently limnic silicites.

According to their age, the Hungarian silicites can be divided in a) dark Palaeozoic lydites, b) Mesozoic radiolarites and cherts (including one source of flint from the Tevel Hill) and c) wide group of Tertiary (Miocene) limnic silicites (limnic opalites, geyserites) that are still called by some Hungarian authors as limnic quartzites or hydroquartzites (see discussion in a paper of Biró 2010a). In the scope of the last group there have been described many types according to their finding sites, so the author is aware of the reality he has introduced only some of them in this book. A detailed description of all Hungarian siliceous raw materials can be found both in published catalogues of the Lithotheca deposited at the Hungarian National Museum in Budapest (Biró & Dobósi 1991; Biró, Dobósi & Schléder 2000) and on internet (www.ace.hu/litot).

II.2.8.1. Palaeozoic silicites (lydites)

General Overview: Black radiolarian lydite of the Tapolcsány Formation in the Uppony Mts. (NE part of the country) represents one of the oldest silicites in Hungary. The formation is composed from alternation of grey to dark-grey shales, siliceous shales and black radiolarian lydites (S. Kovács in Haas, ed. 2001, 110). A high content of organic matter, occurrence of small pyrite concretions or lenses and no carbonates are typical signs for the mentioned rocks. No fossils have been found in the formation; that is why based on analogies in the Northern Greywacke Zone of the Eastern Alps it is believed to be of the Silurian and Devonian age. Rarely the shales with bedded lydites appear in the Abod Limestone Formation of the Late Devonian (Famenian) age.

Another source of the Palaeozoic lydites lies in the scope of geological unit cropping out north of the Balaton Lake and called the Transdanubian Range Unit (Ordovician to Lower Devonian). A part of the unit is the Lovas Slate Formation (Silurian) containing layers of lydites (S. Kovács in Haas, ed. 2001, 37). Radiolarian lydites have been described also from the borehole Kékkút-4 in the depth 910–1000 m in the scope of Lower Devonian pelagic limestones.

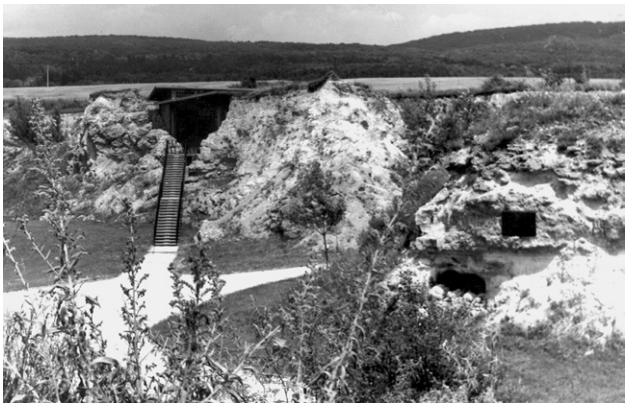

Fig. 74. Vértesszölös, northern Hungary. The Old Palaeolithic locality situated on a travertine mound with chipped small pebbles of silicites, quartz and quartzites from Pleistocene gravels of the nearby Átalér River. Postcard, 1975.

Prehistoric Use: Hungarian Palaeozoic lydites had local significance and were chipped only from secondary sources in fluvial deposits at some places. More authors introduced them from the Middle Palaeolithic station Tata SE of Komárom (Komárno). A detailed description of Palaeozoic (Ordovician and Silurian) lydites from a well-known Lower Palaeolithic settlement on a travertine mound at Vértesszőlős, Gerecse Mts., NW Hungary (Fig. 74) has been done by Varga-Mathé (1990, 289). The lydites are dark rocks (grey, black, brown-grey) that were collected as pebbles at the nearby Átalér River. During their geological development they underwent a low metamorphosis causing a fine schistosity, elongation of originally circular radiolarians and recrystallisation to quartz. Their chipped planes have a matt or earthy low lustre what is a consequence of dark organic matter and clay admixture content. The mentioned authoress has supposed the Silurian age for blood red radiolarites used at Vértesszőlős as well. According to written information of K. T. Biró in 2008 they represent probably classical Jurassic radiolarites.

II.2.8.2. Triassic Buda chert

Background: The first information on the prehistoric use of this raw material was mentioned by I. Dienes (in Gábori-Csánk 1968) who introduced it among chipped artefacts from the Middle Palaeolithic site Érd. A basic characterization of the Buda chert can be found in a paper of Biró (2002).

Location: The chert represents the most important local raw material in the area of Budapest city and its vicinity. Its name is derived from the Buda Mts. and the host rock is dolomite of the Upper Triassic age. The chert sources crop out right in Budapest city XII, for example on slopes above the Farkasrét cemetery or near the Ördögorom pub.

Macroscopic Appearance: The chert does not look as a high quality raw material because it is often intensively cracked (Supplement/Photo 140). It forms concretions with dimensions over 10 cm sharply limited against the hosted carbonate. Tiny crystallized dolomite occurs as relics on the concretional cortex but it does not react with the diluted HCl. The concretions can have an oval or broken shape. The colour of siliceous mass varies from very light grey (N 8) to light bluish grey (5B 7/1) or to medium bluish grey (5B 5/1).

Stereomicroscopic Appearance: The non-translucent siliceous groundmass is milky clouded and contains small bluish grey lenses ("schliers") of partly translucent chalcedony in a length of a few cm, in some cases this chalcedony badly translucent mass prevails and in contrary it includes milky clouded parts. Hair-like thin cracks are often visible. There have been found no determinable microfossils. Small white dolomite crystals of rhombohedral shape or cloud-like accumulations of dark organic matter appear as inclusions (Supplement/Photo 141).

Prehistoric Use: Chipped artefacts of the chert have been ascertained within a radius of 30 km from the source in various prehistoric periods, especially at the end of

the Eneolithic and in the Early Bronze Age (the Baden culture, Bell Beaker culture – Csepel group). With the last mentioned group is connected a few smaller depots of chipped tools (semi-finished artefacts) made of the chert in Budapest on the island Csepel, on the street Hollandi or in Budapest-Albertfalva. Even a fragment of an antler mining tool has been discovered on the street Denéver at the Farkasrét cemetery. That is why V. Gábori-Csánk carried out an investigation of the place to prove a prehistoric mining. A found charcoal dated by C^{14} method yielded the age GrN15567 40350 ± 950 BP. In accordance with the Middle Palaeolithic use of the chert she believed the mining was in progress already in the Middle Palaeolithic as well. Another antler age determination gave only 3470 ± 80 BP; it means the Bronze Age (Vörös 2000). In the last comprehensive paper on prehistoric mining in Hungary (Biró 2010a) the locality of Farkasrét is believed to be a mining place allegedly in the Middle Palaeolithic, more probably in the Late Copper Age/Early Bronze Age.

According to written information of K. T. Biró, the same Upper Triassic chert is also known from the Keszthely Mts. and Bükk Mts.; even from the Cserhát Mts. Hungarian archaeologists have data on the utilisation of the Bükk Mts. chert at some Palaeolithic cave sites (Szeleta, Büdöspest and Subalyuk).

II.2.8.3. Upper Triassic and Lower Jurassic cherts from the Bakony Mts., Keszthely Mts. and Balaton Highland

General Overview: Cherts of a low quality have been known from the Upper Triassic and Lower Jurassic limestones in the area of the Bakony Mts. that represent the largest part of the Transdanubian Range north of the Balaton Lake. Biró & Regenye (2003) introduced the Triassic cherts from the Keszthely Mts. at the SW Balaton edge or from the Megyehegy Formation in the Balaton Highland (to the south of the Bakony Mts.). The Lower Jurassic cherts crop out also in the surroundings of the well-known radiolarite localities Bakonycsernye, Úrkút, Lókút and Szentgál. The all mentioned cherts were chipped around their sources but no one was distributed to a large area. At some places (especially around Lókút) it is possible to find transitions between cherts with sponge spicules of probably shallow-water origin and radiolarian cherts or typical radiolarites.

II.2.8.4. Jurassic radiolarite of the Szentgál type

Background: According to Biró (1995, 402) it is probably the first Hungarian silicite raw material mentioned in the written literature because researchers knew it already in 1876. Locality of Szentgál is mentioned as a prehistoric site place at the beginning of the 20th century. The name of radiolarite finding place Tűzköveshegy (Flint Mount) gives evidence about its use for striking fire in the Middle Ages.

Hungarian archaeologists recognized the locality as a source of significant prehistoric raw material in 1982, then in 1983–1985 and 1993–1995 there were realized archaeological excavations.

Location: From geomorphological point of view the village of Szentgál lies in the Dunántúli Középhegység (Transdanubian Range) in the partial unit Bakony Mts. The locality is situated near Ajka about 20 km west of Veszprém or 30 km west of the NW Balaton Lake edge.

Geological Setting: The raw material occurs in the Middle Jurassic (Dogger) limestones with more precise timing to the stages Bathonian – Callovian. In the terms of regional geolo-gy the host rocks are called the Lókút Radiolarite Formation and they represent the basinal development of sedimentation at the end of Middle Jurassic.

Macroscopic Appearance: The concretions can reach dimensions up to 15 cm and as a characteristic feature it is possible to introduce several cm thick cortex with a very pale orange (10YR 8/2) colour. The cortex has been preserved very often on artefacts found also far away of the source. The colour of siliceous mass is another typical sign that can be used for determination of the raw material because it differs by its pale hue from other Carpathians radiolarites for example from the Pieniny Klippen Belt or from the source at Vienna-Mauer. The colour varies between meat-like red to cinnamon-like brown, according to the Munsell colour chart between moderate reddish brown (10R 4/6) to moderate brown (5YR 4/4). Irregular inclusions (petrosilexes) up to a few cm big can occur in central part of bigger concretions (Supplement/Photo 142) and they have usually a pale brown hue.

Stereomicroscopic Appearance: Small circular spots – phantoms after radiolarians filled by translucent chalcedony are preserved in the almost non-translucent red siliceous mass (Supplement/Photo 143). They are present in the very pale orange cortex as well. Bigger elongated white chips are probably sea urchin spines. The border between cortex and red siliceous mass is sharp but "islands" similar to cortex can appear inside the concretion. Fine black pigmentation is spread more or less regularly in the siliceous mass as well.

Thin Section: The groundmass of pale cortex is strongly pigmented so it is not possible to determine individual minerals using the polarising microscope. Microcrystalline quartz is clearly visible only in the oval phantoms after radiolarians. In the silicite own mass it is difficult to distinguish the radiolarians because there is missing their filling by bigger fibrous chalcedony.

Prehistoric Use: The mining place Szentgál-Tüzköveshegy probably represented the most important centre of such type during the Neolithic in Hungary. Maximal mining activities are supposed to be connected with the Lengyel culture (Biró & Regénye 2003, 59) but an important extraction had to be carried out already in the period of Linear Pottery culture as is testified by a large distribution of the raw material towards SW Slovakia (Děvínská Nová Ves, Supplement/Photo 144) and Lower Austria (Supplement/Photo 145). Low but regular presence of the Szentgál radiolarite has been ascertained at almost all important Bohemian and Moravian Neolithic sites. It is interesting that settlements with the Linear Pottery have not been found in he vicinity of the

Szentgál-Tüzköveshegy that is why there are supposed only mining expeditions in that time. In the younger stage of Lengyel culture the source locality is surrounded by circular arrangement of 9 settlements concentrated as workshops on the processing of the Szentgál radiolarite (Biró & Regenye 1991).

II.2.8.5. Jurassic radiolarite from Bakonycsernye

Background: The finding place is a well-known geological profile. During its investigation geologist L. Kocsis found traces not only after a prehistoric mining but also a few antler tools. E. Bácskay carried out a small archaeological excavation there in 1975 and she also characterized the mining place in the scope of Appendix to the Bochum catalogue of prehistoric flint mines in Europe (Bácskay 1995). The locality is also presented in detail on the www.flintsource.net pages (Elburg 2002).

Location: The village of Bakonycsernye is situated on the northern edge of the Bakony Mts. The raw material crops out in a ravine called Tűzkövesárok (Flint ravine) 4 km south of the village. Veszprém and Székesfehérvár are the nearest bigger towns.

Geological Setting: The geological profile shows a sequence of the Mesozoic formations prevalently of Jurassic age and it is the type locality for the Lower Jurassic (Pliensbachian) limestones of the Tűzkövesárok Formation. The radiolarites crop out as a part of the superposed Lókút radiolarite Formation and they correspond to the Middle Jurassic age (the Bathonian and Callovian stages).

Macroscopic Appearance: The samples have extensive colour variability. Red, brown red or yellow brown colours with more vivid hues comparing the Szentgál radiolarite prevail. Some pieces have a black colouring caused by manganese oxides and hydroxides. According to Elburg (2002), the raw material is rather fractured and it is difficult to prepare for example a suitable core.

Prehistoric Use: Unfortunately, the small mining pits containing antler wedges and other mining tools have not been dated till now. There are also no published data on the raw material distribution.

II.2.8.6. Jurassic radiolarite from Hárskút

Background: According to published information the prehistoric mining place was found by geologist J. Konda from the Hungarian Geological Survey during his fieldwork in 1970. In the scope of Appendix to the Bochum catalogue of prehistoric flint mines in Europe the locality with number H9 was characterized by Bácskay (1995a) and following data on geological setting are borrowed from it.

Location: Hárskút lies about 13 km north of Veszprém; from geomorphological point of view it is again the northern part of the Bakony Mts. The sites with radiolarite exploitation are called Édesvízmajor (Bácskay 1995a) and Gyenespuszta (Biró & Regenye 2003, 58) and there are located 3 km NW of the village.

Geological Setting: Limestone and marlstone beds of Jurassic age crop out at the locality but they are partly covered by Pleistocene loess with boulders of subjacent radiolarite and limestone. There was no archaeological excavation on the site that is why there is missing more detailed information.

Macroscopic Appearance: The samples the author has had to the disposal by courtesy by K. T. Biró from the Hungarian National Museum show wide colour variability, some of them resemble even the radiolarite from Szentgál but they have not such vivid colours. Part of radiolarites is almost dark brown (Gyenespuszta), radiolarites from Édesvízmajor are of various colours, for example dark reddish brown to blackish red (10R 3/4–10R 2/3). Elongated radiolarite lenses have a thickness up to 6 (and more) cm and they are intensively transverse cracked (Supplement/Photo 146).

Stereomicroscopic Appearance: The strongly clouded siliceous groundmass contains usually well visible clear circular sections of radiolarians, especially in the dark brown variety. Quantity of radiolarians is concentrated in the thick (0.5–1 cm) whitish cortex. The radiolarian arrangement and their flattening show rather distinctly the original bedding (Supplement/Photo 147).

Prehistoric Use: Four antler-mining tools were found at the locality. The mining activities were carried out probably as quarrying at rocky outcrops or as shallow pits. Some data about chronological position or raw material can be found in a paper of Biró & Regenye (2003).

II.2.8.7. Jurassic radiolarites from Lábatlan and Dunaszentmiklós (Gerecse Mts.)

Location and Geological Setting: The Gerecse Mts. is situated in northern Hungary between the town of Tatabánya and the state boundary with Slovakia (northwest of Budapest). Beside the Triassic limestones and Cretaceous clastic rocks a part of the mountains is built of Jurassic limestones with radiolarites. There are many outcrops with radiolarites in the area and some of them were exploited in prehistoric times. The most important mining place at Tata is characterized separately in the next chapter.

Macroscopic Appearance: The author has had to his disposal radiolarite samples marked only Gerecse or Lábatlan. Concretions with diameter up to 7 cm are built of rather intensively cracked radiolarites of greyish red to dark reddish brown colour (10R 4/2–10R 3/4). Some of them have a thick cortex (up to 0.5 cm) of light rose colour. The cracks form several parallel systems that cause a disintegration of the raw material in elongated cube shapes. The fracture of radiolarite is conchoidal and the lustre is dull (Supplement/Photo 148). If the prehistoric man found a non-cracked raw material it could be relatively of good quality.

Stereomicroscopic Appearance: Circular sections of radiolarians filled by either translucent chalcedony or white siliceous mass are visible in the non-translucent reddish brown siliceous mass.

Thin Section: It is conspicuous quantity of non-pigmented oval relics of radiolarians usually with diameter about 0.1 mm but bigger ones can appear as well. The

surrounding siliceous mass is not pigmented by fine spread hematite uniformly; in places it is concentrated in darker smudges (Supplement/Photo 149).

Other Analyses: In the scope of the master thesis of Cheben (2005) there was carried out a chemical analysis in the ACME laboratories (Canada) with the result: 96,2 % SiO_2; 0,73 % Al_2O_3; 0,39 % Fe_2O_3 (total Fe); 0,07 % MgO; 0,43 % CaO; 0,06 Na_2O; 0,18 K_2O; 0,02 % TiO_2; 0,03 % P_2O_5; 0,02 % MnO and loss of ignition 1,9 %. Rare earth elements and trace elements (in ppm): La 3,7; Ce 8,6; Pr 1; Nd 4; Sm 0,9; Eu 0,22; Gd 0,9; Tb 0,1; Dy 0,7; Ho 0,14; Er 0,34; Tm 0,06; Yb 0,28; Lu 0,04; Ba 33,8; Be < 1; Co 2,6; Cs 1,2; Ga 1,3; Hf < 0,5; Nb 0,6; Rb 5,7; Sn < 1; Sr 24; Ta 0,1; Th 0,6; U 1; V < 5; W < 0,1; Zr 5; Y 5,1; Mo 0,1; Cu 8,1; Pb 9,3; Zn 5; Ni 8,5; As 1,1; Cd < 0,1; Sb 0,2; Bi 0,1; Ag < 0,1; Au < 0,5; Hg 0; Tl < 0,1; Se < 0,5. The composition of radiolarite is generally rather similar to other 21 analysed radiolarites from various localities in Slovakia, Austria, Poland and Hungary with the exception of Pb (the highest content is in the Gerecse radiolarite), on the other hand the sample has a very low presence of Ba and Sr. For comparison see geochemical data on Hungarian radiolarites including archaelogical and geological samples from the Gerecse Mts. published by Biró et al. 2002, 2009.

Prehistoric Use: Traces after prehistoric radiolarite mining have been found at two places near Lábatlan (H11 Margittető and H12 Pisznicetető) and at H10 Dunaszentmiklós-Hosszúvontató. Bácskay (1995c) prepared a preliminary characterization of all three localities. No archaeological excavation has been done at the mentioned localities, so the raw material mining is supposed on the base of indirect evidence such is the quantity of waste material and finds of quartzite pebbles interpreted as mining tools.

II.2.8.8. Jurassic radiolarite to radiolarian chert from Tata (Gerecse Mts.)

General Overview: The town of Tata lies in northern Hungary near the Slovakian border, about 15 km SE of Komárom. From gemorphological point of view it is a part of the Transdanubian Range, more explicitly the western margin of the Gerecse Mts. Since 1967 evidence on the prehistoric mining of Jurassic radiolarites to radiolarian cherts has been known from the Kálváriadomb Hill (Fülöp 1973, 1999). The locality is registered under number H3 in the Bochum catalogue of prehistoric mines.

The silicites have the Bathonian to Callovian age (upper part of the Middle Jurassic) and their thickness varies between 1–1.5 m. The bedrock is built of crinoidal limestones, nodular and brecciated limestones form the capping bed. Mining pits follow the dip of beds and reach a depth up to 4.5 m. Antler tools and stone hammers made of quartzites and other metamorphic rocks were found in the pits. According to a non-calibrated date 1860 ± 65 BC and a potsherd of the Badenian culture it is possible to place the mining to the Middle and Late Eneolithic.

Radiolarites form layers and they are sharply limited against the surrounding limestone (Supplement/Photos 150, 151). They have a greyish red colour (5R 4/2) and a lot of cracks. These are filled by white calcite veinlets. In places they are changed in the radiolarian cherts, again strongly cracked. So-called dendrites (tree-like compounds of Mn and Fe) occur often along joint planes. Radiolarians are usually filled by white substance both in the radiolarites and grey cherts.

Prehistoric Use: Published data give evidence about use of the Tata raw material only in the vicinity but some times it is difficult to distinguish it from other radiolarites or radiola-rian cherts in the Gerecse Mts.

II.2.8.9. Upper Jurassic to Lower Cretaceous chert from Sümeg

Background: The prehistoric mining field was found du-ring geological mapping in 1958/59 and later Vértes (1964) carried out its archaeological investigation. Later, geological, geophysical and archaeological excavation revealed the mining area with dimensions about 300 x 50 m and Fülöp (1975) described characteristics of the mining. Bácskay (1995b) published comprehensive information on the locality.

Location: The small town of Sümeg is situated again in the area of Transdanubian Range in the Veszprém district at the SW margin of the Bakony Mts. (about 20 km to the north of the Balaton Lake). The outcrop of raw material appears at the Mogyorósdomb Hill two kilometres south of the town. The locality is a geological and archaeological protected site partly covered by roof, partly enclosed.

Geological Setting: Beds of the Upper Jurassic and Lower Cretaceous age crop out on the hill in a vertical position as a consequence of the tectonic influence. From the stratigraphical point of view they cover the Upper Tithonian, Berriasian and Valangian stages and the rocks are represented especially by white Tintinnina limestones with layers of dark grey radiolarian cherts (Fülöp 1975, 72). Besides the Upper Tithonian cherts with a lower quality the Berriasian radiolarian cherts forming lenses and layers are more important. The last mentioned raw material was mined.

Macroscopic Appearance: In the eastern part of the mining field the raw material forms either lenses with thickness up to 40–50 cm or more frequently irregular concretions of the length about 15 cm are present. Their quality, however, is bad because the raw material is brittle and disintegrating into pieces. In the western part of the mining area the Berriasian radiolarian cherts of higher quality usually having light or dark grey colour, in places also with brown or pink colour. Elburg (2006) has characterized colours as prevalently grey (N6, 10YR 5/6–6/1 to 10YR, 2.5Y 7/2–2.5Y 7/3), rarely light olive grey (5Y 5/2). The author has at his disposal samples corresponding to especially medium dark grey colour (N4) – see Supplement/Photo 152.

Stereomicroscopic Appearance: Transparent or white radiolarians with a diameter up to 0.1 mm occur in a partly translucent grey siliceous groundmass. Numerous cracks parallel or transversal to the bedding are accentuated by

an ochre or red pigmentation; eventually they are filled by hair-like thin veinlets. The Sümeg radiolarian chert does not make an impression of a quality raw material (Supplement/Photo 153).

Prehistoric Use: The Sümeg radiolarian chert has been found at more Hungarian Middle Neolithic and Eneolithic sites but always only in small amounts. It is in contrast with the estimated quantity extracted in the prehistoric times. Radiometric dating of the mines yielded data from 4520 ± 160 BP to 5960 ± 95 BP (Bácskay 1995b, 392). The raw material was distributed especially to the southwestern or western part of Hungary within a radius of 70 km and it is found at settlements from the period of Linear Pottery culture and Želiezovce group up to the Late Eneolithic.

II.2.8.10. Cretaceous Tevel flint

Location: Flint in harmony with the petrographic definition we know in Hungary only at a small occurrence near the village of Nagytevel, about 10 km SE of Pápa at the northwestern margin of the Bakony Mts. The Tevelhegy Hill is situated at the border of Bakony Mts. with flat area of Kisäfold. The raw material is accessible in a small local quarry for limestone.

Geological Setting: The Tevel flint forms concretions in the Upper Cretaceous (Campanian to Upper Maastrichtian, formerly Senonian) very pure limestone. Field survey in the quarry at the Tevel-hegy Hill shows the raw material is partly struck by tectonics in places.

Macroscopic Appearance: The concretion diameter varies usually from 10 to 20 cm but it can appear concretions up to 40 cm. The raw material has conchoidal fracture and matt lustre. A concentric structure formed by a few mm thick bands is typical of the Tevel flint and the bands change the colour from white grey to dark grey towards the centre of concretion. The dark grey central part has usually bigger or smaller white spots or it contains oval petrosilexes with dimensions up to 2–3 cm (Supplement/Photo 154).

Stereomicroscopic Appearance: In the siliceous mass there is an alternation of grey white non-translucent parts with partly translucent ones (Supplement/Photo 155). Many small white spicules of simple shape (monoaxons) with a length of about 0.1 mm are present in the both parts. Opaque minerals are rare. The cortex is usually smooth and it can contain $CaCO_3$.

Prehistoric Use: This quality silicite had been chipped since the Palaeolithic but its maximal use was probably in the period of the Linear Pottery culture and Lengyel cultural complex. In 2005–2008 there were made excavatiions on the prehistoric quarry area and a large mining field was identified (Biró & Regenye 2007). The utilisation is connected especially with the Linear Pottery culture and Lengyel culture. The raw material distribution in particular as long blades has been described from western and northern Hungary, a few pieces of the raw material we know also from southern Slovakia. The maximal distance of transport is estimated about 200 km (Biró 2003).

II.2.8.11. Palaeogene nummulitic cherts

General Overview: Geological occurrences of Palaeogene nummulitic chert pebbles in northern Hungary crop out in a large area elongated in the NE – SW direction, it is roughly between Ipolytarnóc (the Ipoly River) and Budafok or Délegyháza south of Budapest – see Markó & Kázmér (2004). The area borders with similar natural deposits north of the Ipoly (Ipeľ) River in Slovakia (Chapter II.2.7.9.). The primary geological source has not been found yet.

The raw material forms pebbles in Lower Miocene and younger gravels (or conglomerates). The colour can be grey, brown or yellowish but conchoidal naturally or artificially chipped surface is usually strongly patinated and pebble cortex is dark to black, so it is very often difficult to determine the colour. The black pebble cortex is similar to that of Krumlovský les chert in Moravia (Chapter II.2.3.10.).

Markó & Kázmér (2004) described several kinds of *Nummulites* and other foraminifer genera, a boring sponge, remains of annelids, molluscs, corals, crinoids, moss animals, echinoids and algae that were identified in the chert pebbles. They also mentioned previous determinations of foraminifers and other fossils by L. Bartkó and M. Váňová.

Prehistoric Use: This specific raw material was surprisingly used for a long time in prehistory but usually only in a small number. It was found already at the Early Palaeolithic site of Vértesszőlős (Vargha-Máthé 1990), Middle Palaeolithic settlement of Tata (Végh & Viczián 1964) and more Upper Palaeolithic localities. For example at the Upper Palaeolithic (Pebble Gravettian or Sagvárian) site of Szob the nummulitic chert represents almost 12 %, i. e. 65 artefacts (Markó 2007). It was chipped even in the Neolithic and the Bronze Age.

II.2.8.12. Tertiary geyserites (hydroquartzites), limnic silicites and limnic opalites (for example Miskolc, Korlát, Erdőbénye)

General Overview: The raw materials crop out in northeastern to northern Hungary where are connected with the Tertiary volcanic mountains represented by the Tokaj-Zempléni, Bükk, Mátra, Cserhát, Börzsöny and Pilis Mts. According to a paper of Biró (1985), there are more sources of such raw materials in the mentioned mountains. As well-known natural occurrences exploited in the prehistoric times it is possible to introduce hydroquartzite (in fact geyserite) from the Avas Hill at Miskolc (NE margin of the Bükk Mts.), limnic silicites from Korlát (the Ravaszlyuktető Hill near Arka, western margin of the Tokaj-Zemplén Mts.) and limnic silicites (opalites) from Erdőbénye-Sás patak (Borsod district, Tokaj-Zempléni hégység Mts.). These three raw materials are briefly characterized to the following lines. A local geyserite was used during the Neolithic also on the Tihany peninsula in the Balaton Lake (Biró & Regenye 2003, 58).

The geyserite („hydroquartzite“) from the Avas Hill crops out as lenses in the formation of Tertiary rhyolite

tuffs and marlstones. It originated as a consequence of thermal springs activity (Simán 1995a, 375). The prehistoric mining was focussed probably on the geyserite connected with the lower two tuff layers. Quality of the raw material is changeable; it is usually banded with white, yellow and brown colours. Geyserite of red or blue colour can appear as well. At the end of twentieth of the last century it was J. Hillebrand who highlighted the prehistoric mining. Its timing varies between the Mesolithic and the Middle Ages.

Limnic silicite from Korlát is believed to be a product of the Neogene postvolcanic hydrotermal activity and its bed lies on the Tertiary rhyolites and rhyolite tuffs. The finding place represents the first known Palaeolithic station in Hungary and J. Mihalik mentioned local prehistoric mines already at the end of 19th century (Simán 1995, 43). Large workshop on the hilltop have been chronologically placed from the Middle Palaeolithic to Mesolithic, probably the last view published by Simán (1995, 57) has preferred the Upper Palaeolithic. Several pieces of the limnic silicite from Korlát should be ascertained at the Upper Palaeolithic stations Kašov and Kechnec in Slovakia.

The raw material from Erdőbénye-Sás patak is called by Bácskay (1995c) as limnic opalite cropping out within a complex of the Miocene rhyolite tuffs and tuffites with the underlying bed of diatomite. The limnic opalite is an attractive rock with pale yellow to dark brown colour, sometimes with bends of various hues and always with a high lustre. On the other hand, the raw material is fragile and it has usually a heterogeneous structure. It was chipped during the Upper Palaeolithic only in the vicinity of the source.

Stereomicroscopic Appearance: The author has had to his disposal samples of the Avas geyserite (hydroquartzite) coming from the collection of the Czech geologist K. Žebera. They are smudged to banded rocks prevalently of light colours (light brown to reddish), some smudges having dark brown hue as a consequence of higher content of iron compounds. Small cavities up to 1.5 cm elongated with the coloured smudges and filled by chalcedony or fine crystallized quartz represent a characteristic feature for determination. No microfossils have been found. This conclusion has been proved by thin section investigation: only the cavities filled by fibrous chalcedony or crystallized quartz are conspicuous in the siliceous microcrystalline mass.

Limnic silicite from Korlát can be classified as a typical one with a high colour variability (usually with pale hues) and content of grass or bush relics.

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II.3. Silica minerals

II.3.1. Quartz (Fig. 75)

Background: Quartz belongs to the most wide-spread minerals, and, at the same time, those most resistant to weathering, thus being accumulated in the form of fragments on slope or deluviofluvial sediments close to the natural outcrops of quartz dykes. As it is resistant to transport too, it appears in the form of pebbles in all river gravel terraces, and is also a component of many conglomerates. It represented a well accessible hard raw material that is why almost all chipped industries believed to be Lower Palaeolithic have been made of it. Ancient origin of the word is supported by its similarity in most European languages (quarz in German, quartz in English, cuarzo in Spain, kwarc in Polish, kvarc in Russian, quartz in French, kova in Hungarian). The Czech word „křemen" is derived from the Russian (Pan-Slav) term „kremeň" which means flint in the present Russian, originally probably a mineral or rock used for making a fire.

Location: There are hundreds of localities in Central Europe where quartz could be obtained as a raw material for chipped artefacts, both from quartz dykes or more frequenly as pebble from gravels (Fig. 75). It is necessary to mention at least gigantic quartz dykes represented by the Bavarian and Bohemian Quartz Lode. They form in the landscape so conspicuous geomorphological elements they could not be overlooked by prehistoric man.

The Bavarian Quartz Lode (in German: Teufelsmauer, Grossen Pfahl at Viechtach) can be followed in the direction NW – SE from Cham through Viechtach, Regen, Grafenau up to Freytung which represents with small gaps more than 85 km. The Bohemian Quartz Lode has the N – S direction in the western surroundings of Mariánské Lázně; than it runs from Tachov through the vicinity of Přimda and Poběžovice up to the Domažlice Pass in the NNW – SSE direction. Its total length is about 55 km, thickness up to 50 m and it juts out several metres over the surrounding landscape. Next huge quartz dykes are introduced for example between Prachatice and Husinec in a length of about 3 km (outcrop at Skalka near Prachatice), in the SE vicinity of the Choustník castle 13 km NE of Soběslav or a dyke running through the village of Člunek 10 km SE of Jindřichův Hradec (Hejtman 1981, 250). Gnojek & Přichystal (1997, 231) described a big quartz dyke (300 m long, 15 m wide, 8 m high) from Karlstift in the westernmost part of Lower Austrian Waldviertel. The Brno Quartz Lode found near the Brno Dam represents with its total length about 1 km the biggest quartz dyke in southern Moravia (Přichystal & Slobodník 2011). The village Bílý Kámen near Podhořany in the Železné hory Mts. received its name after a big boulder of milky white quartz.

Data on quartz pebble contents and their characterization in the biggest minig pits for sandy gravels in Moravia (from the north to the south: Mohelnice, Náklo, Tovačov, Ostrožská Nová ves, Bratčice, Hrušovany, Božice) have been published by Krejčíř (1982).

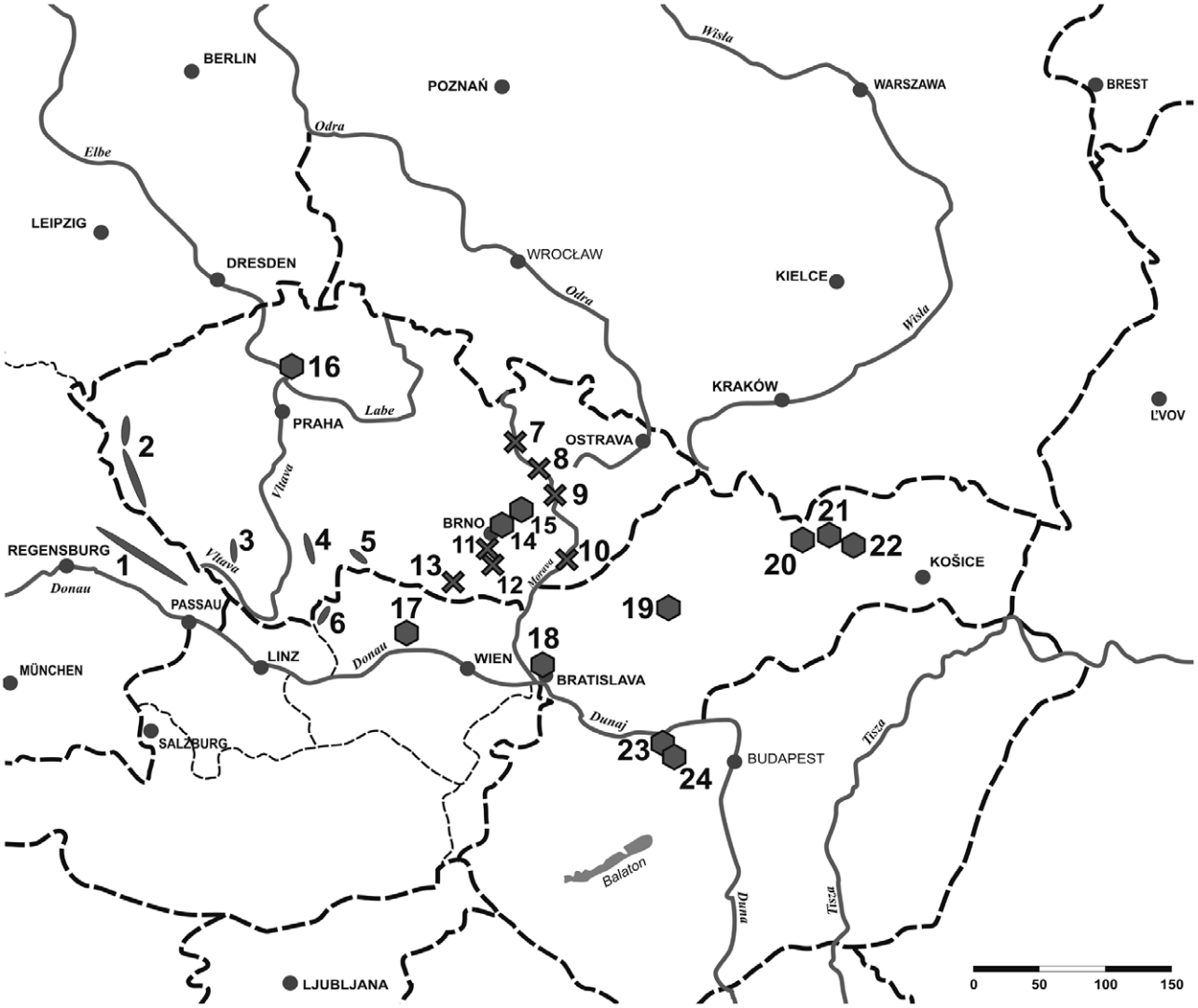

Fig. 75. The most important natural occurrences of quartz and some archaeological localities with chipped quartz. 1 – Bavarian Quartz Lode (Grosser Pfahl, Teufelsmauer), 2 – Bohemian Quartz Lode. Other quartz dikes: 3 – Prachatice-Husinec, 4 – at the Choustník castle, 5 – SW of Jindřichův Hradec, 6 – Karlstift in Lower Austria. Gravel pits at the Morava and Dyje rivers mentioned in the text – 7 to 13. Archaeological localities with quartz artefacts: 14 – Brno-Rozdrojovice, 15 – Kůlna cave, 16 – Mlazice, 17 – Gudenushöhle, 18 – Bratislava, 19 – Bojnice, 20 – Gánovce, 21 – Hôrka-Ondrej, 22 – Beharovce-Sobocisko, 23 – Tata, 24 – Vértesszölös.

Macroscopic Appearance: Quartz is most often colourless, grey-white or milky white but its varieties with brown, yellowish, grey-black, reddish colour are known as well (Supplement/Photo 164). Comparing related semi-precious varieties (rock crystal, smoky quartz, rose quartz), the common quartz is not translucent. Its lustre is vitreous, from mineralogical viewpoint quartz has no cleavage, nearly always contains tiny bubbles filled by liquid or gas. Other minerals are often closed in quartz (rutile needles, chlorite or muscovite flakes, parts of feldspar and pyrite crystals). A very good identification mark of quartz is its hardness – a steel needle or a knife tip only wipes its surface as quartz has No. 7 in the Mohs' scale of hardness and is the hardest of common minerals. It does not react with diluted HCl. Chemically it is pure SiO_2, although it may contain negligible admixtures. Column-like crystals ended with rhombohedrons sometimes occur in central parts of quartz dykes.

Filling of the Bohemian Quartz Lode has been described e.g. by Vejnar et al. (1977, 50) from a quarry at the southern margin of Chodov (west Bohemia). The huge dyke has a partly brecciated structure where chips of surrounding crystalline rocks are cemented by grey or rosy quartz of the first generation having glassy lustre. Small younger veins of whitish quartz of the second generation have vugs with quartz crystals. These have

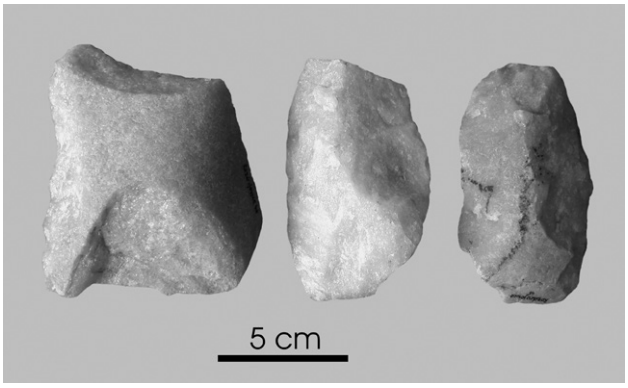

Fig. 76. Quartz artefacts worked by flat retouche from the Palaeolithic (Szeletian) site at Rozdrojovice near Brno. Photo by the author.

a pronounced zonal texture showing rhytmical process of crystalization. Pitted weathered quartz filling with cavities containing earthy limonite (goethite) has been found in the lode vicinity.

Prehistoric Use: In the Lower and Middle Palaeolithic, quartz pebbles served as a decisive raw material for the production of the so-called pebble industries that are usually found on the surface of highly situated river terraces (for example Mlazice near the confluence of the Vltava and Labe Rivers in Bohemia). In central Bohemia such pebble industries are recorded from as early as the Lower Palaeolithic, and according to Žebera (1970) the quartz comes from the fluvial sediments of the Vltava River, most frequently from the Günz 1 terrace, which is characterized by rather rough gravels. In southern Bohemia collecting of pebbles may be assumed particularly in the Upper Pliocene moldavite-bearing gravels where there is a big quantity of them, with the dimensions of several dozens of cm. These quartzes feature yellow to brownish pebble cortex and a distinct banded or brecciated structure.

The Taubachian settlement in the Kůlna Cave represents an example of quartz working in the Middle Palaeolithic in Moravia. It was used quartz both as pebbles and natural chips of a dyke. The quartz forms 34 % of the used raw materials. Neruda (2001, 7) was successful even to find the quartz dyke serving as a source of the raw material. It lies about 5 km to the NNW of the Kůlna Cave at the margin of Němčice village (from geological point of view it is in the frame of Brno Batholith granitoid rocks).

As a raw material of chipped industry quartz occurs rat-her exceptionally even in the Upper Palaeolithic. In Moravia the Szeletian station at Rozdrojovice near Brno is an exception from this point of view; here even flat retouched tools were commonly manufactured from the quartz pebbles (Fig. 76). The raw material was acquired from the terrace gravels of the Svratka River. Isolated leaf-shaped points of quartz are also known from other Upper Palaeolithic stations (for example from the Aurignacian locality on the Velký Kosíř Hill near Olomouc). In the Neolithic and Eneolithic the intentionally chipped quartz occurs entirely exceptionally – quartz artefacts are usually parts of original pebble hammers or crushers that were broken during their using.

Quartz was chipped during the Middle Palaeolithic in Slovakia as well – in the Prepoštská Cave at Bojnice. According to Bárta (1972, 17), Palaeolithic man collected the raw material in the close Handlovka and Nitra Rivers. Worked quartz pebbles were found also at the Lower and Middle Palaeolithic settlements on travertine heaps Vértesszölös and Tata in northern Hungary or at the Aurignacian site Stratzing north of Krems in Lower Austria.

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II.3.2. Rock crystal, citrine, smoky quartz, rose quartz (Fig.77)

Background: These semi-precious usually crystallised varieties of quartz had been in the centre of prehistoric men's attention since the Middle Palaeolithic. They were surely attractive both due to the occurrence of geometric shapes, originating from the regular layout of crystal faces, and because of their captivating appearance. Rock crystal is clear, colourless, and transparent crystallized quartz the appearance of which evokes ice (in Greek "krýstallos" means frozen water or ice). Ancient physicists (e.g. Pliny the Elder) believed it was deeply frozen water due to long-term incidence of frost in high mountains, under

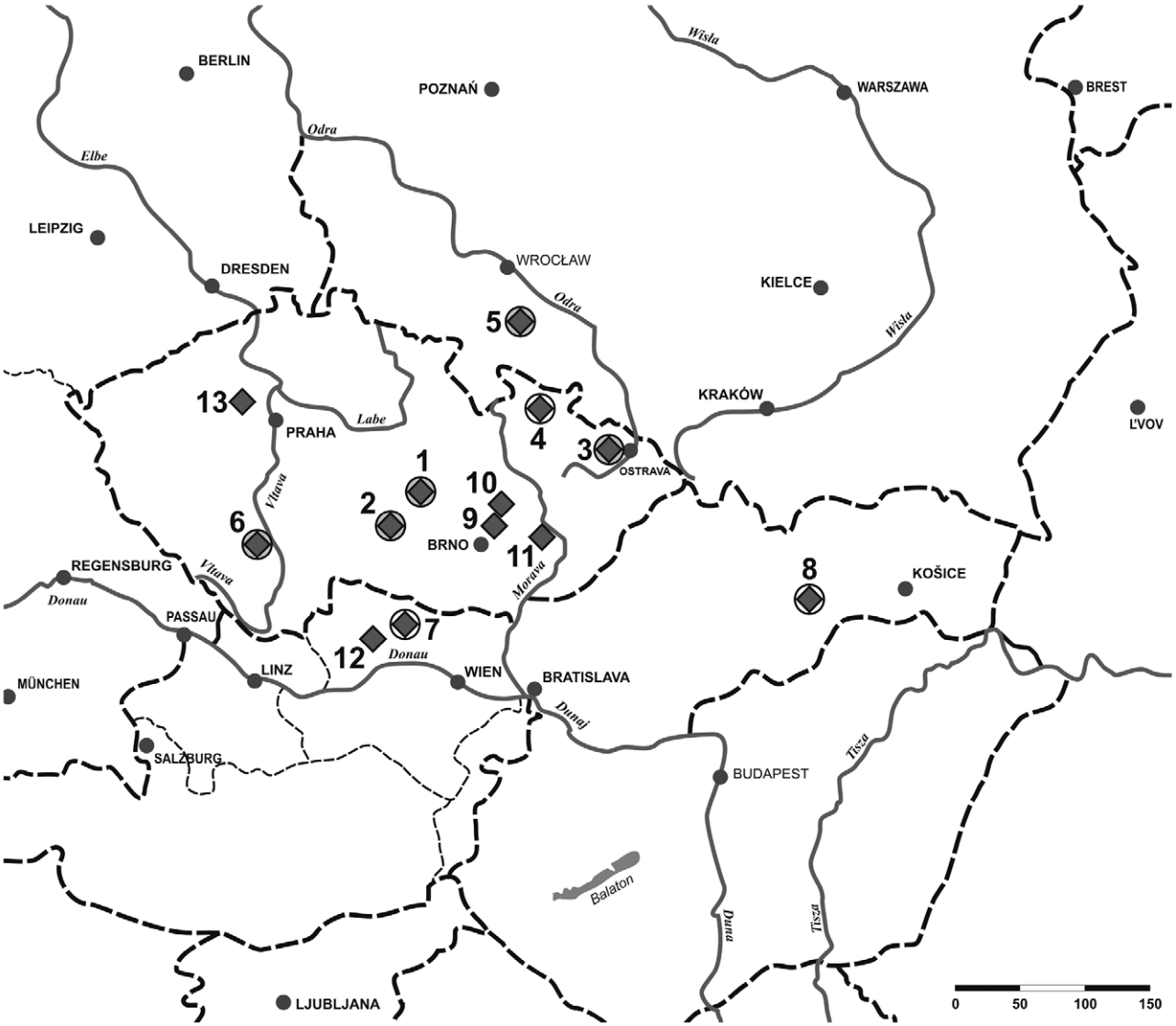

Fig. 77. The most important natural occurrences of rock crystal (in some cases with citrine and smoky quartz) and archaeological sites with chipped rock crystal in eastern Central Europe. Natural sources (in circles): 1 – area of Žďár nad Sázavou, 2 – area of Brtnice, 3 – area of Bílovec, 4 – Žulová-Andělské domky, Velká Kraš, Stará Červená Voda, 5 – Jegłowa (Poland), 6 – area of Písek, 7 – Nödersdorf near Pernegg (Austria), 8 – Revúca (Slovakia). Sites with chipped rock crystal out of the sources: 9 – Žitného cave, 10 – Kůlna cave, 11 – Nová Dědina near Kroměříž, 12 – Gudenushöhle near Hartenstein, 13 – Kvíc near Slaný.

the co-incidence of heavenly power ("heavenly ice"). Therefore anomalous properties and miraculous abilities were attributed to it. Citrine is of a yellow shade. In the archaeological literature both of these varieties are sometimes designated as rock crystal as the yellowish shade may simply be overlooked. Smoky quartz also forms crystals and excels in splendid shades of brown or smoky grey; rose quartz is a pink, non-crystalline variety (Supplement/Photo 165).

The role of rock crystal in the ancient era is of interest. It was worked by the inhabitants of Babel, Persia, India, and Egypt. In ancient Greece, the famous sculptor Feidiás used it for the decoration of one of the Seven Wonders of the World, the statue of Zeus in Olympia, as documented by the finds of several pieces of rock crystal at Feidiás' workshop. The Romans have noticed its thermal conductivity and, in rich families, they used to cool down their hands on rock crystal balls in hot days. At the archaeological excavations of the La Tène-Roman trade and cult locality on the Magdalensberg Hill, in the vicinity of the capital of the Roman province of Noricum (roughly the present Körnten; Magdalensberg is situated not far from Klagenfurt) plentiful carried-in crystallised rock crystals have been found originating from the High Tauern Mountains; these were to serve for the production of the rock crystal balls.

The role of rock crystal and of other semi-precious quartz varieties was so significant in Central Europe that the occurrences of these raw materials both at archaeological localities and at primary geological sources will be commented under the individual territories.

According to present knowledge, Moravia is undoubtedly the richest in these finds. Rock crystal or citrine chipped artefacts are systematically presented already in the Middle Palaeolithic assemblage from the Kůlna Cave in the Moravian Karst, at the beginning of the Eneolithic in the younger stage of the Moravian Painted Ware culture this attractive raw material replaced obsidian imported from far away before.

Probably the most strange rock crystal artefact in Europe comes from Serbia, the finding place of Krčevina-Milina skela, Karavukovo, and is connected with the Vinča culture, the Middle Neolithic (Vukmanovičová et al. 1978). It is 4 cm high subject polished from rock crystal and denoted as an amulet. Taking into consideration the hardness of rock crystal (No. 7 in the Mohs' scale of hardness; only topaz, corundum and diamond are harder) and the age of the artefact, it represents something completely unique.

II.3.2.1. Moravia

Prehistoric Use: In Moravia we are aware of the use of these raw materials as early in the first half of the latest (Würm) glacial, i.e. roughly 75 to 40,000 years ago. From the viewpoint of archaeologists these are the supreme cultures of the Mousterian Complex (Middle Palaeolithic), when rock crystal, citrine, and smoky quartz first appeared as raw materials for the manufacture of chipped artefacts. On the one hand this seems surprising, as with regard to their chipping properties these materials are substantially more difficult to work than silicites; on the other hand in the Middle Palaeolithic the primeval man has still widely used the easiest available raw material, i.e. quartz, thus having vast experience with this type of raw material.

It is first of all the Kůlna Cave in the Moravian Karst from where Valoch (1987, 264; 1988) refers to a small amount of rock crystal among the artefacts of the Middle Palaeolithic cultures (Taubachian and Micoquian). Its contents vary between 0.18 to 2.75 % with a marked increase towards the younger layers. In the Micoquian layer no. 7a there were 34 pieces of this uncommon raw material ascertained, among them even hand axes of rock crystal with the length of 11 cm and of smoky quartz 10 cm long. The big and relatively frequent Micoquian artefacts of rock crystal or smoky quartz in the Kůlna Cave testify for carrying-in of these raw materials from a not very big distance, i.e. from the Bohemian-Moravian Highlands.

During the older phase of Upper Palaeolithic (the Bohunician and Szeletian cultures, about 39,500 to 35,000 years ago) rock crystal occurs only sporadically (Hajany, SSW of Brno). From a Palaeolithic station at Mohelno-Boleniska a bigger piece of rock crystal was described with a preserved crystal plane (Oliva in Koštuřík et al. 1986). Later hunters with the Aurignacien culture (ca 32,000 to 29,000 years ago) must have been characterised by a substantially more complicated relation to the used materials as in some of their stations this distant raw material is significantly represented (perhaps due to ritual reasons), even in the case when resources of silicites capable of easy chipping were situated at a shorter distance. An example of this is an Aurignacian station Nová Dědina near Kroměříž, located on the flysch rocks of the Chřiby Highland, far from any rock crystal source; despite of this over 500 rock crystal artefacts have been found there. Again, 6 pieces of smoky quartz are represented as well (Plch 1977). Rock crystal occurs (though by far not so markedly) even at other Aurignacian localities of the Kroměříž region (Bělov, Kvasice II, Lhotka). From this period of time we are only aware of rock crystal exceptionally from other sites (Ondratice II in the Prostějov region). A rock crystal scraper, most likely of the Aurignacian age, is referred to from the brickworks near Loštice, and a blade of smoky quartz has been found at a probably Aurignacian station at Jaroměřice nad Rokytnou in the Třebíč area (Oliva in Koštuřík et al. 1986).

In the many-thousand collections of chipped artefacts from the Pavlovian localities rock crystal (or possibly smoky quartz) occurs only rarely, and these are usually pebbles or their parts. For example in Dolní Věstonice Plch (1977, Tab. 4) refers to the occurrence of a smoky quartz pebble of the 5 x 3 cm size, and to a roughly twice as big pebble of quartz verging into smoky quartz. In the Pavlovian the semi-precious varieties of quartz did not play the specific role, which we could observe in the course of Aurignacian. In all probability in the period of the last culminating glacial epoch their sources in the Bohemian-Moravian Highland either were not accessible to the Pavlovian hunters, or their activities were prevalently concentrated only around rivers, to the depressions between the Bohemian Massif and the Western Carpathians, and they acquired rock crystal and smoky quartz only upon incidental finds in the terrace gravels of rivers, most likely just of the Thaya River flowing under Pavlovské vrchy from the Bohemian-Moravian Highland with rock crystal and smoky quartz sources. A relatively higher representation of rock crystal seems to appear at the wonderful station of the horse hunters at the Stránská skála IV Hill (the Epigravettian) where two pieces of the 243–artefact assemblage were made of this raw material.

From the viewpoint of the rock crystal occurrence the last Palaeolithic culture (Magdalenian) is of a substantially greater interest. In a small quantity rock crystal occurs practically at all the best known localities situated in caves – i.e. the caves of Pekárna, Býčí skála, Kůlna, Žitného in the Moravian Karst, and the Šipka Cave near Štramberk (northern Moravia). For example Klíma (1974, 38, Tab. XX) specifies 21 rock crystals from the Pekárna Cave, when assessing the collection of 4,700 artefacts (i.e. 0.44 %). In the Magdalenian layers in the Kůlna Cave its content varies between 0.61 and 1.13 % (Valoch 1988). Rock crystal exceptionally occurs even in a Magdalenian

surface station in Brno-Maloměřice (Borky I). During the Magdalenian we again come across one locality exceptionally rich in rock crystal – the Žitného jeskyně Cave near Křtiny. Of the 538 chipped tools 55 pieces are of rock crystal (10.2 %). Within the overall number of finds the rock crystal even represents 23.8 % (285 pcs of 1,175), not to mention other 280 fine flakes (Valoch 1957) that have not been taken into consideration. It is obvious that the Magdalenian hunters intentionally searched for rock crystal; moreover they worked it in a systematic manner in the Žitného jeskyně Cave. Rock crystal rarely occurred even at some Late Palaeolithic localities near natural resources (Třebíč II-Táborský mlýn). Rock crystal is relatively markedly represented at some settlements of the Mesolithic. In Moravia, it is mentioned both at Smolín and Přibice.

In the Neolithic cultures of the earliest farmers with the Linear and Stroked Pottery the rock crystal appears only exceptionally. The situation changed during the older period of the Moravian Painted Ware culture. Within the Ia phase, the rock crystal plaid practically no role: in Těšetice-Kyjovice near Znojmo only three pieces were of rock crystal, and smoky quartz has appeared once among 1629 artefacts belonging into this period. However, a different situation turned up in the course of the Ib younger phase of this culture when obsidian began to be replaced by rock crystal, as has already been pointed out by several authors earlier on (Střelice-Sklep in the Znojmo region, Jaroměřice nad Rokytnou, and other settlements between Znojmo and Oslavany; in the Brno area for example Brno-Žebětín). In the course of the Eneolithic the rock crystal basically does not occur among artefacts. One ascertained exception could represent rock crystal artefacts in the area of the Eneolithic hillfort settlement Hlinsko near Lipník. The used rock crystal parts are macroscopically different from the West Moravian ones, and their source may highly probably be assumed at Jegłowa in the Polish Silesia.

Later on rock crystal appears in Moravia in the form of pendants from the Migration Period at some Langobardian burial grounds (first half of 6th century AD). Their assessment may be found in the work of Mrázek (1996) that includes a photographic documentation. A pentagonal rock crystal pendant with the 45 mm diameter and a seal ring-shaped pendant (35 mm diameter) originate from the well-known necropolis Holubice I (east of Brno). The third rock crystal pendant, this time globular, with the diameter amounting to nearly 29 mm, has been described from Znojmo.

The substantial presence of rock crystal at some Moravian Palaeolithic stations, and among the artefacts of the culture with Moravian Painted Ware, has resulted in a wide discussion as to from where this raw material was transported. For the industry from the Žitného jeskyně Cave it was considered the rock crystal has originated in the Alps (Kruťa in Valoch 1957); for the Aurignacian station at Nová Dědina a view on the origin of this rock crystal in the crystalline units of the Bohemian Massif, no matter whether from the West Moravian pegmatites (the

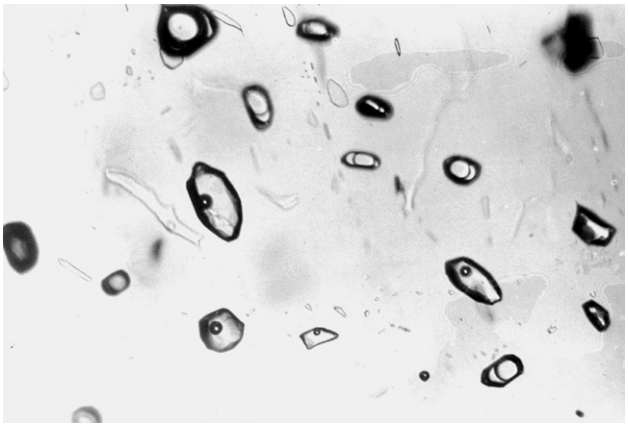

Fig. 78. Various types of inclusions in a rock crystal from the natural occurrence at Bobrůvka, district of Žďár nad Sázavou. Length of the picture is 1.1 mm. After Plch (1977).

village of Dolní Bory and the surroundings) or from the pegmatite to quartz dykes in the proximity of the Žulová Pluton in the Silesicum was predominant from the very beginning. After a detailed mineralogical study, including the assessment of gas/liquid inclusions, the view that the rock crystals both from Nová Dědina and from the Žitného jeskyně Cave (and most likely from other Moravian localities as well) originate from the West Moravian pegmatites (Staněk & Plch 1980) has prevailed. Indeed, the surface research carried out in the West Moravian crystalline complexes in the subsequent years has brought positive results: finds of chipped artefacts just at rock crystal sources in the Bohemian-Moravian Highland – SE of Žďár nad Sázavou and SE of Jihlava (Přichystal 1989).

Nowadays we know besides a series of natural rock crystal occurrences in the Bohemian-Moravian Highland (especially SE of Žďár nad Sázavou and S of Brtnice near Jihlava) another important rock crystal source area in the surroundings of Žulová-Strzelin granite Pluton that extends in Polish and Czech Silesia (Jegłowa, Vidnava, Česká Ves u Jeseníku, Stará Červená Voda, Velká Kraš, Žulová-Andělské Domky). The fourth potential source region (till present time it has not been taken into consideration at all in specialized literature) is the central part of the Hrubý Jeseník Mts. where veins of the "Alpine paragenesis" occur, e.g. at Krásné near Hraběšice or at Vernířovice, with rock crystals up to 14–16 cm long and 4 cm thick (Sládek 1973).

As it follows from the text above there is more important rock crystal sources in eastern Central Europe and to determine reliably the origin of artefacts will be necessary to characterize the sources based on a study of their fluid inclusions (Fig. 78) and microchemistry. Plch (1977) and Staněk & Plch (1980) started with such investigation thirty years before. After a long gap we have continued with research of rock crystal sources in western Moravia (Halavínová & Přichystal 2008) and in Silesia (Slobodník & Peša 2008). This investigation is not so advanced to be possible based on these data to distinguish the individual sources in this monograph.

Sources of citrine, rock crystal and smoky quartz SE of Žďár nad Sázavou (western Moravia)

Location: Among collectors known famous occurrences of crystal varieties of SiO_2 are spread in the Křižanov Highland (a subunit of the Bíteš Highland in the central part of the Bohemian-Moravian Highland, especially among the villages of Sklené nad Oslavou – Dolní Bory – Suky, it is 10–15 km SE of Žďár nad Sázavou. One of the localities, the pegmatite at Dolní Bory was mined in 1887–1972 as a source of feldspar. The altitude of the area varies between 520–630 m above sea level. This source area was probably the most important in the Moravian prehistory.

Geological Setting: From the viewpoint of regional geology the area is situated in the Moldanubicum and built of the Varied Group. Dyke bodies of pegmatites crop out in the environment of strongly metamorphosed rocks (sillimanite-biotite gneiss, amphibolite, granulite, serpentinite). Semi-precious varieties of quartz both fill cavities in pegmatites (Dolní Bory, Rousměrov, Sklené nad Oslavou, Bobrůvka, Laštovičky, Suky) and in the secondary position they are a part of deluvial to deluviofluvial sediments. These deposits situated on the prevalent sillimanite-biotite gneisses form an extensive belt of the NW – SE direction, 7 km long and 4 km broad (Mrázek 1977). The stage of citrine and rock crystal rounding is lesser comparing typical fluvial gravels.

Macroscopic Appearance: Pegmatite at Dolní Bory yielded numerous crystals of smoky quartz weighting even more than 100 kg. For the smoky quartz from Dolní Bory is characteristic a parallel growth of smaller light smoke coloured crystals. The small crystals have a bipyramidal habit, the pyramidal planes absolutely prevail, prismatic planes are developed only as narrow ones. Individual crystals of the second generation can have the prismatic planes as dominant. Planes of other shapes have never been found on them (Staněk 1999, 17). Etching by the HF acid ascertained the growths are according to both the Dauphine and Brasil Laws. The crystals of younger generation have big gas-fluid inclusions reaching up to 1 cm^3 and visible by naked eye.

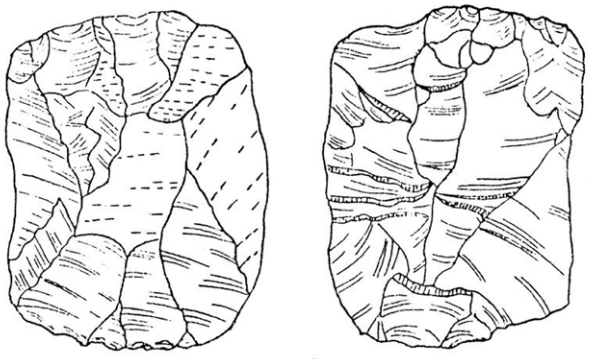

Fig. 79. Citrine chipped artefact (core) from the natural occurence at the Sklené Pond (district of Žďár nad Sázavou), western Moravia. The height is 4.6 cm. Drawing by L. Najmrová.

Partly rounded citrine crystals weighting up to 2 kg and having dimensions up to 10–15 cm prevail in the deluviofluvial deposits. They are of high quality, without cracks and such suitable for jewel making in some cases. They have a pale yellowish hue. Crystal planes are dull with fine dots as a consequence of movement on the slopes and their edges are slightly rounded (Supplement/Photo 166). The citrine crystals are almost isometric, non-elongated or only shortly elongated; pyramidal and short prismatic planes are well developed as is the crystal shapes concerned.

Prehistoric Use: Just in the mentioned belt of deluviofluvial deposits it was possible to find chipped both local citrines and rock crystals (Fig. 79) and imported raw materials (cherts from the Krumlovský les, chocolate silicite from Poland, siliceous weathering products of serpentinites). Přichystal (1989) called attention on these citrine and rock crystal artefacts for the first time, later Valoch (2004) summarized data on the artefacts from various private collections and described them from localities Bobrůvka I-VI, Bohdalec, Cyrilov, Hodíškov, Kněževes, Krásněves, Laštovičky, Netín I-IV, Olší nad Oslavou, Radenice I-II, Radostín nad Oslavou, Rousměrov, Sklené nad Oslavou I-II and Suky II-III. The total number of citrine, rock crystal and silicite artefacts from the area has already exceeded a few ten of items in spite of it that numerous next artefacts are probably hidden in private collections of mineralogists.

As is their timing concerned, Valoch (2004, 159–160) supposes on the basis of their typology and patination the Middle Palaeolithic (Micoquian) age in some cases and he believes that just the Neanderthal men from the Kůlna Cave in the Moravian Karst (more than fifty km far to the east) were looking for citrine and rock crystal in the Moravian-Bohemian Highland. A part of the found artefacts is with no doubt of the Upper Palaeolithic (most probably Aurignacian) age. A few artefacts can be connected to the Magdalenian. Prevalent part of the citrine, rock crystal and silicite non-patinated artefacts has relationship to the Post-Palaeolithic cultures: small cores to microcores can be related to the Moravian Painted Ware but there are also very probably Eneolithic artefacts.

Sources of rock crystal and smoky quartz south of Brtnice near Jihlava (western Moravia)

Location: Occurrences of rock crystal lie about 15 km to the SSE of Jihlava, again in the Bohemian-Moravian Highland, in its gemorphological subunit called the Brtnice Highland. Finding places both of raw material and artefacts are situated in the cadastral areas of Brtnice, Jestřebí, Kněžice, Hladov and Brtnička. Their altitude varies between 550–680 m above sea level.

Geological Setting: The raw material has been collected in deluvial to deluviofluvial sediments lying on weathered sillimanite-biotite gneisses, moderately migmatitized in pla-ces. Some deposits with rock crystals represent immediately weathered parts of simple pegmatites or quartz veins in-situ (the eluvium).

Macroscopic Appearance: Crystals of the raw material do not reach such dimensions as those in the area SE of Žďár nad Sázavou. Prevalent part of our collection does not exceed 5 cm. Rounding of rock crystal and smoky quartz is very low; usually they form natural angular chips. There is almost missing a semi-precious variety with the yellowish hue (citrine), one can find either rock crystal or smoky quartz (Supplement/Photo 167). Many pieces represent a transitional variety between rock crystal and quartz with many cracks coated by pale brown oxides and hydroxides of iron; it causes an impression the whole quartz mass has yellow tint but the variety can not be called citrine.

Prehistoric Use: Diviš & Grepl (1984) called our attention to finds of rock crystal and silicite artefacts in this rock crystal source area. Between 1976 and 1995 J. Diviš has put together a vast collection of 163 chipped pieces from the pro-ximity of Kněžice (16 km SSE of Jihlava) where rock crystal and smoky quartz were significantly represented among artefacts, apart from chert and flint; exceptionally small obsidian cores were found as well. In his gatherings rock crystal and smoky quartz represent 65 artefacts, i.e. 40 % (Diviš 1995, 42). Apart from scrapes and small blades, he rather frequently refers to fine points among the artefacts, and the collection apparently contains tools of a wide temporal range from the Late Palaeolithic to the Eneolithic. The rock crystal and silicite chipped artefacts were also ascertained in the cadastral areas of the neighbouring municipalities of Brtnice, Jestřebí, Hladov, and Brtnička (Přichystal 1989).

Sources of smoky quartz and rock crystal in the surroundings of Bílovec (northern Moravia)

Location: In north Moravia interesting small natural sources of pale smoky quartz and rock crystal are described in the Lower Carboniferous (the Culm) sediments in the surroundings of Bílovec (especially towards Bílov), at the north edge of the Moravian Gateway, approximately 20 km SW of Ostrava. From the geomorphological point of view it is the eastern part of the Nízký Jeseník Highland (the Vítkov Highland). Druses of quartz and rock crystal have been also referred from analogical dykes at the village of Třísek 3 km north of Bílovec; furthermore, rock crystal of the same ge-nesis was found at Slatina, Bílovec-Stará Ves, Těškovice and Zbyslavice.

Geological Setting: Quartz dykes with vugs, in which crystallised quartz, rock crystal, and smoky quartz occur, transect greywackes and shales of the Hradec-Kyjovice Formation of the Lower Carboniferous (Upper Viséan) age. The dykes and veins usually accompany tectonic (overthrust) planes in local sedimentary rocks. It is well visible at a classical locality of this phenomenon – big abandoned quarry at Bílovec-Stará Ves. The veins are prevalently filled by milky-white quartz with a compact building or forming only small crystals up to 0.5 cm. Bigger crystals of quartz, rock crystal or smoky quartz are present only at some of them.

Macroscopic Appearance: Crystallized quartz, rock crystal and smoky quartz can reach up to 4 cm (Kruťa 1957, 12) that was confirmed by our field survey. The smoky quartz even resembles the well-known smoky quartz of the pegmatite at Dolní Bory in western Moravia. It is not brown but in fact light grey to light brownish grey (5YR 6/1) and in addition the colour is not spread regularly in the whole crystal but is especially developed near the termination of smoky quartz. Its crystals are often terminated from both sides by rhombohedrons and usually form a repeated twinning. The citrine specified from there as well is only a quartz coloured by iron in places (Kruťa 1957).

Prehistoric Use: An extensive using cannot be supposed because of small raw material concentration at sources. On the other hand a nice crystal shaping could attract the prehistoric man and the crystals were collected as rarities. As an example can be introduced information of Hlas & Krasnokutská (2006, 117) who described in two features of the Platěnice culture in the close municipality of Klimkovice (about 10 km to the NE of Bílovec) smoky quartz crystals and according to their shape we are almost sure they have origin from quartz dykes in this part of Moravo-Silesian Lower Carboniferous (the Culm), very probably in the surroundings of Bílovec (Supplement/Photo 168).

II.3.2.2. Czech and Polish Silesia

A feature linking together rock crystal localities in this part of the Bohemian Massif is their occurrence at quartz veins in the metamorphic rocks forming the mantle of large granite Strzelin-Žulová Pluton. Genesis of the quartz veins can be connected very probably with intrusion of the pluton in the Upper Carboniferous when the surrounding mantle rocks were strongly affected by thermal metamorphosis and as a consequence it caused a migration of liquid and gas fluids including some chemical compounds (especially SiO_2).

Source of rock crystal at Žulová-Andělské domky (Czech Silesia)

Location: Among collectors a well-known rock crystal occurrence lies 1 km east of Žulová, on the SE slope of the Boží hora hill, in a small grove at a field path north of the road from Žulová to Černá Voda. Under the name Korálové jámy (Coral Pits) or Andělské Domky (Angel Cottages) according to a close lonely place, is published in the mineralogical literature.

Geological Setting: The deposit has been explored and described by more authors (Albrechtová, Klement & Skácel 1970; Novotný 1997; Novotný & Dobeš 1999). The quartz and rock crystal are bounded to quartz dykes having a thickness up to 2 m and cutting through local, usually kaolinized granite. They are accompanied by older dykes of aplite or pegmatite.

The best rock crystals are situated in up to 30 cm thick lens-like cavities filled with solid, grey-blue clay in the centre of the quartz dykes. The rock crystal analysis showed the composition of 99.38 % of SiO_2, 0.07 % of Al_2O_3, and 0.006 % of TiO_2 (Albrechtová, Klement & Skácel 1970).

Macroscopic Appearance: Quartz and rock crystal have usually a columnar shape with a long hexagonal

prism. Novotný (1997) describes the quartz as non-translucent, grey-white or whitish with a vitreous lustre. Partly clouded rock crystal can reach the length up to 10 cm; clear colourless crystals have maximally 6–7 cm (Supplement/Photo 169). But they are very often tectonically stroked, the prism or rhombohedron edges are broken off or cracks appear in the central part of crystals. Sometimes they have a pale green hue as a consequence of included fine-grained (1–1.5 mm) scales of chlorite. The above-mentioned author also described inclusions of fibrous mineral (asbestos ?) especially in the lower part of crystals.

Prehistoric Use: No rock crystal artefacts have been obtained either in close or wider surroundings of this locality but because of its relatively good accessibility we can suppose the knowledge of it in the prehistoric times. According to published data, the extraction of rock crystal for the manufacture of souvenirs for the guests of the nearby Jeseník Spa was carried out there as early as in the latter half of the 18th century and at the beginning of the 19th century.

Source of rock crystal at Jegłowa near Strzelin (Polish Silesia)

Location: According to our present knowledge the most important finding place of rock crystal used in the prehistory in the whole Silesia is the village of Jegłowa, 9 km SE of Strzelin, 44 km SSE of Wrocław in the Polish part of Silesia. From geomorphological point of view the unit is called the Wzgórze Strzelińskie Hilly land. A big quarry has been opened at the locality with mining of the local quartzite schist as a heat-resistant raw material.

Geological Setting: The occurrences of rock crystal are connected with the Lower Devonian quartzite schist and quartzite that are a part of crystalline mantle of the Strzelin (Strzelin-Žulová) Pluton. The quartzite schist has a whitish colour (sometimes with a pale green hue) and an expressive plane parallel to pencil structure. It contains beside totally prevalent quartz (up to 99 %) also sericite and kaolinized feldspars, in places small columns or needles of black tourmaline occur as an accessory mineral. The crystalline mantle of the Strzelin Pluton is also built of sericite schist, phyllite and small tuffite intercalations.

Macroscopic Appearance: An elongated habit of perfectly limited crystals reaching a length up to 20 cm is typical (Supplement/Photo 170), but it is highly probable there were found even bigger pieces as could be evidenced by polished stones dating back to 10th to 12th centuries and discovered at the Ostrów Tumski Island in the Odra River, the first early medieval settled centre in Wrocław. Among 263 stones there are also 94 rock crystals and 50 smoky quartzes, for which Kaźmierczyk & Sachanbiński (1980) assume the origin of the rock crystal from Jegłowa and Krzywina near Strzelin.

Prehistoric Use: In the late 20th century at the Mesolithic station Jegłowa 2 lying 1.5 km north of the natural rock crystal resource in Jegłowa, 28 rock crystal artefacts in various stages of processing were discovered: raw material, semi-finished artefacts, waste, cores and tools (Bobak 2000). Isolated rock crystal artefacts have been found also at Bielawa 12 and Karpnik. Preserving of elongated prismatic parts is characteristic for raw material and core artefacts. As already mentioned above, several rock crystal artefacts found in the area of Eneolithic hillfort Hlinsko near Lipník have these elongated shapes, too (Supplement/Photo 171). They were most probably carried from the source at Jegłowa, which would represent a distance of 140 km as the crow flies. In fact the transport went probably around the Nízký Jeseník Highland and followed a route about 200 km long. Findings of rock crystal artefacts were ascertained also at the Mesolithic sites west of Jegłowa, for example four pieces at Ratno Dolne 2, NW of Kłodsko, where their provenance has not been unambiguously solved yet.

II.3.2.3. Southern Bohemia

Location: As already mentioned by Dubský (1949), southern Bohemia is famous for the use of the above raw materials. In this region the semi-precious varieties of quartz with sizes suitable for chipped artefacts occur in vugs of pegmatite dykes primarily in the Písek area, although pegmatites with the above quartz varieties are also found in the Bechyně and Tábor areas. Nevertheless, it is usually rather difficult to determine concrete place of acquiring of these raw materials; indeed e.g. the number of newly described natural incidences of rock crystal in south Bohemia is specified as 38 only between 1966 and 1998 (Novák 2002, 334). We usually consider the natural occurrences that are closest to the studied archaeological site with the finds of such artefacts.

Prehistoric Use: In the course of studying the Pre-Neolithic settlements of southern Bohemia (Přichystal 2006) the use of the semi-precious quartz varieties was ascertained at a number of stations in the surroundings of Písek (Ražice – Putim, Žďár I and II, Písek I), but even at some localities of the Strakonice region (Blanice 6, Němetice I). Thus it is not rare, and the origin of the quartz varieties from the nearby pegmatites is nearly sure, although in the case of our localities we do not expect their extraction directly from pegmatites, but from deluviofluvial or fluvial gravels in their surroundings. Similarly to quartz, even on rock crystals or rose quartzes (for example Žďár I south-west of Písek) relics of rolled surfaces are sometimes preserved. Pebble surfaces have been found even on rose quartz artefacts from the locality Blatnice 6 SW of Bavorov. On the other hand, at the locality Písek I the rock crystal has been found with a sculpted surface, analogously to moldavite.

In view of these raw materials a special reference should be made to the Mesolithic stations in the Šumava Mts., in the area of the Vltavice Furrow, in particular in the place of the present Lipno Dam reservoir. In this area the high representation of rock crystal, rose quartz, and smoky quartz, namely at Hůrka 4, where the number of these artefacts reaches 103 of 2,256, i.e. 5.3 % (Vencl 1989, 493) is surprising. For the purpose of comparison – even at the richest site of the Písek region (Žďár I) the overall

number of artefacts of these raw materials is only 34, i.e. 4.3 %. At that the Písek region is famous for the occurrences of pegmatites with the semi-precious SiO_2 varieties, therefore for the Šumava localities we have to assume a local source of these raw materials. Novák (2002, 186) refers to a cluster of pegmatite dykes at Muckov near Černá v Pošumaví, i.e. in the immediate surroundings. Rock crystal has also been described at the Mesolithic station in Hradišťko, Jindřichův Hradec district (Vencl 1992).

Chipping of rock crystal is known even from other parts of Bohemia. Žebera (1955, 23) refers to a few rock crystal artefacts from the surface Magdalenian station at Kvíc near Slaný (central Bohemia). It is known even from East Bohemian Mesolithic stations, e.g. at Pardubice its share is 6 % (Vencl 1990, 236). On the other hand, from the Mesolithic stations of western and northern Bohemia rock crystals have not been described, which again shows these parts of Bohemia to be distant from the source areas.

In the Old Neolithic the situation in Bohemia is similar to Moravia; e.g. the very known settlement with the Linear and Stroked Pottery at Bylany near Kutná Hora has only yielded two pieces out of 1,282 artefacts (Přichystal 1985). Rock crystal was very rarely found also in features of younger prehistoric cultures. It was not a raw material for chipped artefact but it attracted by its crystal shape as a natural rarity. As an example it is possible to introduce a well shaped 2.6 cm long rock crystal found in the grave No. 37 at a burial ground of the Urnfield culture at Třebešov, district of Rychnov nad Kněžnou, eastern Bohemia (Vokolek 1966, 20). We cannot exclude its origin from the mentioned source at Polish Jegłowa where such elongated rock crystals are typical.

II.3.2.4. Austria

Location: Austrian part of the Bohemian Massif also provided sources of the semi-precious quartz varieties connected especially with pegmatites or quartz dykes. The most interesting area from this point of view is a part of Lower Austria called Waldviertel. Götzinger (2008) published an overview of mineral occurrences (including rock crystal, smoky quartz and citrine) in Waldviertel. Some of the semi-precious quartz varieties occur in the Eisgarn granite of the Moldanubian Pluton (Südböhmische Pluton), for example in the surroundings of Brunn (NW of Dobersberg) where nice crystals of smoky quartz up to 20 cm long have been found. Citrine occurs there also, in places as partly rounded pieces in a secondary position. Other localities can be found in NW Waldviertel (Angelbach near Grossperthol z, Kalvarienberg Hill at Weitra, Albrechts near Gmünd, Schlag bei Litschau). Nödersdorf west of Pernegg (north of Horn) represents a finding place of rock crystal (up to 15 cm big pieces) from quartz dyke in the Bíteš gneiss of the Moravicum.

Prehistoric Use: Rock crystal with preserved crystal surfaces coming from the Middle Palaeolithic layers of one of the most important archaeological localities of the Lower Austria – from the Gudenushöhle Cave near Hartenstein – has been exhibited in the Museum of Natural Sciences in Vienna together with nine smoky quartz artefacts.

In the Late Palaeolithic, rock crystal from the famous Alpine "cellars" (Alpine veins) in the High Tauern Mts. has already been surely used; for example at Abri von Unken an der Saalach (Moosleitner 1994), which has been dated by means of C^{14} to the turn of the 10th and 9th millennium B.C., and where there has been a significant share of rock crystal.

An investigation of rock crystal sources in high Alpine regions in western Austria and southern Tyrol (Leitner 2002, 2008; Hammerschmied 2011) showed an extensive use of local rock crystal in the Mesolithic and Neolithic. The area of Riepenkar in the Tux Alps (Tuxer Alpen in German), which lies in the "Tauern Window" from the geological viewpoint, played an essential role in the procurement of the rock crystal raw material.

II.3.2.5. Slovakia

Location: Probably the most interesting source of semi-precious quartz varieties suitable for prehistoric chipping could be the Kohút and Smolárka Mt. near Revúca because crystals of local citrine and smoky quartz can reach up to 0.3–0.5 m (they are exhibited in the National Museum in Bratislava). Herčko (1984) summarized principal natural occurrences of Slovakian rock crystals: Banská Štiavnica-Šobov with rock crystals up to 20 cm, Medačka near Lučenec, Tisovec and Kokava nad Rimavicou. Nice findings of smoky quartz have been referred at Hnúšťa. Bigger pieces of rock crystal we know also from Banská Belá near Banská Štiavnica. It is a question if small idiomorphic rock crystals (up to 2 cm) coming from the flysch sediments of the Krosno Nappe Unit also in Slovakia and among collectors called the "Marmarosch diamonts" (according to the type locality in Transkarpathian Ukraine) could be used in prehistory as natural rarity.

Prehistoric Use: Comparing the surroundings lands, Slovakia is poorest in the findings of prehistoric rock crystal artefacts. Kaminská (2001) published an overview on raw materials used during the Palaeolithic in Slovakia but the rock crystal has not mentioned at all. A few rock crystal artefacts should be found at the famous Palaeolithic station Moravany nad Váhom (according to a manuscript report of L. Zotz, for more see Hromada 2000); one rock crystal artefact has been ascertained at Kašov I. If the rock crystal artefacts are absolutely exceptional at Slovakian Palaeolithic localities, there have not been introduced among the Slovakian Neolithic chipped artefacts at all (Točík et al. 1970). In spite of it we can not exclude some rare finds of rock crystal artefacts in the future it is evident this raw material played an insignificant role in Slovakia comparing Moravia or Lower Austria. The ascertained situation is probably connected with the very strong influence of east Slovakian sources of obsidian both in the Palaeolithic and in the period of Lengyel cultural complex.

II.3.2.6. Hungary

Location: Hungarian mineralogical papers concentrated on topographical mineralogy (e.g. Szakáll & Jánosi 1996) have mentioned a few localities with natural occurrences of several cm long colourless transparent quartz crystals, for example in the surroundings of Telkibánya (the Tokaj-Zemplén Mts.), in quartz veins with a restricted Alpine type assemblage in phyllite (the Szendrö Mts.), quartz-bearing veins between Gyöngyösoroszi and Mátraszentimre (the Mátra Mts.), rarely also in the secondary position in gravels (near Szentendre and Pomáz, the Visegrád Mts.). Their small dimensions probably did not allow using them for chipped artefacts, in any case the local Hungarian occurrences have not been mentioned as potential sources by Hungarian authors. Gatter (1986) tried to characterize potential rock crystal sources from the Carpathian Basin and its surroundings on the basis of fluid inclusions investigation.

Prehistoric Use: As a rare and exotic material, rock crystal is also found at some Hungarian Upper Palaeolithic localities. Dobosi & Gatter (1996) have studied 14 pieces of rock crystal artefacts deposited in the Hungarian National Museum that come from nine sites. In the southern foothills of the Tokaj-Zemplén Mountains in Bodrogkeresztúr-Henye, one rock crystal blade was found; two surface finds of rock crystal flakes originate from Megyaszó-Szelestető (the Szerencs Highlands). Both localities correspond with the Lower Gravettian types of industries. The third locality, Andornaktálya-Alsótető SE of Eger perhaps represents the old Upper Palaeolithic without a more exact classification. It has provided a surface find of a rock crystal fragment of a wide blade. Another rock crystal flake is from Jászfelsőszentgyögy-Székesdűlő (northern edge of Alföld, i.e. Great Hungarian Plain) and as for time classification it belongs to the Upper Gravettien. The last four sites are located in the surroundings of Pilismarót, 15 km east of Esztergom, and again correspond to the Upper Gravettien. Nine rock crystal artefacts originate from them (the richest locality is Bánom with six pieces). Evaluating all mentioned rock crystal artefacts from the viewpoint of their size, nine pieces have dimensions up to 30 mm, the biggest two pieces are 45 and 48 mm long.

Dobosi & Gatter (1966) have also carried out a microthermometric study of the inclusions in rock crystal artefacts. In five samples no inclusions were found; in the others two-phase fluid inclusions of the H_2O-type were ascertained (with only 5 to 20 % vol. of the gaseous phase), or H_2O – CO_2 (up to 100 to 80 % of the gaseous phase). Furthermore, they have discussed the possible origin of the rock crystal from genetically different deposits not only of Hungary but the Carpathian area and the close surroundings as well. They exclude the origin from intrusive and effusive rocks (small dimensions of crystals, distortion by glassy or gas-liquid inclusions), pegmatites (due to dark or rose colour and the corrosion of crystals), probably even from hydrothermal dykes (small dimensions of crystals; big, up to several millimetre sized inclusions), from hydrothermal occurrences in sediments (common presence of inclusions with hydrocarbons). As the most probable source of rock crystals at the Hungarian Upper Palaeolithic stations they consider the so-called Alpine paragenesis of the quartz dykes originating from epizonal to mesozonal metamorphosed rocks, in this particular case most probably from the Eastern Alps.

It is necessary to point out to this interesting work that the exclusion of the pegmatite origin on the basis of the dark colour of SiO_2 is insufficient as apart from smoky quartz both from the Moravian and Czech pegmatites we are aware of not only very slightly coloured citrines (so that even in specialist literature these are commonly designated as rock crystals) but also typical clear rock crystals.

II.3.2.7. Significance of rock crystal, citrine and smoky quartz from the Bohemian Massif

In conclusion it can be stated that irrespective of its markedly worse chipping characteristics in comparison to silicites, the rock crystal, citrine, and smoky quartz attracted men as early as from the Middle Palaeolithic, as corroborated by the finds from the Kůlna Cave in Moravia or from the Gudenus-Höhle Cave in Lower Austria. There did even localities exist in Moravia in the Aurignacian and Magdalenian where this raw material was the prevailing. Thus it was intentionally searched for and systematically processed. Rock crystal has also plaid its important role in the Bohemian Mesolithic, and in the Neolithic culture with the Moravian Painted Ware. A long-term, and in some primeval periods also an intense processing of rock crystal (and possibly of citrine and smoky quartz) at the localities situated in Moravia and in Bohemia, finds of chipped artefacts directly at the West-Moravian pegmatites and in the surroundings of South-Bohemian pegmatites prove the utilisation of these sources in the prehistory and the necessity to take them into consideration even when solving the provenance of rock crystal artefacts in the surrounding countries. Another source in use was related to the quartz veins in the Devonian quartzite in Polish Silesia (Jegłowa near Strzelin). Most probably only towards the end of the Palaeolithic, after the withdrawal of the Würm mountain glaciers, another source began to be chipped and distributed in greater quantities, i.e. rock crystal from the Alps, the processing of which has then culminated in the ancient and medieval times when magic and cult object were made of it by grinding and polishing.

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II.3.3. Hydrotermal chalcedony and its varieties (jasper, agate) from Permian volcanic rocks

General Overview: From the chemical viewpoint the chalcedony is a variety of silica having fibrous or cryptocrystalline texture and usually light bluish-grey (also white or grey) colour. In the course of time it changes to quartz. Because of contents of iron compounds these mixtures of chalcedony and cryptocrystalline quartz can have various brown-red or green hues and they are called jaspers. If chalcedony alternates with fine-grained quartz in concentric zones, such variety is branded as agate (Supplement/Photo 174). Common pale to glassy varieties of chalcedony form often cauliflower-like nodules and they are collected in the secondary position at numerous finding places in the Krkonoše Piedmont Basin or Intra-Sudetic Basin (Supplement/Photos 175–177).

Sources of the raw material are genetically connected with filling of cavities and cracks especially in the Permian or Tertiary volcanites. That is why in this book they are distinguished from the various coloured chalcedony or opal originating by weathering processes on serpentinites. These are described in the following chapter. In addition, it is necessary to differ the hydrotermal chalcedony from non-translucent dark red Permian limnic silicites occurring for example in gravels at a mining deposit of Bohemian garnets at Vestřev south of Hostinné.

Hydrotermal chalcedony and its varieties originated in the Permian volcanic rocks that are traditionally named as melaphyres in Central Europe (in reality they are basaltic andesites) and they crop out at many places of northern Bohemia, Lower Silesia and Saxony. Prehistoric using of some sources has been proved. In the Krkonoše Piedmont Basin there are many finding places connected both with melaphyres (basaltic andesites) and weathered out from them and replaced to slope or fluvial deposits. Prehistoric chipping of jasper from the Kozákov Hill has been described in more archaeological papers. On the other hand it is necessary to note occurrences of jasper in other melaphyre bodies (Frýdštejn, Doubravice near Železnice, other small localities in the Nová Paka and Český Dub areas) and transport of jasper pieces by the Jizera and Cidlina Rivers far to the south to central Bohemia – to the surroundings of Chlumec nad Cidlinou, Kolín, Poděbrady, Pečky, Brandýs nad Labem (e.g. Ziegler 1974, 43).

II.3.3.1. Kozákov jasper

Background: The Kozákov Hill had been famous already in the Middle Ages by the occurrences of chalcedony and jasper being used as semi-precious and decorative stones in the reign of Charles IV and Rudolph II. An important medieval Bohemian writer Balbín (1679) did not mention just the Kozákov Hill but he has stated: "In Bohemia there is so much jasper it is not almost considered to be a precious stone". A table of Rudolph II decorated by jasper was believed to be the eighth wonder of the world.

Fig. 80. Pseudokarst cave Babí pec in sandstones on the western slope of the Kozákov Hill, northern Bohemia. The cave is famous by the find of a few thousand chipped artefacts (prevalently made of local jaspers) weighting more than 17 kg. Photo by the author.

Location: The top of "precious stone hill" (i.e. the Kozákov Hill) lies in northern Bohemia 7 km east of Turnov. A private museum of Mr. Votrubec with local minerals is situated at the road to the hilltop and an abandoned quarry of the same name popular with collectors has been open at the altitude 576 m close to the museum. In the time of active mining in the quarry an old shaft probably from the period of Emperor Rudolph II was discovered (Řídkošil 1995). Since 1985 the western slope of the hill has been protected as a National Natural Sight with area 162,8 ha. Pseudokarst caves (in the Czech called "pece" that mean baking ovens) used for settlement in prehistory (Babí, Kudrnáč's and Zeman's ones) have been developed in the Cretaceous sandstones and siltstones in this area called Proskalí (Fig. 80).

Geological Setting: The semi-precious varieties of silica (jasper, chalcedony, agate, amethyst) are fixed on filling of cracks, cavities and dykes in basaltic andesite (melaphyre) of the Permian age. It is possible to distinguish seven lava flows in the 40 m high wall of the Votrubec's quarry. Jasper is bound especially to dykes (the most important is the Charles dyke) while rock crystal, amethyst, chalcedony, agate and rarely even smoky quartz fill cavities in the volcanic rock.

Macroscopic Appearance: Jasper dykes of the Kozákov Hill can have a thickness over 10 cm, dark green smudges (5G 3/2) or simple agate textures of grey-white colour appear towards their margin. The dyke margins are almost black-green as a consequence of chlorite content. The central parts have dark red (5R 3/4) or dark brown-red (10R 3/4) colour, in places white parts are filled by calcite (Supplement/Photo 172).

Microscopic Appearance: Using the stereomicroscope and water immersion one can see in the Kozákov jasper numerous moss-like red formations that are intensively waved and connected together in transparent chalcedonic mass. Small agate structures with a simple zoned banding having dimensions up to a few mm occur in places (Supplement/Photo 173). Grains of younger calcite with evident cleavage can appear in central parts of these small agates.

Other Analyses: Magnetic susceptibility is only a little above the detection limit (0.00–0.03 x 10^{-3} SI) but the mother rock (melaphyre) reaches higher values 0.5–1 x 10^{-3} SI (for comparison a melaphyre from Frýdštejn has magnetic susceptibility 7.5–9 x 10^{-3} SI).

Prehistoric Using: The Kozákov jasper was ascertained as a raw material for prehistoric chipped artefacts during excavations in the mentioned pseudokarst caves. They were carried out in the Zeman's pec Cave already in 1909, in the Babí and Kudrnáč's pece Caves in the period 1936–1937. Numerous chipped artefacts were found in the all caves but the most important assemblage – a few thousand pieces weighting over 17 kg – comes from the Babí pec Cave (Vaníček 1936). Besides the dominant red and green jasper there was used also chert, chalcedony and quartz. During the prevalent part of the 20th century the finds had been interpreted as Eneolithic workshops connected with the Funnel Beaker culture (Filip 1947, 25). The quantity of jasper, its relative homogeneity and small presence of chalcedony testifies for raw material mining, not for any collecting in the slope or fluvial sediments. Recently Šída (2007) has supposed the Mesolithic age for the prevalent part of the assemblage from the Babí pec Cave.

J. Filip also mentioned the Kozákov jasper from a close archaeological locality at Štěpánovice (5 km SSW of the Kozákov Hill) where it was found again with parts of a funnel beaker. According to Pleslová-Štiková (1981, 44) the jasper rarely appeared already with finds of the Stroked Pottery culture or Moravian Painted Ware culture (Mašov – "Čertova ruka", Novák's pec Cave). Based on archaeological excavations at the rise Hrada and rocky promontory Klamorna close to the top hill Mužský (463 m) she believes that more probably the people with Řivnáč culture extracted the Kozákov jasper in the Late Eneolithic. At the Hrada rise a fragment of jasper artefact (probably a borer) was found in one of the La-Tène features.

From data mentioned above it follows the Kozákov jasper was chipped in the surroundings of its natural source and it was only of regional significance. An exposition in the Museum of Bohemian Paradise in 1998 presented evidence on the Kozákov jasper utilisation in the period of the Funnel Beaker culture (Vesec pod Kozákovem) and of the Corded Ware culture (Svijany, Svijanský Újezd, Turnov).

II.3.3.2. Bezděčín chalcedony

Location: The village of Bezděčín (district of Jablonec nad Nisou) is situated in northern Bohemia, 9 km to the SSW of the district town.

Geological Setting: Chalcedony fills joints and rock interstices in Permian basaltic andesites (melaphyres) and it can form oval or circular boulders weighting up to 100 kg.

Macroscopic Appearance: Red, orange, yellow, purple colours prevail but there were found black, rose and

raspberry-like red chalcedonies as well (Šída 1992). Agate fillings with striped structures were ascertained besides the homogenous single-coloured pieces. Together with jasper it is present calcite, barite or moss-like configurations built of chlorite (dellesite). Pieces of the best quality have almost glassy appearance.

Prehistoric Using: Till now it has not been described.

II.3.3.3. Jasper and chalcedony from the Polish part of the Intra-Sudetic Basin

Location: The Intra-Sudetic Basin (depresja or niecką śródsudecka in Polish) is an important geological unit with the direction NW – SE filled by sedimentary rocks of limnic Upper Carboniferous to Permian, Triassic and Cretaceous age. The basin is spread among the Krkonoše-Jizerské hory Crystalline Unit in the west, the Sowie góry block in the north and the Orlické hory Crystalline Unit in the east. It is situated partly in the Czech Republic, partly in Poland.

Geological Setting: Jasper and chalcedony (or other silica minerals) are fixed to filling of cavities or fissures in Permian basaltic andesites (melaphyres). There are more such sources in the Intra-Sudetic Basin, for example according to a field survey of J. Bronowicki it is a NW – SE ridge built of Permian melaphyres between Raszków and Kamieniec, about 6–14 km west of Kłodsko (Sawicki 1995).

Macroscopic Appearance: Jasper pieces can have dimensions up to 10 x 9 cm and the colour is variable even in one sample. It varies usually between greyish red (10R 4/2) and pale reddish brown (10R 5/4) but darker red spots or parts with lighter jasper mass (light brown 5YR 5/6) are present as well – Supplement/Photo 176. Magnetic susceptibility is often only slightly above the detection limit using the portable kappameter (0.00–0.05 x 10^{-3} SI); the host rock has values substantially higher (0.9–1.2 x 10^{-3} SI).

Stereomicroscopic Appearance: "Moss-like" structure, it means numerous yellow brown to red brown interlaced fibres built of hydroxides and oxides of iron in clear chalcedony mass, is typical for the raw material (Supplement/Photo 177). Lighter to yellowish brown chalcedony varieties are totally overfilled with such fibrous formations and clear chalcedony is almost missing.

Prehistoric Using: J. Bronowicki found a few Mesolithic sites just at the source or its surroundings and local jasper has been ascertained in their raw material spectrum. Explicitly it is possible to mention Mieroszów 9 where more artefacts are made of rose beige chalcedony originating from Permian melaphyres (determination of M. Pawlikowski in Bronowicki & Bobak 1999, 59).

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II.3.4. Opals from Tertiary volcanic rocks of the Western Carpathians

II.3.4.1. Central Slovakia

Location: Various opals are present in volcanic mountains built of the Upper Tertiary (Miocene) andesites and rhyolites in the Central Western Carpathians. An important group of finding places is situated in the volcanic mountains of Central Slovakia (Vtáčnik, Pohronský Inovec, Štiavnické vrchy, Kremnické vrchy, Poľana, Javorie). In some places they crop out together with silicified (opalized) woods that are classified by Slovakian authors as woody opals but in this book they are described in the chapter II.6.4. Silicifed woods.

Overviews on opal localities in Slovakia can be found in comprehensive publications on Slovakian minerals (Herčko 1984; Koděra et al. 1986–1990; Ďuďa & Pauliš 2005), in papers concentrated only on opals (Mrázek & Rejl 1982; Ďuďa 1996) or focused in selected finding places (Horáková 1977). Common opals crop out at more places in Central Slovakian Tertiary volcanic rocks: Badín, Horné Pršany and Rakytovce south of Banská Bystrica; Bartošova Lehôtka and Nevoľné south of Kremnica; Hutná dolina and Jamešná in the surroundings of Ľubietová; Kozelník near Banská Štiavnica; Kosorina

north of Žiar nad Hronom; Osrblie south of Brezno nad Hronom; Cígeľ near Prievidza; Stará Huta and Orovnica east of Zlaté Moravce and others.

Geological Setting: Common opals occur in Badenian to Sarmatian andesites or in their tuffs and tuffites. Opal nodules, breccias, dykes or impregnations originated as a consequence of post-volcanic processes accompanied by contribution of SiO_2. Part of opals could be also connected with weathering processes of vitrified tuffs (Gregor 2005). Precious opal was found only exceptionally at Sitnianska Lehôtka and Banská Štiavnica. Some opals have been crushed and again cemented by younger opal. According to Ďuďa (1996, 256) opal from Osrblie south of Brezno nad Hronom is exceptional from genetic point of view because its origin is a consequence of oxidation in upper parts of ore veins.

Macroscopic Appearance: Common opals are usually massive, non-transparent or only rarely translucent, with resinous lustre and conchoidal fracture. The appearance covers a wide colour spectrum from yellow brown, brown, red brown, brown green to black green or black and green. Opals coming from pyroxene-amphibole andesite between the village of Nevoľné and Kremnica are very attractive because of their zoned structure (green margin, brown and white zones, bright yellow central part, so they resemble a cut egg).

Thin Section: Opal has isotropic appearance in crossed polars. Green colour of the zonal opal from Nevoľné is caused by fine-grained pyrite and chlorite; yellow coloration is connected with finely spread hydroxides of iron and white zone with occurrence of clay minerals (Horáková 1977, 316).

Other Analyses: Gregor (2005) studied opals of Central Slovakian provenance (Badín, Nevoľné, Mochovce, Lehôtka pod Brehmi) using the x-ray powder diffraction analysis, scanning microscope, electron microprobe, energy dispersed analysis x-ray (EDAX) and infrared absorption spectroscopy. He divided them to A-opals (amorphous), C-opals (with content of α-cristobalite) and CT-opals (with occurrence of α-cristobalite and α-tridymite). From his results it follows the opal from Mochovce corresponds to CT-opal while samples from Badín, Nevoľné and Lehôtka pod Brehmi can be compare with metastabile transitions CT/A-opal or A/CT-opal (Nevoľné). In addition to it, there were identified layered silicates of the smectite type in opal from Badín or Nevoľné and kaolinite in opal from Lehôtka pod Brehmi. Based on the microprobe analysis M. Gregor ascertained probably monazite and covellite in Central Slovakian opals as well. He allows origin of opals by weathering processes of volcanic glass.

Prehistoric Use: Ďuďa & Pauliš (2005) estimate more than 140 natural occurrences of various opals in Slovakia with their origin prevalently in Tertiary volcanic rocks. The provenance of opal raw material is necessary to solve independently for individual archaeological sites.

Siliceous masses composed from opal and chalcedony were chipped already in the Middle Palaeolithic in Central Slovakia, for example at a Mousterian locality Prievidza-Mariánský vršek where they represented the prevalent raw material (29 % according to Kaminská 2001, 90). The raw material was probably extracted in the nearby Kremnické vrchy Mts.

An Eneolithic workshop with about 600 chipped tools, roughouts and waste made of prevalently yellowish opal has been described from Brodzany (4 km SW of Partizánské). The site is classified to the Lengyel cultural complex, more explicit to the Brodzany-Nitra group, when higher altitudes were settled in connection with supposed activities of lithic raw material prospectors (Němejcová-Pavúková 1970, 145). A source area of this opal lies probably at a well-known natural finding place close to the village of Cigeľ at the eastern periphery of the Vtáčnik Mts. (about 25 km to the NE) or at Stará Huta and Orovnica in the Pohronský Inovec Mts., roughly of the same distance from Brodzany.

II.3.4.2. Eastern Slovakia

Background: East-Slovakian opals were in the centre of attention already in the Roman period because the first written report on the Dubník precious opal comes from the time of Marcus Antonius, 86–31 BC (Herčko 1984). Classical mining is supposed roughly from the 11th century AD. As is the Czech geological literature concerned, information on opal from Červenica near Prešov appeared already in a mineralogical key written by "father" of Czech geology Krejčí (1865, 109).

Location: Principal occurrences of common opal are in the Slanské vrchy Mts. (Lesíček, Vyšná Kamenica, Herľany, Dargov, Slanec and others); two localities (Vinné a Petrovce) are mentioned from the Vihorlat Mts. The surroundings of Červenica and Dubník represent the most important Slovakian area with deposits of precious, milky and vitreous opal.

Geological Setting: The origin of opal is similar to that in the Central-Slovakian volcanic mountains but East-Slovakian volcanic rocks are somewhat younger (Sarmatian to Pannonian). Common opals at Herľany crop out in the peripheral part of the stratovolcano Strechov built of andesite lava flows and pyroclastic rocks, partly redeposited. Opals form irregular lenses with a length about 10–30 m and a thickness up to 1.3 m (Ďuďa 1996, 256). Another situation has been ascertained at Dargov where opals fill vertical joints and numerous big cavities in the brecciated andesite lava flows. The vertical joints are in the subsurface parts intensively limonitized, so the opals have a distinctive ochre or brown black colour.

Macroscopic Appearance: Yellow brown, ochre, brown to chocolate brown opals (e.g. Dargov – Supplement/Photo 178) prevail also in the Slanské vrchy Mts. A special type of flesh-coloured opal crops out at Herľany together with white yellow and striped brown black opals. Green brown and green opals have been described from Slanec and Petrovec in the Vihorlat Mts. Besides prevalent massive structures there are present also lumpy to fluidal (Ďuďa 1996, 256), rarely striped (Herľany, Vyšná Kamenica).

Prehistoric Use: Opal and chalcedony were chipped already in the Middle Palaeolithic (Mousterian) sites

Banské and Červenica in east Slovakia (Kaminská 2001). But genera-lly the local opal was used in eastern Slovakia relatively little because of strong influence of obsidian, limnic silicite, radiolarite and other high-quality raw materials from also East-Slovakian sources. Usually only several chipped artefacts are ascertained; somewhat more pieces from opal and chalcedony were found at an Epigravettian settlement Hrčel-Pivničky (38 artefacts, i.e. 0.5 % of the whole collection) or at Veľaty I (opal with chalcedony form even 1.69 %).

II.3.4.3. Northern Hungary

Location: North-Hungarian mountains built of Tertiary (Miocene) andesites and rhyolites have yielded also occurrences of opals probably of post-volcanic genesis. The mountain belt runs from the Tokaj-Zemplén Mts. (Tokaji-Zempléni-hegység) in the east via Bükk, Mátra, Cserhát up to Börzsöny-Visegrád in the west. Two catalogues of the Hungarian lithotheca (Biró & Dobosi 1991; Biró, Dobosi & Schléder) have introduced numerous sources in the mentioned mountains, for example three localities from the Tokaj Mts. (Tállya, Telkibánya, Boldogkőváralja), similarly from Mátra (Gyöngyösoroszi, Hasznos, Mátraháza), Szokolya from the Börzsöny Mts. and Püspökhatvan from the Cserhát Mts.

In some cases opals form filling of small basins and they are evidently of sedimentary origin with banded (layered) structure (e. g. Szardokpüspöki in the Mátra Mts.), sometimes they crop out together with typical limnic silicites and Hungarian researchers call them as opalites or limnic opalites (if their sedimentation was in small lakes). Such varieties should be classified as limnic silicites from the genetic point of view.

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II.3.5. Siliceous weathering products of serpentinites and of other metamorphic rocks (Fig. 81)

General Overview: The bodies of serpentinites and of some other metamorphic rocks (e.g. dolomite marbles, erlans) in the crystalline complexes of the Bohemian Massif have undergone an intensive chemical weathering under the then markedly warmer climate in the course of the Mesozoic and Lower Tertiary. This weathering has resulted in the creation of nodular to platy formations of brown, brown yellow, red, or green chalcedony (plasma), variously coloured opals, or only matt, usually greenish grey siliciophites (silicified ultrabasic rocks). However, opal and chalcedony have apparently emerged also in the course of hydrothermal, or possibly even metamorphic changes of the above rocks (for more details see e.g. Novák 1996). In the area of crystalline rocks of the Bohemian Massif we know a lot of natural localities with such raw material also besides the territory of the Czech Republic (Fig. 81).

Plasma (green coloured chalcedony) from the weathering crust on serpentinite is built of cryptocrystalline chalcedony or quartz together with relics of silicate minerals (especially chlorites). Investigation of thin sections using the polarizing microscope shows worm-like arranged chlorites and opaque minerals (magnetite) that causes a higher magnetic susceptibility. It can be often measured even by portable kappameter. These properties and no microfossils occurrence allow us to distinguish reliably the siliceous weathering products of serpentinites contrary green or brown coloured radiolarites (generally silicites) or volcanogenic jaspers.

Opals originating by weathering processes of serpentinites have very variable colours – milky white, black, red brown, yellowish, and grey brown, often with colour alternation. The colours are undoubtedly connected with

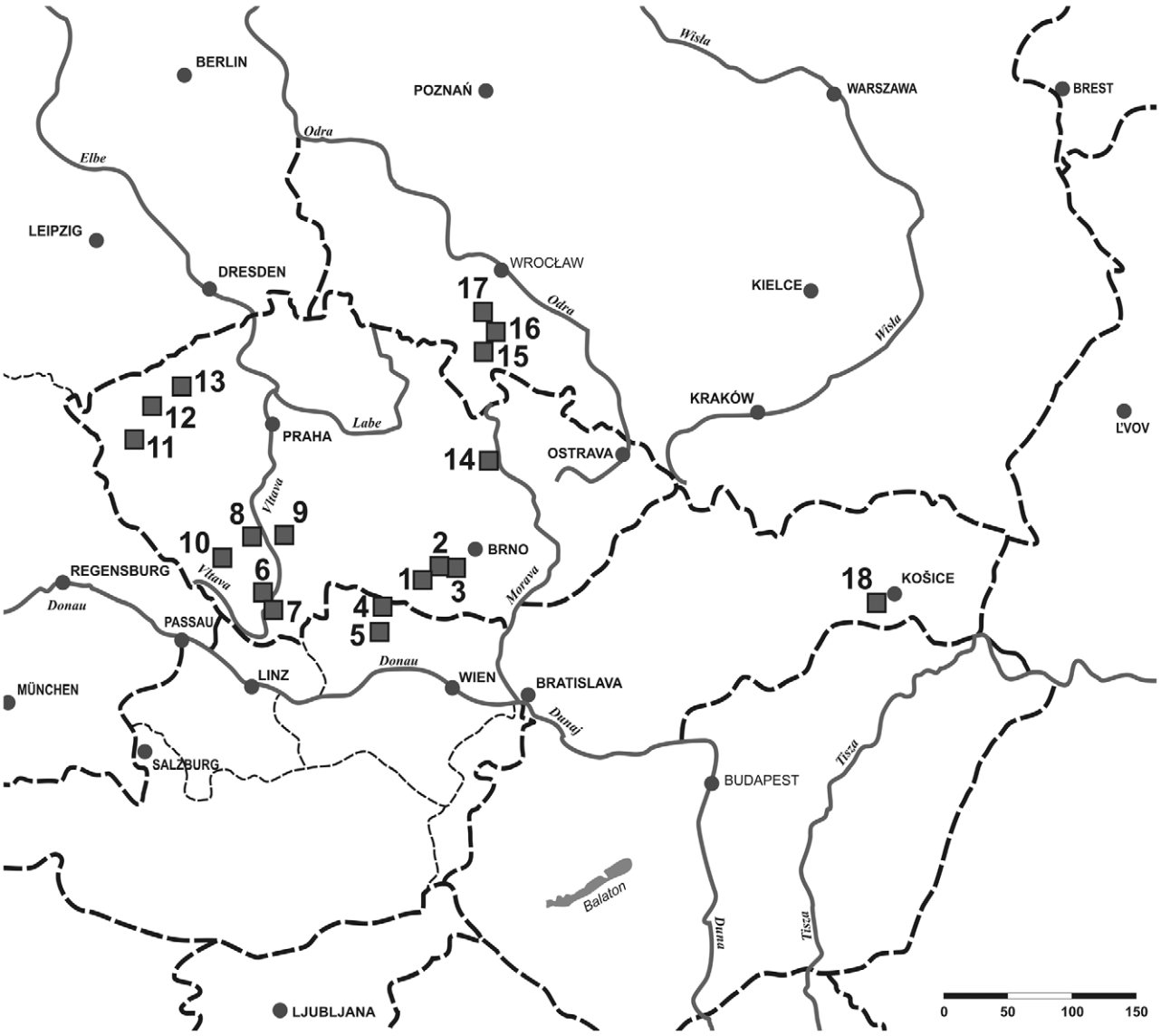

Fig. 81. Sources of siliceous weathering products of serpentinites and other metamorphites. 1 – area of Jevišovice, 2 – Mohelno and surroundings, 3 – Hrubšice, 4 – Japons (Lower Austria), 5 – Wanzenau and St. Leonhard am Hornerwald (Lower Austria), 6 – Křemže and surroundings, 7 – Zlatá Koruna-Srnín, 8 – area of Písek, 9 – area of Bechyně, 10 – Zahořice and Malenice (area of Strakonice), 11 – Mnichov near Mariánské Lázně, 12 – Lučina, 13 – Černovice, Ahníkov, 14 – Moravská Třebová, Boršov, 15 – Braszowice-Brzeżnica (Poland), 16 – Szklary (Poland), 17 – Gogolów-Jordanów (Poland), 18 – Hodkovice near Košice (Slovakia).

the content of various iron compounds in different stage of oxidation and hydratation. Opals from serpentinites are non-transparent and non-translucent with typical wax lustre. Opal is isotropic in the thin section using crossed polars.

II.3.5.1. Western Moravia

Background: It was already Moravian mineralogist Klvaňa (1882) who noticed occurrences of "siliceous masses and semi-opals similar to chert or flint" on serpentinites from Hrubšice and Jamolice in west Moravia. Přichystal (1980, 1984) introduced them as a new raw material for chipped tools in the archaeological literature when he studied lithic industries from the Neolithic site of Těšetice-Kyjovice near Znojmo. Kovárník (1977, 96) registered the raw material already earlier but he believed to be a Cretaceous chert. At first sight the unusual raw material appeared in the course of time as an important local source for chipped artefacts at numerous archaeological sites of SW Moravia and Lower Austria. We can suppose the utilization of these siliceous weathering products from serpentinites in Polish and German parts of the Bohemian Massif as well.

Location: There are many sources of siliceous weathering products of serpentinites in west Moravia, for example Kruťa (1966, 332) mentioned in his topographic

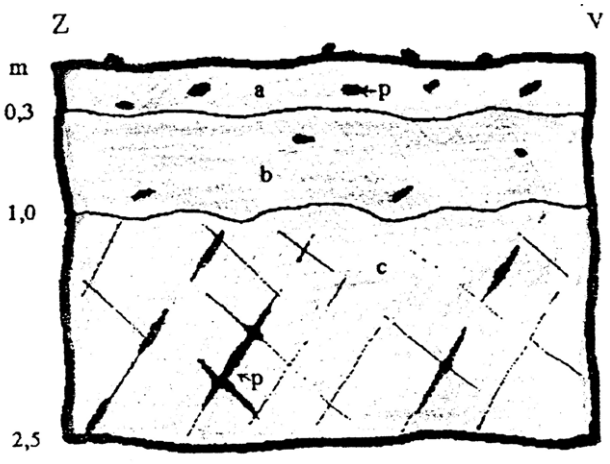

Fig. 82. Position of siliceous weathering products in the weathered serpentinite at Jiřice near Jevišovice, western Moravia (after Mátl 1999). Black (p) – siliceous weathering products (plasma); 0 to 0.3 m – loam with siliceous chips, 0.3 to 1 m – deluvium of serpentinite with siliceous chips, 1 to 2.5 m – weathered serpentinite with platy occurrences of siliceous mass along joint planes.

mineralogy of Moravia under the term "plasma" (green chalcedony originated by weathering of serpentinites) 17 localities from the West-Moravian crystalline units, additional occurrences are probably hidden under the terms "opal" and "chalcedony". It is necessary to take into consideration the siliceous weathering products originated probably at all serpentinite bodies in the Bohemian Massif but later they were more or less denudated. We know the most important natural finding places in the west and SW surroundings of Jevišovice (towards Bojanovice), next five small bodies with siliceous weathering products were mapped to the NE and E of Jiřice (Matějovská, ed. 1983) or near Grešlové Mýto. Other important occurrences are situated at Černín, Medlice, Tavíkovice, Biskupice-Slatina, Mohelno, Hrubšice and Dubňany. Many of sources have not been found till the present time as it was shown by investigations of Vokáč (2004) at Neolithic sites in SW Moravia because he had to use preliminary names according to archaeological sites for siliceous weathering pro-ducts used for chipped tools (siliceous weathering products of the Ctidružice, Lesůňky, Vysočany types). M. Vokáč also drew our attention to another group of natural finding places in the Hrotovice area (Hrotovice, Radkovice-Pulkov, Bačice, Krhov) or around the middle part of Jihlava River (Slavětice, Rešice, Dukovany, Rouchovany, Kordula). As is concerned siliceous weathering products coming from another rock, it is possible to introduce brown striped opal originated on dolomite marble at Třebíč-Borovina.

Geological Setting: Serpentinite bodies crop out within the Varied Group of the Moravian Moldanubicum. In the tectonostratigraphic division it is the Gföhl Unit. Surrounding rocks are represented by the Gföhl ortogneiss (Jevišovice area, Hrotovice area) or granulites (Mohelno, Hrubšice).

Macroscopic Appearance: Siliceous weathering products have usually shapes of oval or small loaf-like pieces; platy shapes originated at joints (Fig. 82). They are brightly coloured: for example in the Jevišovice area the brown or yellow brown, rarely red brown colours prevail but the green variety (plasma) or two-coloured pieces (green colour just under the cover and brown in the central part) are present as well. The last two varieties are used as semi-precious stones in recent time. Nodular pieces have a few cm thick whitish or greenish cover layer (Supplement/Photo 180). The opal from Třebíč-Borovina has a characteristic alternation of thin whitish and yellowish to dark brown stripes.

Stereomicroscopic Appearance: Brown or yellow brown weathering products have a grey translucent siliceous mass with numerous slightly bended and elongated formations coloured by ochre pigmentation. Similar inclusions in green varieties are around 1–2 mm long and they have whitish hue. In both cases they show more or less distinct transversal cleavage. The inclusions can be interpreted as altered relics of phyllosilicate minerals, probably of chlorites or phlogopite. Opaque minerals sometimes with crystal cubic shapes are visible in places as well (Supplement/Photo 181).

Thin Section: Comparing silicites, fibrous chalcedony is substantially more present, in places it covers more than 50 % of the thin section (Supplement/Photo 182). Chalcedony borders bigger opaque minerals or it forms polygonal formations adjoining each other, at their margins with brown or green pigmentation, aptly with accumulations of fine-grained opaque minerals. Some pieces contain occurrences of bended brown-coloured phyllosilicates (Fig. 83) in the microcrystalline siliceous mass. No such thing has been described from silicites (flints, cherts) of sedimentary origin.

Other Analyses: Almost always the siliceous weathering products of serpentinites have a gently higher magnetic susceptibility what is an important sign to distinguish

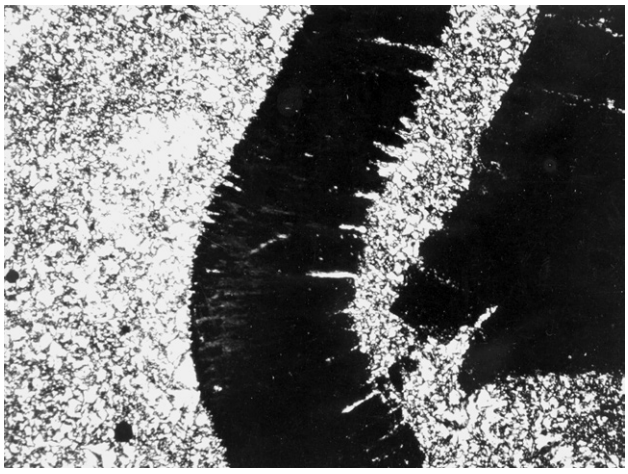

Fig. 83. Siliceous weathering product of serpentinite in thin section, Bojanovice near Jevišovice, western Moravia. Accumulations of phylosilicate (black) in chalcedony mosaic of groundmass. Length of the picture 1.7 mm, crossed polars. Photo by the author.

them in comparison with red and green silicites. Magnetic susceptibility usually varies between 0.01–0.07 x 10^{-3} SI (it also corresponds to the artefact dimensions), rarely it can reach up to 0.15 x 10^{-3} SI. There in no doubt it is connected with relics of magnetic minerals from the host serpentines.

Prehistoric Use: There are tens of sites with the Moravian Painted Ware in SW Moravia where chipped siliceous weathering products have been found. They are represented both by various coloured chalcedonies including plasma and opals. The raw material has been ascertained at settlements with the Moravian Painted Ware also in the Brno area (for example Brno-Žebětín) and more to the NE along the eastern margin of the Bohemian Massif (the Vyškov and Prostějov areas). Grillo (1997, 14) has described from a few Neolithic localities in Bavaria individual chipped artefacts (1 to 4 pieces) that he compares to the striped opal from Třebíč-Borovina but it can be more probably a siliceous weathering product from southern Bohemia or even from Bavaria.

II.3.5.2. Lower Austria and Burgenland

Location: The most important occurrences of siliceous weathering products lie 7–12 km SW of Horn around the municipalities of Wanzenau and St. Leonhard am Hornerwald (roughly 5 and 8 km west of Gars am Kamp). Another significant locality is situated in fields between the villages of Japons and Oberhumeritz, 10 km west of Geras or 17 km NW of Horn. Also in Burgenland one can find places with opal of such genesis, for example at Bernstein.

Geological Setting: Siliceous weathering products north of Wanzenau are connected with a small serpentinite body in the St. Leonhard granulite massif, a part of the Varied (Gföhl) Unit of the Moldanubicum in Waldviertel. According to "Geologische Karte von Niederösterreich 1 : 200 000, Wien 2002" there are no serpentinites in the vicinity of St. Leonhard and Japons but only amphibolites as representatives of mafic rocks.

Macroscopic Appearance: In the northern vicinity of Wanzenau it is possible to gather multicoloured varieties of chalcedony (brown red, grey, greenish). Nice milky white opals with dimensions over 10 cm have been described from around St. Leonhard. Siliceous weathering products at Japons (Supplement/Photo 183) are very variable and include both prevalent opals with a characteristic waxy lustre (milky white opal with brown to grey schliers or dark spots; dark brown, greenish, and striped opals) and chalcedony masses usually of ochre or yellowish brown colour.

Milky white and waxy brown opals originated on the local serpentinite body at Bernstein. The milky white opal with many black dendrites can reach dimensions up to 0.75 m and a weight up to 180 kg but they are often brecciated. The brown Bernstein opal forms nodules even over 10 cm and it makes a good impression as a suitable raw material for chipped tools.

Stereomicroscopic Appearance: The opals are non-translucent and heavily filled with a brown, black or white pigmentation. They contain small cavities with reniform opal, sometimes translucent. A waxy lustre is typical for conchoidal fracture.

Chalcedony masses are also heavily pigmented in dark brown colour, the pigmentation is homogenous and there are no parts without the pigmentation. Chalcedony chips have very often a thick yellowish to brownish white patina.

Thin Section: Very fine-grained cryptocrystalline siliceous mass from Japons contains irregular formations of opaque mineral and cloudy accumulations of ochre pigmentation. No fibrous chalcedony has been observed comparing the siliceous weathering products of serpentinites from western Moravia.

Other Analyses: Magnetic susceptibility measured on the samples from Japons shows values around the detection limit (0.00–0.01 x 10^{-3} SI). A big sample from Wanzenau classified as "jasper" and deposited at the Institute für Ur- und Frühgeschichte, Universität Wien (the Vienna lithotheca) has a relatively high magnetic susceptibility (0.49 x 10^{-3} SI), a higher magnetic susceptibility yielded also chipped artefacts made of this raw material from a settlement with the Linear Pottery at Mold SE of Horn. Brown opal from Bernstein has also gently higher readings between 0.02–0.12 x 10^{-3} SI.

Prehistoric Use: Chipped yellowish brown siliceous weat hering products probably of Lower Austrian provenance were found already in the Mousterian layer at a well known archaeological site Gudenushöhle (Nöhagen) nearby the confluence of Kleine and Grosse Krems Rivers. Several Palaeolithic and Late Palaeolithic stations (Rosenburg-Graselhöhle, Kamegg, Horn-Raabserstrasse, Horn-Galgenberg; for more details see Neugebauer-Maresch et al. 1995) are situated close to a source of siliceous weathering products SW Horn, so we can suppose their use at the sites. Ott (1996) studied an Upper Palaeolithic station Rosenburg-Bei Hofmühle and she confirmed flaking of chalcedony of this origin (5 %) and also of a green opal called "Krötenstein". As is the opals from Bernstein concerned, their prehistoric use has not been described in the archaeological literature till recent time.

II.3.5.3. Southern Bohemia: the Křemže Basin

Background: Žebera (1952) was the first who noticed the use of such unusual raw material for chipped tools in south Bohemia. He described it from an Epipalaeolithic station on the Kravčí Hill near Holubov (2 km SE of Křemže), now the locality is believed to be a Mesolithic site (Vencl et al. 2006).

Location: The best-known finding sites of such raw material are represented by the bodies of serpentinized ultrabasic rocks in the area of Křemže Basin about 15 km SW of České Budějovice, just at the eastern margin of the Blanský les Mts. and the protected landscape of the same name. The localities are represented by occurrences at Holubov, between Křemže and Chlum, Stupná and Chlumeček, Chmelná and Bohouškovice, Rojšín and Lhota, Hamry and Červený Mlýn. Another group of

finding places lies more to the SE near the Vltava valley between Zlatá Koruna and Srbín.

Geological Setting: The Varied Group of the Moldanubicum forms geological fundament of the Křemže Basin and Blanský les Mts. The area is built of a large granulite massif (dark and leucocratic granulites, granulite gneiss) with elongated bodies of serpentinized ultrabasic rocks with a length up to 1 km. There are several occurrences in the surroundings of Křemže where the products of the laterite weathering reach up to 30 m, and particularly in their top zone (3 to 8 m thick "red ground"; Odehnal in Čech et al. 1962, 152) it is possible to find plentiful nodules and beds of siliciophites (= siliceous weathering products). Laterite deposits were in the centre of attention in the middle of the 20th century as a possible source of iron and nickel ores.

Macroscopic Appearance: In the surroundings of Křemže we have acquired both the greenish grey siliciophites, not too attractive at first sight (Kravčí Hill near Holubov), and various types of opals: non-transparent, sometimes translucent white opals, glassy, greyish, yellowish, yellow-brown, bluish, yellow-green to green colour; moreover, sometimes with marked black dendrites (Bohouškovice, Stupná) – see Supplement/Photos 184, 187. At the last specified sources it is possible to collect up to 20 to 30 cm long flat pieces of milky white opal, and probably also prehistoric chipped opal artefacts. From the group of finding sites between Zlatá Koruna and Srnín nodules and plates of opal coloured grey, milky white, red-brown to red (in places even black) are referred by Mrázek & Rejl (1981).

Stereomicroscopic Appearance: The milky white opals are rather uniform with only thin veinlets of clear opal or ochre coatings and black dendrites on fractures. Greenish siliciophites from the Kravčí Hill near Holubov have surprisingly low magnetic susceptibility around the detection limit, dull lustre, and non-translucent siliceous mass cutting through by thin veinlets of clear chalcedony, in places with small rock crystals.

Thin Section: As a typical sign for the South-Bohemian opals it is possible to mention globular texture composed of small spherolites (0.05–0.07 mm) that are filled by a fibrous mineral supposed to be lusatite. The spherolites occur in only slightly anisotropic opal groundmass.

Prehistoric Use: In south Bohemia the siliceous weathering products represent the dominant local raw material used in the Pre-Neolithic times. They include a wide range of aesthetically magnificent milky white to bluish white opals, brown red or green chalcedonies up to dull greenish grey or brown porous silicified serpentinites (siliciophites). The last varieties sometimes contain macroscopically visible magnetite grains that cause a higher magnetic susceptibility (some chipped artefacts from Putim have up to 1.2×10^{-3} SI). For comparison, all varieties of silicites (erratic flint, Bavarian and other cherts) from this Pre-Neolithic site have magnetic susceptibility under the detection limit of the portable kappameter.

II.3.5.4. Southern Bohemia: the areas of Písek, Bechyně and Strakonice

Location: The area of Písek: the town of Písek (part called Síbrovna, vicinity of the hospital), Mlaka – Paseky (7–8 km east and southeast of Písek), Písecká Smoleč (12 km east of Písek), Smrkovice (4 km south of Písek).

The area of Bechyně: Hvožďany (2 km SW of Bechyně), Nuzice (3 km SSW of Bechyně), Všechlapy (6 km NE of Bechyně).

The area of Strakonice: Zahorčice (8 km SW of Strakonice), Malenice (14 km S of Strakonice).

Geological Setting: Siliceous weathering products used to originate in warm periods of the Tertiary or Mesozoic not only on serpentinites but also on other rocks of the Moldanubicum – on erlans or marbles (Písecká Smoleň), pyroxene aplites to pegmatites, and magnesian skarns (Trnka 1982), and this could be used to explain the natural occurrences of opal, chalcedony, and of other siliceous substances in the immediate proximity of Písek (Písek-hospital, Písek-Síbrovna), where they are stated by Krejčí (1927) or Dubský (1949); however according to geological maps serpentinite bodies have not been present here. For example from Písek-Síbrovna we are aware of pale to whitish opal substance or pale greenish grey chalcedony; J. Fröhlich has even found a solitary artefact here. According to the 1: 50 000 scale geological map, sheet 22–41 Písek (Fišera, ed. 1990) a pearl paragneiss with the leucocratic granite occurs here in the fundament. Similarly at a finding place of opal and chalcedony near Smrkovice only biotite to muscovite-biotite orthogneiss has been recorded. With a part of these opals and siliceous weathering products in general, the origin due to hydrothermal activity cannot be excluded either, as they sometimes occur in the centre of quartz dykes in the Nature park Písecké hory or in a pegmatite at the Mlaka crossing in the cadastral area of the municipality of Paseky, east of Písek (verbal communication of J. Cícha from the Prácheň Museum in Písek).

Similar geological situations result from the geological maps 1: 50 00 for the Strakonice and Bechyně areas where again no occurrences of ultrabasic rocks have been recorded excluding Všechlapy (west of the village a body of serpentinized peridotite has been mapped). In these cases siliceous weathering products originated by weathering probably of erlans (they crop out both at the SE margin of Hvožďany and SW of Nuzice in the Bechyně area), or likely by marbles north of Malenice (district of Strakonice). At some natural sources we cannot exclude the chalcedony substance could form the central part of quartz dykes.

Macroscopic Appearance: Siliceous weathering products from Písek-Síbrovna have prevalently light shades (brownish grey white, pale brown), usually with the greasy lustre similar to opal, sometimes they turn into quartz with relics of silicified gneiss. Krejčí (1925, 24) introduced similar waxy opal from the fundament of the Písek hospital. The whole spectrum of multicoloured siliceous substances (dark brown, grey with dark spots, yellowish grey white) was found at the Mlaka crossing in

the cadastral area of Paseky (Supplement/Photo 185). The pieces have a very low magnetic susceptibility (0.00–0.04 x 10^{-3} SI). A very nice yellow brown or reddish brown opal comes from Písecká Smoleč; similarly good pieces of greenish yellow opal big up to 15 cm from Smrkovice are deposited in the Prácheň museum in Písek (Supplement/Photo 186).

Siliceous weathering substances from Zahorčice in the Strakonice area are pale brown with the veinlets of transparent chalcedony, the raw material from around Malenice is dark brown with small quartz crystals on the fissure planes, partly it contains massive white quartz. The magnetic susceptibility varies in the range 0.00–0.03 x 10^{-3} SI. Big pieces (up to 8 cm) of green grey coloured chalcedony substance with the magnetic susceptibility under the detection limit can be found at Hvožďany near Bechyně.

Stereomicroscopic Appearance: Non-translucent spotted brown substances with small quartz crystals on fissure plains represent siliceous weathering products from Malenice. In contrary, the raw material from Hvožďany is colourless to whitish, relatively well translucent chalcedony mass with inclusions of green silicate minerals and ochre spots.

Thin Section: Čech (1951, 74) studied the thin section made of a siliciophite from Hvožďany. According to him, the green colour of specimen is connected with chloritized or baueritized biotite. He found also opal with only partial recrystallization but aggregates of spherolithic chalcedony or coarse-grained quartz are present as well. Chalcedony forms also veinlets or coatings of microscopic cavities. Bitotite is dark green, brown green or yellowish, it partly resembles chlorite. Siliciophites from Hvožďany can contain relics of serpentinite texture or apatite, talc, leuchtenbergite, amphibole and magnetite as accessory minerals.

Prehistoric Use: A Pre-Neolithic site Smrkovice I is situa-ted near the mentioned source and all 38 artefacts were chipped from the local raw material. Siliceous weathering products of relatively low quality were chipped as a matter of course at the group of Pre-Neolithic stations close the Řežabinec Pond (cadastral areas of Putim and Ražice). Chipped artefacts have been gathered also at a few places in the area of Hvožďany; some of them are made of siliceous weathering products (Vencl et al. 2006, 137). The knowledge of these raw materials from the Mlaka crossing, at least in the Neolithic, is documented by the finds of prehistoric pottery and solitary polished and possibly even chipped tools in the surroundings – see archaeological finds in the cadastral area of Paseky (Fröhlich 1997). In the future further archaeological sites with such raw materials will be probably found. It will be necessary to investigate in detail siliceous weathering products from natural finding places and to distinguish individual sources in southern Bohemia.

II.3.5.5. North-western Bohemia

General overview: Siliceous weathering products have been described from three natural occurrences in this region. From viewpoint of regional geology, they are situated close to the border between the Bohemicum and the Saxothuringicum. The first occurrence lies at Mnichov in the Mariánské Lázně Complex of metabasic and ultrabasic rocks, the second one near the western slope of the Doupovské hory Mts. and small ultrabasic bodies at Ahníkov and Černovice SW of Chomutov represent the last localities.

Kratochvíl (1938, 960) has mentioned black opals and chalcedony filling fissures in the serpentinite body at Mnichov (NE of Mariánské Lázně). Even more interesting siliceous weathering products have been preserved on a small massiv built of amphibolite, eclogite and serpentinite close to the contact of Karlovy Vary granite massif and volcanic rocks of the Doupovské hory Mts., 5 km east of the municipality of Lučina. Mlčoch (2006) described from this place siliceous weathering products (in his article classified incorrectly as silicites) that form almost 1 m big blocks after a disintegrated weathering crust (duricrust) with the porous surface. The weathering products have pale brown colour and brecciated structure: sharp chips of brown siliceous substance are cemented by whitish massive chalcedony or crystallized quartz. In places there are preserved relics of serpentinite or grains of limonitized magnetite (up to 2 mm and with 4–5 % of Cr_2O_3). Mlčoch (2006) mentioned also a piece of bluish chalcedony with dimensions 5 x 8 cm. The use of the raw material in prehistoric times has not been recorded till now.

We know siliceous weathering products also from the Czech part of the Saxothuringian Region where they originated on an ultrabasic body (pyroxenite) at Černovice and Ahníkov; the second village has been destroyed as a consequence of the brown coal mining in 1965. Černovice lies 4 km SW of Chomutov. The raw material from Ahníkov has appearance of low quality common opal with characteristic waxy lustre. Alternation of dark brown and yellow brown parts seems to be a typical sign. Under the stereomicroscope it has microbrecciated structure: the brown aphanite opal groundmass is cut by numerous thin veinlets filled with a black opaque mineral. This forms also individual bigger grains. The high magnetic susceptibility around 4 x 10^{-3} SI of specimens proves the opaque mineral is magnetite.

Possible prehistoric use of the raw material cannot be excluded because the source area is close to the prehistoric mines of quartzite at Tušimice (see chapter II.5.1.4.).

II.3.5.6. North-western Moravia: Moravská Třebová and Boršov

Location: Siliceous substances crop out on the one hand about 600 m to the SE of the municipality of Boršov, on the other hand in the part called Peklo (Hell) roughly 1.3 km SSE of the Moravská Třebová centre. Both finding places lie in the district of Svitavy. Based on the geological situation it seems to be very likely the siliceous substances represent weathering products of serpentinized ultrabasic rocks in combination with the hydrotermal activity. In the older mineralogical literature the raw material is classified inexactly as jasper or chert.

Geological Setting: Phyllites, partly graphitic or silicified, or mica schists to two-mica gneisses of the Zábřeh Crystalline Unit form the underlying rocks of the siliceous raw material. Quartzite beds and small bodies of strongly serpentinized ultrabasic rocks occur within the complex of phyllite to gneisses. Mrázek & Rejl (1979) have described besides the minerals of serpentinite group also opaque minerals (magnetite, chrome spinel) and quartz-chalcedony veinlets in the ultrabasic rocks. The siliceous products build about 3 m thick and at least 8 m long lenticular body with the elongation parallel to the foliation of surrounding phyllites and it is situated just at the contact between phyllites and a serpentinite body (see also Šanca 1999, 226).

Macroscopical Appearance: According to published data, "white jasper" with red brown spots and veinlets alternating into red brown jasper with white veinlets and spots represents the prevalent siliceous substance at the locality of Boršov. Quartz crystals up to 8 mm big, aptly small crystals of rock crystal, amethyst, smoky quartz, or chalcedony including agate structure appear in small cavities. Siliceous masses with plenty of veinlets have pseudobrecciated structure. They desintegrate in pieces with around 10 cm in diameter but they can reach up to 25 cm.

Siliceous substances at Moravská Třebová have been found only in deluvial sediments together with parts of phyllite. Red brown to purple or russet brown colours, in places with dark grey spots or non-distinctive stripes, are typical for them.

Thin Section: Mrázek & Rejl (1979) found prevalently quartz, furthermore lepidoblastic minerals and a mixture of chalcedonic aggregates. The colour is created by fine spread hematite pigmentation. The veinlets are filled by quartz or chalcedony. Some siliceous masses have relics of quartzitic (psammitic) texture, so the authors have supposed their origin by consequent silicification of quartzites when silica was realized during serpentinization of the ultrabasic rocks.

II.3.5.7. Lower Silesia

Location: Siliceous weathering products originated and have been preserved on ultrabasic rocks in the Polish (Lower Silesian) part of the Bohemian Massif. Some well-known localities occur in the Szklary serpentinite massif (Szklary, Ząbkowice Śląskie, Koźmice, Tomice), further in the Braszowice – Brzeżnica serpentinite massif (Brazsowice, Grochów) and small finding places are also in the Gogolów – Jordanów serpentinite massif SE of Sobótka.

Geological Setting: The mentioned massifs of ultrabasic rocks border the Sovie Góry block in the north (Gogolów – Jordanów), in the east (Szklary) and in the south-east (Braszowice – Brzeżnica). Similarly as in other parts of the Bohemian Massif we suppose the principal time interval of weathering in the Oligocene. The thickness of weathered products in Szklary reaches on average around 20–30 m.

Chrysopras from Szklary is the most popular product of serpentinite weathering in Lower Silesia. It became a famous Polish jewel stone especially in the 18th to 19th centuries and it was intensively mined in the vicinity of Ząbkowice Śląskie. The serpentinite massif at Szklary was up to the middle of the 20th century the most important centre of chrysoprase extraction in the world. The raw material is possible to find both in the weathered cover and in the serpentinite rock.

Macroscopic Appearance: Chrysoprase is a variety of chalcedony having apple-green colour. This special green hue is caused by regularly spread mineral Ni-pimelite. Sachanbiński (1979, 131) described in detail the chrysoprase occurrence in Szklary. It forms dykes or plates with a thickness from a few mm to 15 cm and the length can reach up to 3 m. In addition there are circular (nest) accumulations of diameter 50 cm having on the surface conspicuous triangular or square skeleton formations. Druses of greenish quartz with crystals up to several cm can appear very rarely. The local chrysoprase is distinguished in two basic varieties: a) glassy variety, well translucent, with unimpressive conchoidal fracture and smooth fracture surface resembling opal; b) dull variety, translucent only at edges, with rough fracture surface, more resembling chalcedony (Supplement/Photo 179).

Stereomicroscopic Appearance: The high-quality chrysoprase raw material has a homogenous apple green colouring of the chalcedony substance. It does not contain any inclusions excluding cavities filled in limonite or limonite coating on fissures. Using a high magnification one can observe an ultra fine opaque pigmentation, probably magnetite, because magnetic susceptibility is usually gently higher (up to 0.25 x 10^{-3} SI). Some chalcedony masses have a whitish grey or grey colour with islands of apple-green hue. Part of pieces is damaged by conspicuously porous (pitted) structure, in addition filled in brown hydroxides of iron.

Prehistoric Use: The raw material probably occurs at many Mesolithic stations in the Polish Sudety region, especially in the surroundings of Kłodsko. Bronowicki & Bobak (1999, 57) have mentioned for example from the station at Morzyszów about 40 artefacts, 3 of them made of ash green chalcedony coming from chalcedony dykes either from the Braszowice-Brzeżnica serpentinite massif or from Szklary (determination by M. Pawlikowski). Based on a find of the mining tool, the authors even think about possible prehistoric mining of the raw material. Similar chalcedony artefacts were ascertained at the Mesolithic sites of Podtynie 3 and Lawica 8 as well. Also opal chipped tools gathered at more stations (for example Ratno Dolne) could have their provenance from weathered serpentinite massifs of Lower Silesia.

II.3.5.8. Eastern Slovakia

General Overview: In Slovakia, the siliceous weathering products have been described only from Hodkovice near Košice where we know the largest body of ultrabasic rocks (especially serpentinized peridotite) in the Western Carpathians. The raw material originated as a consequence of weathering processes that were in progress probably in the Palaeogene to the Miocene. The weathering products have been preserved because the

younger Pliocene gravels cover the considerable part of the ultrabasic body.

Spišiak & Hovorka (1979) investigated opal-chalcedony veinlets and filling of cavities from the ultrabasic body at Hodkovice. Thickness of the veinlets was usually up to 1 cm but they found also veins 3–5 cm thick. The colour of siliceous weathering products (prevalently opals) is very variable (milky white, brown black, dark brown, brown green, brown yellow, spotted grey). According to the authors the crystal modification SiO_2 x nH_2O corresponds to the lower temperature tridymite. The colour of opal is mostly influenced by iron content presented in the form of heterogeneous inclusions, a higher content of Ni and Cr create green yellow or green hues.

Prehistoric Use: Prehistoric chipping of the raw material has not been ascertained yet.

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II.4. Natural glasses (Fig. 84)

In an ideal state, natural glasses are homogenous, amorphous, and isotropic substances that have formed by a rapid solidification of a melt without crystallisation. A detailed discussion on the definition of natural glasses may be found in the work by Bouška et al. (1987, 11). The characteristic features of some of them (hardness, conchoidal fracture) enable to simply acquire chips with a sharp cutting edge. Therefore prehistoric man focused his interest at these materials as they comply with the requirements for raw materials of chipped tools. From natural glasses it is obsidian, glass of volcanic origin, mostly occurring among the raw materials for the manufacture of chipped artefacts in Central Europe. Furthermore, occasional chipping of moldavite, from the tectite group, is documented; another volcanic glass, Saxon pitchstone, could have been used too, and theoretically even a rare occurrence of chipped fulgurite (glass originating from a thunder stroke) cannot be totally excluded.

Volcanic glasses in Central Europe (Fig. 84) originated from a rapid solidification of primarily acid rhyolite magma (obsidian, perlite, pitchstone, pumice), rarely also of basalt magma (tachylite). Acid volcanic glasses differ by the water content (the lowest being in obsidian) on one hand and by their structure or the other hand. Perlite is unsuitable for chipping due to its globular disintegration, pumice due to its extremely vesicular structure; therefore they were not utilised. Thus obsidian played the decisive role of the prehistoric raw material not only in Central Europe, but also in the Mediterranean, in the Near East, and in the North, Central and South Americas.

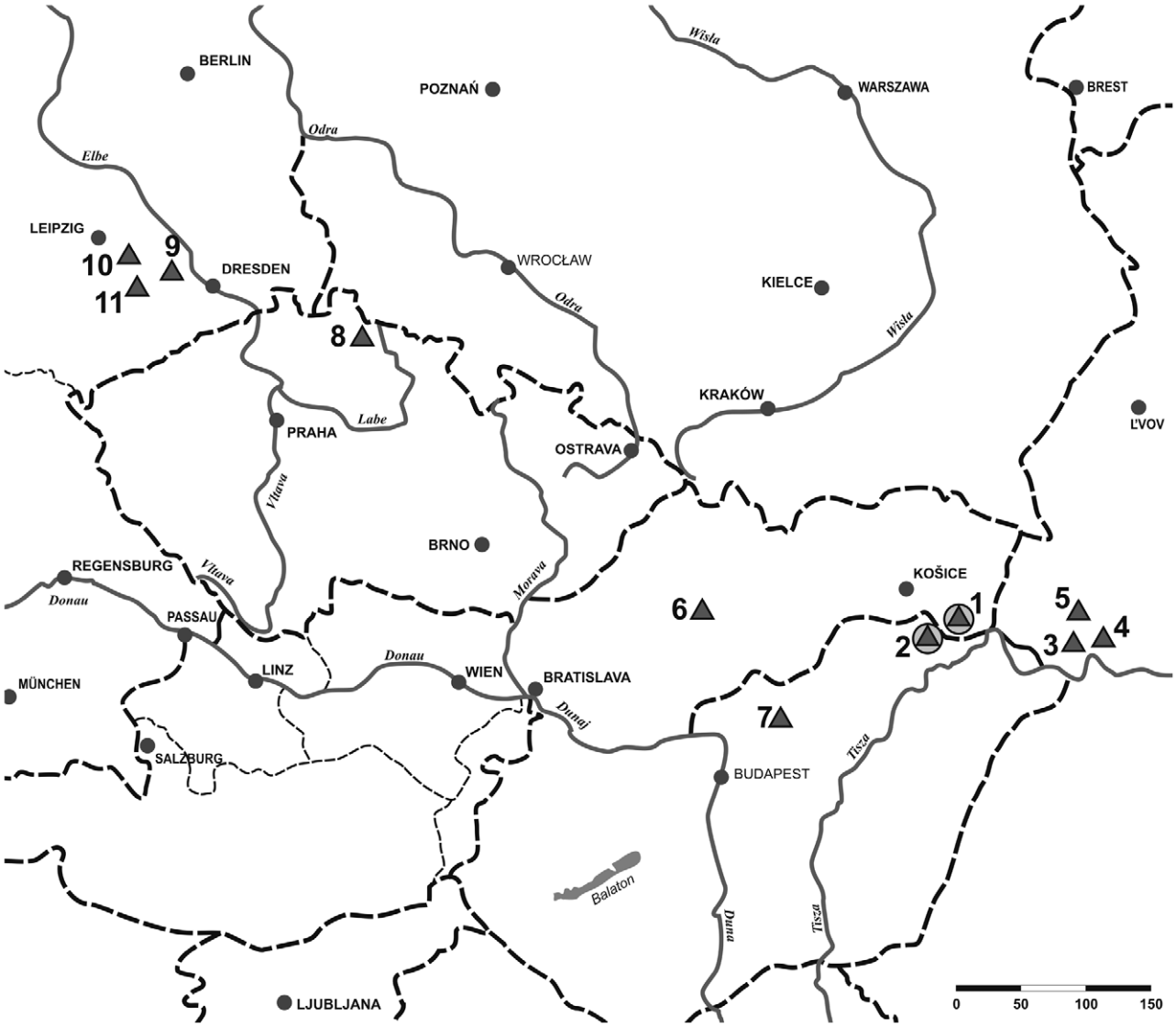

Fig. 84. Natural occurrences of volcanic glasses in eastern Central Europe. 1 – Viničky, Malá and Velká Bara, Streda nad Bodrogom, 2 – Erdöbénye-Ligetmayor, Erdöbénye-Aranyospatak, Tolcsva, 3 – Beregovo Hilly land, 4 – surroundings of Chust, 5 – Gercovce-Fedeleschovce, 6 – Hliník nad Hronom, 7 – Gyöngyössolymos-Kishegy, 8 – Kozákov, 9 – surroundings of Meissen, 10 – NW Saxony, 11 – surroundings of Zwickau.

Obsidian and perlite

General Overview: Obsidian is a compact, non-altered volcanic glass with very low water content, under 1% as a rule. Its name occurs as early as in the work of the Roman polymath Pliny the Elder (29 to 79 AD), who specified it has originated from the name of the Roman citizen Obsius who had found this glass in Aithiopia (Plinius Secundus 1974, 322). Pliny the Elder also called attention to the fact that various pictures were found in the glass, but these were probably only freaks of nature. Today we are aware this is a characteristic feature of obsidian – the fluidal structure, where a certain orientation of fine crystals (microlites) occurs when the vitreous mass creeps. Obsidian is also mentioned, under the name Ethiopian stone, as an important part of Egyptian mummification process in the texts of the Ancient Greek historian Hérodotos: "A divine-mummificator drew a cut on the left side of a dead body's abdomen and cut the flesh through by Ethiopian stone to a prescribed depth."

Analogies from a recent past (for example from the Small Andaman Isle in the Indian Ocean – Cipriani 1971) show that the excellent properties of obsidian chips enable their use, without further modifications, for shaving, cutting of nails, or for tattoo. In the Central and South Americas obsidian was used for sacrificial, hygienic, or medical operations; in Peru modified obsidian points belonged to sets of surgical instruments to carry out craniotomy. The outstanding properties of obsidian tools have been documented by experimental operations carried out in the USA in 1983, and by founding of the Aztenics Company, which produces obsidian scalpels for surgical operations. Their cutting blades are reportedly many times sharper than on scalpels of special steels, thus causing a lesser invasion of a tissue (Kukal et al. 1989, 128–129).

In America even vessels and other objects, apparently of a cultish nature, were exceptionally made of obsidian. The National Museum in Mexico owns a unique, 13.7 cm high vessel made of polished obsidian in the shape of a sitting monkey (Late Aztec culture, around 1500 AD), or a 45 cm high, most probably a cultish object of bizarre shapes, which was made of the same raw material by the Mayas around 6th century AD (Burland 1975, Figs. 113 and 134). Both from Mexico and Asia Minor (Çatalhöyük) the use of smoothly tooled obsidian lumps as mirrors has been described, or vase was made of it (Acemhöyük, Turkey, 19th century BC). Some habitations in the Near East have profited from the long-distance trade with obsidian from Anatolia. One of the oldest towns in the world, Jericho, is given as an example; also from Çatalhöyük a number of obsidian objects are known from the 6th millennium BC, for example a mirror with a 4 cm diameter or a set of lance heads and arrow heads (Temizsoy et al., 1994, 33). A perfect homogeneity of some obsidian enabled the manufacture of unbelievably long blades with the length around 40 cm, as documented by huge cores exhibited in the Anatolian Civilizations Museum in Ankara (Fig. 41).

The colour of obsidian is usually grey-black to black but nearly clear obsidians are known as well (macusanites from Peru, Ecuador and Columbia). Bluish, greenish or rosy shades may sometimes be found out when observing chips in penetrating light. We can ascertained also the bluish colouring e.g. with some artefacts of the culture with Moravian Painted Ware in SW Moravia; obsidians originating from the surroundings of Van Lake in SE Turkey have a green translucence. The density of obsidian varies between 2.27 and 2.40 g/cm^3, the light refractive index is specified as 1.480 to 1.493, their porosity is low (0.1 %). An important macroscopic observation feature is the sculpture of the obsidian nodules surface, i.e. the chemical corrosion of not entirely homogenous fluidal glass by soil acids with the creation of a system of small dimples and grooves that evoke the surface of a prune.

All over Europe obsidians are bound to the young, acid volcanic activity from the Miocene to the recent age (older glasses, if existed, underwent the devitrification process), which implies the geological delimitation of their main source areas. Such a volcanic activity has never been known in the Czech Republic, Poland, Austria, and Germany, and the finds of obsidian artefacts in these territories thus represent imports from a big distance. The sources from some islands in the Mediterranean Sea (Sardinia, Lipari and Palmarola, Pantelleria, Milos, Giali near Rhodos) were widely used in prehistoric Europe. The most important source in the eastern part of the Mediterranean Sea and the Aegean Sea seems to be in Milos Island where the obsidian was mined at two places at least 10 000 years ago (Xydous 2006).

As is the Near East (Mesopotamia) concerned, the most important sources are located in Turkey, especially in Central and Eastern Anatolia. In Central Anatolia there are occurrences of high quality obsidian in Cappadocia, in Eastern Anatolia we know obsidian sources around the Lake Van, E of the town of Bingöl and close the town of Pasinler. According to the study of trace elements (Renfrew, Dixon & Cann 1968, Chataigner et al. 1998, Drápalová & Přichystal 2011), the Eastern Anatolia sources have mainly supplied to Kurdistan, Mesopotamia, and Luristan (e.g. as early as in the Palaeolithic it appears in the caves of Zarzi and Shanidar in northern Iraqi, or in one of the oldest agricultural settlements in the world, Djarmo). Apart from Anatolia, the Cappadocian obsidian occurs in Levant as well, and has also been ascertained as far as in Cyprus.

The Central European occurrences of the Tertiary (Miocene) acid glasses may be found in three territories: in the Štiavnické vrchy Mts. in central Slovakia, the Tokaj-Zemplín Mts. along the SE border of Slovakia and NE border of Hungary and, finally, in the Transcarpathian Ukraine. The glasses from central Slovakia are not suitable for chipping because of the perlitic texture and thus disintegration as well, our data on the Transcarpathian Ukraine obsidian are not sufficient, so at present time the Tokaj-Zemplín Mts. appears as the absolutely most important obsidian source in Central Europe.

II.4.1 Carpathian obsidian and perlite

II.4.1.1 Source of obsidian in the Zemplínské vrchy Mts., SE Slovakia

Background: The first information on obsidian in the recent territory of Slovakia (at that time a part of Hungary) was mentioned by Johann Ehrenreich von Fichtel in 1791, a scholar born in Bratislava (for more details see Janšák 1935). The volcanic glass was also called "Icelandic agate" or "luxsaphire". J. E. Fichtel even recorded striking core artefacts but he believed to be natural shapes, specific crystal forms originated by cooling of the volcanic glass. It was an outstanding Slovakian archaeologist Štefan Janšák who has written a comprehensive publication dedicated to this important Carpathian raw material (Janšák 1935).

Location: A small geomorphological unit (14 x 6 km) with the highest point Rozhľadňa (469 m) in SE Slovakia is called the Zemplínské vrchy Mts. In the south it borders on the Bodrog River, in the east and north the unit is limited by the East-Slovakian Lowland, in the west by the East-Slovakian Hilly land. From the Tokaj-Zemplén Mts. it is separated by a narrow depression called the Roňava Gateway. Four natural sources of obsidian are usually referred in the area of the Zemplínské vrchy Mts. (Kaminská & Ďuďa 1985):

a) Viničky (former Seleška, in Hungarian Szőllőske) – vineyards north of the village;

b) Malá Bara – 300 and 500 m south of the village;

c) Veľká Bara – spot height Piliš;

d) Streda nad Bodrogom – elevation west of the village.

Geological setting: The central part of Zemplínské vrchy is built of Upper Palaeozoic and Mesozoic rocks, the Miocene volcanics crop out in the periphery. Obsidian is connected with rhyolites and rhyolite pyroclastic rocks of the Upper Badenian and Lower Sarmatian age in the SW part of Zemplínské vrchy between Streda nad Bodrogom and Veľká Bara. Obsidian from Viničky has been dated by the "fission tracks" method for 11.1 ± 0.8 My (Repčok 1977). Moreover it was dated also obsidian from the Avaš Hill south of Hraň (14.2 ± 0.5 My; Repčok et al. 1988). Fission track data about 15 My for Carpathian 1 obsidian were published also by Bigazzi et al. (2000).

Macroscopic Appearance: In this book it is described obsidian from Viničky in detail because in the principal paper of Williams-Thorpe, Warren & Nandris (1984) the locality of Viničky is believed to be the principal source with designation Carpathians I. Nodules of local obsidian are usually small under 4–5 cm, they can reach only rarely 10–12 cm weighting up to 0.8 kg. Kaminská & Ďuďa (1985, 122–124) have similar experience: they mentioned prevalent dimensions of natural obsidian pieces corresponding to a hazelnut or walnut, extraordinary up to 20 cm. Also at the other localities they have described (Malá a Veľká Bara, Streda nad Bodrogom), the obsidians are prevalently small, greyish black or black, non-translucent, without sculpturing of the surface. Šalát & Ončáková (1964, 30) called the obsidian from Viničky even as marekanite. Local natural pieces of obsidian have usually polyhedral shapes; they are black, non-translucent or subtranslucent only on the edges (Supplement/Photo 188). They have smooth surfaces, substantially without sculpturing and with glassy lustre. It was already Janšák (1935, 5) who noticed the polyhedral shapes of obsidian pieces from Viničky and the appearance similar to grazed irregular crystals. Obsidian from Streda nad Bodrogom has perlite cover.

The description of natural pieces of obsidian from Viničky is inconsistent with the appearance of chipped obsidian artefacts at the prevalent part of Palaeolithic and Neolithic sites in Central Europe including the Palaeolithic stations at Cejkov and Kašov situated nearby Viničky. Obsidian blades from Cejkov and Kašov have often a length about 5–10 cm, two times more comparing the usual size of obsidian pieces from Viničky, they are well translucent and the surface is strikingly sculptured (Supplement/Photo 189). Similarly obsidian artefacts from Moravian Palaeolithic and Mesolithic sites (Kůlna Cave, Uherské Hradiště-Sady, Přibice, Smolín) are well translucent in a greenish hue, an obsidian artefact from the Gravettian site of Dolní Věstonice is even bluish. From the mentioned differences it follows another natural source of obsidian has to exit in Zemplínské vrchy that can be hidden under young Holocene fluvial deposits in recent time or it has not been found yet.

Thin Section: The glass has hyaline texture with plenty of small trichites (hair-like opaque crystal germs) that have fluidal arrangement. They intersect each other and than form several ray star-like formations. Some trichites are colourless with the simple shape of stick. Feldspar and biotite can form small phenocrysts (Supplement/Photo 190).

Other analyses: In an effort to reliably determine the source of Central European obsidian the study of the light refraction index started to be used firstly (Štelcl 1973), however unambiguous results have only been obtained by the trace elements and rare earth elements determination, i.e. a similar methodology that has been employed earlier on for the distinguishing of the obsidian sources in the Near East and Mediterranean areas. An extensive work based on the determination of 15 (for artefacts) to 16 (for geological samples) trace elements, and of Na, $Fe^{tot.}$ by means of instrumental neutron activation analysis was published by the British investigators Williams-Thorpe, Warren & Nandris (1984). This investigation comprised 48 samples from the source area in the Zemplínské vrchy and Tokaj-Zemplén Mts. both in Slovakia and in Hungary and a total of 279 obsidian artefacts, namely from a single occurrence in the Istria Peninsula (Croatia), 8 localities in Moravia (the Czech Republic), 1 in Austria (Wetzleinsdorf), 1 in Poland (Olszanica), the remaining archaeological sites are from Slovakia, Hungary, and from Rumania. For comparison purposes, the authors refer to the results of various authors published earlier on from 6 localities in the surroundings of Trieste in northern Italy and three from Greece. The obsidian artefacts were compared with the sources Carpathian 1 (Slovakia), Carpathian 2a, 2b (Hungary), Lipari (Italy), Milos (Greece), and Çiftlik

(Cappadocia, Turkey). Unfortunately, the obsidian sources in the Transcarpatian Ukraine have not been analysed.

It has followed from the results that all the Central European obsidian artefacts under observation have originated from the sources in the Zemplínské vrchy and Tokaj-Zemplén Mts., the absolute majority (242 samples) from the source Carpathian 1 at the Slovak side; only 16 artefacts were coming from the sources Carpathian 2a and 2b in Hungary.

Prehistoric Use: See the chapter II.4.1.5.

II.4.1.2. Source of obsidian in the Tokaj-Zemplén Mts., NE Hungary

Background: It was again Johann Ehrenreich von Fichtel who mentioned "Icelandic agates" (obsidians) with dimensions up to a fist at the village of Erdőbénye or innumerable finds of obsidian pieces (even if up to a walnut) in the vineyards at Tolcsva in 1791. J. Fichtel noticed also obsidian cores at Erdőbénye but he regarded them wrongly as crystals. Another scholar J. Szabó studied Hungarian obsidians in the second half of the 19th century and he described a lot of possibly natural obsidian occurrences but part of them are with no doubt archaeological finding sites.

Location: A Slovakian geomorphological unit called the Slanské vrchy Mts. continues to Hungary where is named Tokaji-Zempléni-hegység (in English: Tokaj Mts. and Zemplén Mts., see Gercsák 2002) or earlier Eperjes-Tokaji-hegyvidék (Eperjes-Torna Mts.). In this monograph the author has used the designation Tokaj-Zemplén Mts. according to Král (2001). In the west, the Tokaj-Zemplén Mts. are bordered by the Hernád (Hornád) River, in the east it is the Bodrog River. More obsidian localities were described from the mountains in the older papers but recently there have been mentioned only three natural sources: Tolcsva, Erdőbénye-Aranyospatak and Erdőbénye-Ligetmajor (Biró 1981). The sources lie all together about 18 km north of the town of Tokaj. Sometime mentioned Olaszliszka lies also in this area. The Tokaj Hill (515 m) above the town of the same name is built of andesite and no obsidian source can be there, possibly only obsidian artefacts from an archaeological finding site.

Geological Setting: The Tokaj-Zemplén Mts. are composed almost entirely (excluding a small area just at the Slovakian/Hungarian border) from Miocene volcanic rocks, namely from andesites in the central part. Rhyolites and their tuffs are spread substantially in the north, close to the border with Slovakia, and than on the SE slopes between Tolcsva, Szerencs and Megyaszó. Besides obsidian there are present also deposits of perlite that Perlaki & Szöőr (1973) characterized in detail. They have distinguished green and black perlites based on their habit, water content, water loss at different temperatures (thermoanalytical conditions), forms of bounding water and melting characteristics as well.

Macroscopic Appearance: Obsidian pieces weighting over 5 kg have been described from the vicinity of Olaszliszka. The prevalent colour is black grey; in older papers there is also mentioned dark brown, greenish, light red to red brown (in the vicinity of Tolcsva), yellow brown and yellow green. Unfortunately, in some cases we cannot eliminate a possibility that a slag was mistaken for the obsidian (Ulrich 1935, 15). Williams-Thorpe, Warren & Nandris (1984, 184) have affirmed the Hungarian obsidians are almost always black and opaque while the Slovakian obsidians are grey to grey brown and partly translucent. From the previous description of obsidian from Viničky in Slovakia it is evident this ascertainment only partly corresponds to the reality.

Other Analyses: Biró (1981) studied basic chemical composition of Hungarian obsidians and a detailed characterization based on trace elements and rare earth elements has been done by Williams-Thorpe, Warren & Nandris (1984) and Kasztovszky et al. (2008).

They designated the Hungarian source as the Carpathians 2. From the chemical analyses published in both papers it follows the Hungarian source is generally more alkaline, particularly it has higher contents of alkalis and majority of rare earth elements (especially light REES), also Fe, He, Co. In contrary, the Slovakian source Carpathians 1 has higher contents of only Cs and Ta.

Prehistoric Use: See chapter II.4.1.5.

II.4.1.3. Source of obsidian and perlite in Transcarpathian Ukraine

General Overview: The best-known source is described from the territory Gercovce – Fedeleshovce where three obsidian types cover the territory of about 6 km^2 (Bobrievič 1952). The first type represents obsidian of a pinkish colour, the second one is black with spherulites, and the third type is obsidian with the fluidal structure. The first type totally dominates, the other two are known only from debris. The glasses have a small amount of plagioclase phenocrysts (andesine, as determined on the universal stage), biotite, quartz, and amphibole; zircon has appeared in an accessory manner. According to A. P. Bobrievič, the basic substance consists of cristobalite, K-feldspar, quartz, and glass. The silicate analysis shows it is a rhyolite obsidian with the contents of SiO_2, 70.41 %; TiO_2, 0.97 %; Al_2O_3, 14.01 %; Fe_2O_3, 0.72 %; FeO, 3.98 %; CaO, 1.21 %; MgO, 0.19 %; Na_2O, 3.48 %; K_2O, 2.41 %; H_2O^-, 1.31 %; and H_2O^+, 1.08 % (our analysis of obsidian from Rokosovo confirmed only 0.18 % H_2O^+). A prevalence of Na_2O above K_2O and a relatively high content of TiO_2 are obvious from the result.

Kameneckij (1963, 26–29) highlighted other natural occurrences of volcanic glasses (perlite and obsidian) from neovolcanic rocks between the towns of Beregovo and Chust in the territory of Beregovskoe Cholmogorje Hillyland. Both volcanic glasses he has introduced from slopes of more volcanic domes, he mentioned especially localities Varna, Velikaja, Čepka, Šarok, Ardov, Kerek and others. A length of outcrops with vitreous perlite rocks reaches up to one km and a width varies between 50–200 m (even more). The rocks can form also lava sheets in the area of more than 1 km^2 as for example at the village of Zatyšnja. The easternmost lying volcanic massif Velikij Šolles (12–15 km far of Chust) can contain about 4 millions m^3 of perlite and obsidian.

Mackevoj & Rybaček (1984, 173) solved the use of obsidian from Transcarpathian Ukraine in the Mesolithic and they have stated potential sources of suitable volcanic glasses at the villages Turja Paseka and Buněviči or from the Ostraja Mt. and Tolstaja Mt. in the area of Boržava River.

Unfortunately the obsidians from Transcarpathian Ukraine have not been analysed within the extensive work by Williams-Thorpe, Warren & Nandris (1984).

II.4.1.4. Source of perlite from the Szabó skala Rock, Hliník nad Hronom, central Slovakia

Background: The Szabó skala Rock has obtained name after professor J. Szabó (1822–1894) from the Budapest University. He studied volcanic rocks in the Banská Štiavnica area from the geological and petrographical standpoint. The locality represents one of the earliest protected sites in Slovakia (since 1907). This finding place is supposed to be a possible source of the Carpathian obsidian also in some professional papers, probably as a consequence of information in a publication of Šalát & Ončáková (1964, 15–16) on occurrences of all volcanic glasses including obsidian at the Szabó skála Rock. But on the page 33 when the authors have done a detailed description of the finding place they have not mentioned it. Investigation of the last years including that for this book did not confirm obsidian occurrence at the locality.

Location: The Protected Natural Site Szabó skala Rock is situated in the cadastral are of Lehotka pod Brehmi, about 2 km to the east of the Hliník nad Hronom (Central Slovakia).

Geological Setting: The rock wall with a height roughly 50 m is built of rose and grey vitreous rhyolite to perlite. The locality represents the final ascent of strongly viscous lava (so called protrusion) through an older extrusive dome-shaped structure. At the margin of protrusion a belt of perlitic rhyolite to perlite originated (Konečný, Lexa & Šimon, eds. 2001), some authors has mentioned also pechstein. From the viewpoint of stratigraphy it is the Jastrabá Formation covering rhyolite volcanism of the Middle to Upper Sarmatian age. The black glass from the Szabó skala Rock has been dated 14,3 ± 1,4 Ma by the method of fission tracks (Repčok 1977).

Macroscopic Appearance: The medium grey (N 5), non-translucent, prevalently with a matt lustre glass contains irregularly distributed white laths of feldspar (up to 1–2 mm). Spontaneously or as a consequence of chipping it disintegrates into detritus of small chips, so for preparation of chipped artefacts it is absolutely unsuitable. Several cm big pieces of black non-translucent glass appear in places; they contain again white phenocrysts of feldspar up to 0.1 mm.

Stereomicroscopic Appearance: The pieces of black glass have also an indication of perlite disintegration by numerous curved lines. The glass in non-translucent; only colour reflections are visible on plains of the potential disintegration. Small phenocrysts of feldspar and biotite are conspicuous. The glass is non-porous, rarely small cavities after weathered out feldspar phenocrysts can appear on the surface.

Thin Section: A vitreous groundmass is usually recrystallized in spherolites with a radial fibrous pattern. The groundmass has a hyaline, hyalopilitic or spherolitic texture. The phenocrysts are composed of K-feldspar or sanidine, plagioclase, biotite, sometimes also by clinopyroxene, rhombic pyroxene and hornblende; their content does not reach over 9 % (Lajčáková 1980). According to this author it is possible all sampled glasses to classify as perlites based on the thermical and optical properties. Our analysis (analyst P. Kadlec from the Department of Geological Sciences, Masaryk University in Brno) confirmed a high content of water (H_2O^+ = 2.60 %) that is characteristic for perlites.

Prehistoric Use: In several older archaeological papers there are published considerations about exploitation of obsidian in Central Slovakia, for example Neustupný et al. (1960, 108) suggested it for the younger period of the Lengyel cultural group. Perlite disintegration of local glass (including the black variety looking at first sight as a quality one) does not allow prehistoric using. The same can be stated for other perlite sources in Central Slovakia – Lehotka pod Brehmi (Supplement/Photo 191), Jastrabá at the SW margin of the Kremnické vrchy Mts. On the other hand, there are described varieties of vitreous rhyolites from Central Slovakia they could be in places used for chipped tools.

II.4.1.5. Use of obsidian in prehistoric times of Central Europe

The oldest obsidian artefact in Central Europe is referred from the Mousterian settlement Subalyuk in NE Hungary (Vendl 1938). The utilisation of obsidian from the Zemplínské vrchy Mts., as early as in the Mousterian, is evidenced by the data of Skutil (1935) stating that the obsidian industry from the Zemplínské vrchy Mts. and the surroundings also comprises 12 pieces of hand-axes and 115 pieces of Mousterian discoid worked artefacts (see also Žebera 1972). Obsidian is more spread in the course of Upper Palaeolithic; rich Gravettian localities near the source, as e.g. Cejkov, mostly have chipped stone industry manufactured of obsidian (Bánesz 1974), as solitary artefacts they appear at some Aurignacian and Gravettian stations far from the source. In the Aurignacian possibly the farthest transport from the source is represented by Nová Dědina near Kroměříž, Central Moravia; in the Gravettian the obsidian appeared even in Pavlov, south Moravia. Obsidian was ascertained also in the Magdalenian and Epimagdalenian layers of the Kůlna Cave in the Moravian Karst (Valoch 1988, 24–25), in the Late Palaeolithic (Sady near Uherské Hradiště), occasionally it also appeared even at the Mesolithic stations (Přibice and Smolín in Moravia), and at the best known group of the Pre-Neolithic settlements near Putim-Ražice in south Bohemia from where three pieces of obsidian have already been described by Dubský (1949, 40, 44). An evaluation of obsidian use in the Palaeolithic of Hungary can be found in a paper of Biró (1984).

Ścibior (1992) has published an overview of archaeological occurrences of obsidian in Poland. Obsidian was

ascertained already in the Aurignacian chipped collection from Cracow-Zwierzyniec, numerous artefacts were found at some Late Palaeolithic stations in the surroundings of Cracow, obsidian tools have been described from the Mesolithic localities near Rzeszów. As is the Neolithic use concerned, obsidian artefacts were registered at settlements with the Linear Pottery culture in the area of Upper Vistula River (SE Poland) where it varies from a few pieces up to 20%. It is also very often present at Neolithic sites in the Wyżyna Sandomierska Highland (more than 20 localities). The dimensions of obsidian cores and blades show the using of only several cm big original pieces never exceeding 10 cm. Ścibior (1992, 49) describes the Polish archaeological obsidians they are mostly of black grey colour, with a good translucency and they have the provenance from the Zemplínské vrchy Mts. in Slovakia.

Obsidian is an important raw material also in the older stage of the Moravian Painted Ware in Moravia. Investigations of trace elements and rare earth elements proved its origin again in the Slovakian Zemplínské vrchy Mts. (Williams-Torpe, Warren & Nandris 1984; Zeman & Navrátil 1988). One of the westernmost archaeological localities with the obsidian occurrence is the Šestákova skála Rock in the Šárka valley in Prague (Žebera 1955, 38); obsidian is relatively common at Lengyel settlements in east Bohemia.

Only a single obsidian tool (7.5 cm long knife) has been found in the famous Eneolithic burial ground in Varna (Bulgaria), namely in the symbolic grave No. 41 (Ivanov & Avramova 2000, 45). Unfortunately, its provenance has not been studied.

II.4.2. Kozákov tachylite

Location: The Kozákov Hill (744 m) lies 7 km to the east of Trutnov and it represents the highest point of the Komárov Ridge. It was famous already in the Middle Ages because of finds of semiprecious stones. The author has obtained the studied sample of tachylite from Kozákov through a kindness of RNDr. L. Rejl who found it in the eluvium near a footpath going to the top of Kozákov.

Geological Setting: The slopes of Kozákov are built of Permian basaltic andesites (they are still called melaphyres in the geological practice) with the exception of the western part where the Cretaceous sediments cover the Permian volcanic rocks up to 667 m; the Kozákov topical part is formed by an Upper Tertiary (prevalently Pliocene) basanite. Its lava flows from quarries under the Kozákov Hill yielded the age of 3.95–6.60 My based on the K-Ar method (in summary see in Konečný et al. 2006). As a consequence of its rapid cooling a small occurrence of the volcanic glass of basanite composition (tachylite) originated nearby the hilltop.

Macroscopic and Stereomicroscopic Appearance: The glass is absolutely black, opaque and homogenous with conchoidal fracture and a striking lustre. There are no visible phenocrysts (excluding very small light inclusions). The artificial chips have negligible brown translucence at the edges or red brown along joints (probably as a consequence of weathering). Plenty of small star-like or needle-shaped crystallits are well visible in the black glassy mass under the stereomicroscope. From the standpoint of chemistry, this basanite glass is totally different comparing the acid rhyolite glasses (obsidian, pitchstone, and perlite).

Prehistoric Use: Some considerations concerning possible use of the Kozákov tachylite appeared in the professional literature but all glassy artefacts found in this part of Bohemia called the Bohemian Paradise have been made of the imported obsidian from the Zemplínské vrchy Mts. A reliable proof on the use of Kozákov tachylite in prehistoric times has not been found yet.

II.4.3. Saxon pitchstone (Sächsisch Pechstein)

Location: Pietzsch (1962) has mentioned three areas with the occurrences of pitchstone in Saxony: a) surroundings of Meißen (Meißener Hochlands); b) about 45 km SE of Leipzig within the Leisnig "quartzporphyr"; c) between Zwickau and Chemnitz (Karl-Marx-Stadt at that time). An abandoned quarry for pitchstone lies at Garsenbach in the valley of the Triebisch River west of Meißen. The pitchstone had been quarried as a raw material for the production of glass.

Geological Setting: The pitchstone at Garsenbach crops out in the Meißen volcanic complex that is believed to be of the Upper Carboniferous age. It has a rhyodacite composition and corresponds to so called Dobritz lava flow (Breitkreuz et al., eds. 2008, 43).

Macroscopic Appearance: The Saxon pitchstone is a very variable volcanic glass (Supplement/Photo 192); red brown, yellow brown or greenish samples are common (the last variety comes from Wachnitz), possibly the colours can alternate as smudges. We know also black pitchstone east of Lugau, sometimes with small phenocrysts of white feldspars and grey quartz; biotite, pyroxene, zircon and apatite can be visible as well.

Stereomicroscopic Appearance: The yellow brown glass from Garsebach has an evident perlite structure with the diameter of glassy spheroids about 1 mm. Oblong phenocrysts of white feldspars with roughly similar dimensions, grey volcanic quartz and sporadic small lithic chips are conspicuous in the glassy groundmass.

Thin Section: The pitchstone from Garsenbach looks isotropic when it is observed with crossed polars. The perlite structure with circular spherolites (the diameter 0.5–1 mm) is well visible. Phenocrysts of strongly corroded volcanic quartz (even above 1 mm), parts of feldspars and pyroxenes with the characteristic cleavage occur in the glassy groundmass.

Other Analyses: Magnetic susceptibility is relatively high because it reaches values between 0.89–1.09 x 10^{-3} SI (measured on the sample No. 389 deposited at Faculty of Science, Komenský University in Bratislava). Also small chips of the yellow brown pitchstone from Garsebach have a slightly higher magnetic susceptibility. Breitkreuz et al., eds. (2008, 44) published seven chemical analyses of differently coloured pitchstones from Garsebach,

Semmelsberg and Wachnitz. The glasses have a high loss of ignition and the total sum of alkalies is usually over 5%.

Prehistoric Use: It has not been mentioned yet in the archaeological literature.

II.4.4. Moldavites

Apart from the volcanic glasses the prehistoric utilisation of tektites, i.e. natural glasses, the origin of which is related to the impacts of big extraterrestrial objects (meteorites, comets) to the surface of our planet has also been described. For the first time in the modern history they were referred to in the territory of Bohemia and Moravia but analogous glassy substances have been known even from other places worldwide, for example from Australia (australites), south-east Asia (indochinites), the Philippines (philippinites) and elsewhere. The specialized literature presents rather plentiful archaeological finds of philippinites that had the function of magic stones or of amulets. The Aborigines used australites for hunting, as healer's instruments during operations or as subjects of barter trade. Both of the above tektites served also as the raw material for chipped tools. For example in the Rizal-Bulakan area on the Luzon Isle there are 25 Palaeolithic stations described containing processed philippinites. The literature concerning the archaeological finds of philippinites and australites is listed in the work by Adamovská & Adamovský (1968) or O'Keefe, ed. (1976). The chipping of indochinites in the course of the Neolithic or the utilisation of the Libyan Desert Glass 10 000 to 20,000 years ago to make leaf-shaped points or miniature hand-axes has also been described (although this glass is usually ranked among the impact glasses). Its piece of yellow colour is believed

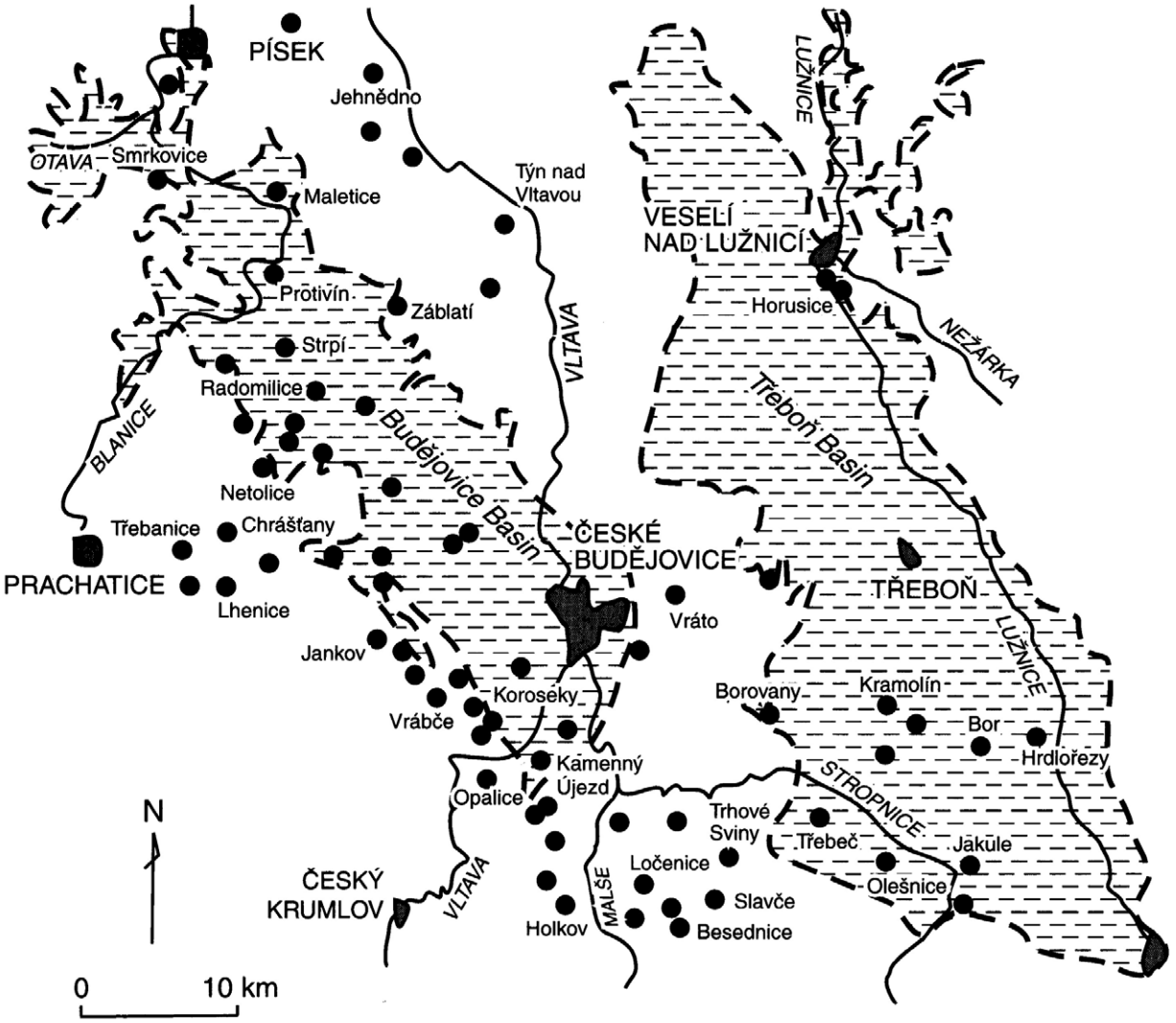

Fig. 85. Finding places of moldavites in southern Bohemia (after Trnka & Houzar 2002).

to be carved as a scarab situated on breastplate of King Tut Ankh Amun.

In Central Europe the tektite group comprises moldavites ("vltavíny" in Czech), the age of which is related to the Ries impact crater of the same age in Bavaria. As already inherent in their name, they were first described in the surroundings of the Vltava River (Moldau in German) in southern Bohemia in 1787. Gradually several dozens of localities have been ascertained in this area with the shape of a thick ellipse elongated in the NW – SE direction, which may be limited by the towns Písek, Veselí nad Lužnicí, České Velenice, Český Krumlov, and Prachatice (Fig. 85). However it should be taken into consideration that solitary pieces of Bohemian moldavites were distributed by the predecessors of the present Vltava and Blanice Rivers farther to the north (the finds in the Písek area and as far as in Prague-Kobylisy). Yet moldavites are not found evenly in the entire specified area; somewhere their finds are cumulated and rich, as is the case of the SW edge of the České Budějovice Basin but only solitary pieces are ascertained elsewhere. The overall area of the moldavite occurrence is estimated to exceed 2,000 km^2 in southern Bohemia (Trnka & Houzar 2002). When considering the suitability of this raw material for chipped artefacts it should be taken into account these are small objects with the size of the first centimetres and their weight most often reaches 1 to 3 g. The mean weight of the Czech moldavites is specified between 6 and 7 g and the hitherto biggest one weights 172 g. The number of discovered pieces is estimated to 60,000 (Supplement/Photo 193).

Roughly a hundred years later (1880) moldavites were also located in western and south-western Moravia where, according to the present knowledge, they form two wide stripes running from the Třebíč area either to the east to Ivančice, and to the south-east to Hrušovany nad Jevišovkou, or directly to the south to Moravské Budějovice (Fig. 86). Irrespective of the rare and sometimes not too reliable finds outside of the specified territories, the area of occurrence of Moravian moldavites covers around 800 km^2. Generally Moravian moldavites are somewhat bigger than the Bohemian ones; according to literature the mean weight is referred to be between 9 and 13.5 g and the biggest Moravian moldavite found weights 258 g. Trnka & Houzar (2002) estimate the number of Moravian moldavites at around 20,000 (Supplement/Photo 194).

Towards the end of the 1960s a minor finding field was described even in the north surroundings of Dresden, Germany, namely between Ottendorf and Cunnersdorf, where moldavites were probably carried by the predecessor of the Elbe River in the Pliocene. About 300 moldavites originate from the area, the biggest one weights 74 g (Trnka & Houzar 2002). Presumably separate strewnfields are represented by sporadic finds (approximately 20 pieces in total, maximum weight 104 g) in the surroundings of the town of Horn in Lower Austria (Radessen, Altenburg, Mahrersdorf) and by moldavites found in the surroundings of Cheb (westernmost Bohemia) in the late 20th century (so far about 1,200 moldavites were found, the biggest piece had 36 g).

In Moravia, moldavite artefacts were searched for as early as towards the end of the 19th century as an evidence of their usage in the Stone Age could have presented an essential contribution to the discussion then in progress whether this was natural or artificial glass. Indeed two such finds were successfully done. Knies (1896) described a waste pit of the culture with the Moravian Painted Ware in the part of Oslavany called Na lužích, where, apart from small obsidian blades, he discovered also a moldavite. A broken moldavite core with several negatives of chipped off small blades found near Dukovany was described and photographically documented by the discoverer of the Moravian moldavites, Dvorský (1898).

Archaeological finds of moldavites prior to the end of the first half of the 20th century were summarised by Skutil (1949); however not all data may be taken as verified. In the late 20th century such summaries were made by Přichystal (1991), Kovárník (1992), and Vokáč (1999), all of them being focused particularly on the Moravian finds. A critical evaluation of the chipped moldavite artefacts in Bohemia has been made by Červený & Fröhlich (1990). As moldavites themselves represent a unique natural material, the artefacts made of them have always been in the centre of attention. Unfortunately, in a number of cases the alleged artefacts have not been properly documented either by photographs or by drawings, or even their deposition has not been specified. Due to this a number of inaccuracies have been published that have been taken over by other authors later on.

As regards the use of moldavites in the Palaeolithic, the only documented seem to be the finds at the Austrian Palaeolithic stations: four blade-like chips from Willendorf II (Gravettian) and one chip from the Gudenushöhle Cave (Bayer 1918, 1921), where it was allegedly found in the layer possibly corresponding to Mousterian. Even in respect of these finds there are several questions though. Reportedly, they were deposited in the Museum of Natural Sciences in Vienna, but after the death of J. Bayer they have been lost. In 1987 a processed moldavite was ascertained in a private collection in the USA, and a microprobe analysis confirmed this was indeed a moldavite, which has most probably represented one of the Willendorf chips (Koeberl et al. 1988, 325). Furthermore, these authors consider a solitary find of a non-worked moldavite at the village Stainz near Graz (Steirmark), which is identical with the Bohemian moldavites by its chemical composition, to be most probably also brought by a prehistoric man. The finds at the Austrian Palaeolithic stations are very surprising due to the fact that hitherto no moldavite artefacts have been definitely corroborated at the Moravian Palaeolithic stations (oral conveyance by P. Škrdla, 2006), despite some of these stations are either directly located at the natural occurrence of moldavites (Mohelno-Boleniska, typologically classified as the Bohunician or possibly Szeletian) or in their

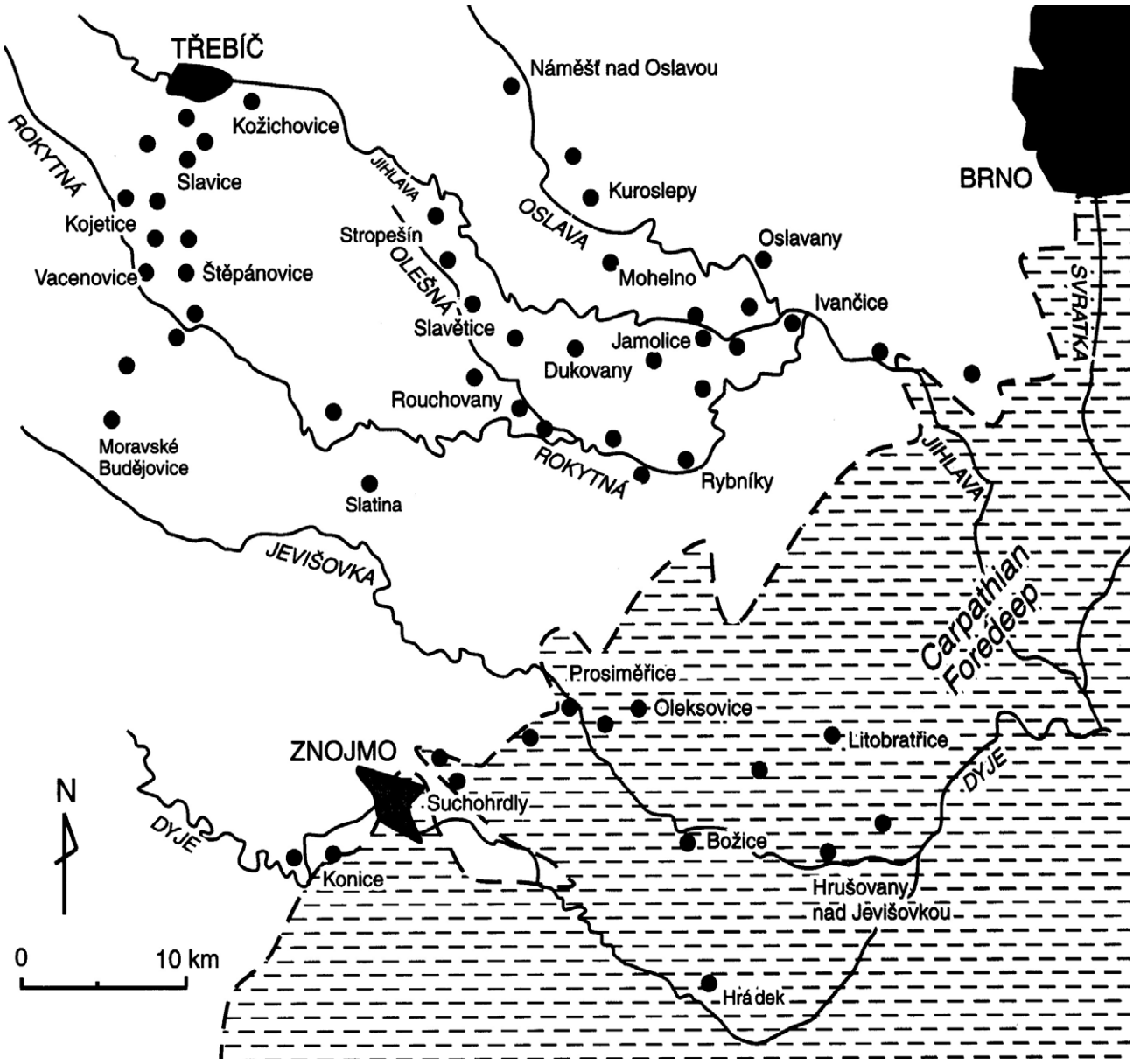

Fig. 86. Finding places of moldavites in western Moravia (after Trnka & Houzar 2002).

immediate surroundings (Dukovany, Lhánice, Senorady). It is true, though, that in his overview Kovárník (1992) concludes that in the southern and south-eastern localities he has ascertained altogether 94 pieces of possible prehistoric moldavite artefacts, and with some of them featuring intensely patinated surfaces (Dukovany, Rouchovany, Skryje, Slatina) he even does not exclude the Middle Palaeolithic (?) age or an older period of the Upper Palaeolithic. He then hives off a group of assumedly Upper Palaeolithic artefacts with a dim lustre on chipped surfaces (Dukovany, Lhánice, Rybníky, Skryje, Suchohrdly, Štěpánovice) and he classifies the artefacts the chipped off surfaces of which feature a high glassy lustre into the third group (the Neolithic and younger prehistoric periods).

However, moldavites have not been found at the important Pavlovian stations under Pavlovské vrchy or in Přerov-Předmostí that are situated much closer to the Moravian moldavite sources, and from which collections in the order of 50,000 of chipped artefacts originate. The statements by Skutil (1949, 91) "that moldavite was reportedly acquired even at the Dolní Věstonice station" or by Kouřimský (1980, 193) "and three were found at the Věstonice Venus discovery site" do not correspond to reality. No such find has been recorded and even long-term investigators, as B. Klíma (verbal communication, 1988) or J. A. Svoboda at present have never come across them at this Pavlovian settlement. Again the question emerges on the origin of the moldavite artefacts at the distant Austrian Palaeolithic stations. Due to a small number of natural finds it does not

seem probable these would have originated in the Austrian territory. Then they would unambiguously prove contacts most probably to the West-Moravian area.

Nevertheless the use of moldavites in Moravia is reliably evidenced in the Neolithic and Eneolithic, although it is explicitly bound to the prehistoric localities in the area of their natural occurrence. However, moldavites have never reached the significance of obsidian imported to Moravia from the Zemplínské vrchy or Tokaj-Zemplén Mountains, from the distance of over 400 km. This may be corroborated by the analysis of the raw materials of chipped artefacts at the big Neolithic settlement of Těšetice-Kyjovice near Znojmo or Kramolín in the Třebíč area. Both sites lay in the immediate proximity of the natural incidences of moldavites and several-thousand collections of chipped artefacts were acquired there; still not even a single moldavite artefact has been ascertained there till now. Contrary to that, in Těšetice-Kyjovice obsidian represents 14 % of the 1,629 artefacts found, i.e. 225 pieces (Přichystal 1984) from the Ia period of the culture with the Moravian Painted Ware. It was just this people that carried out an intense settlement of the Třebíč and Znojmo areas roughly between 4500 and 4000 BC and some of its habitations were situated directly at the natural finding sites of moldavites. Evidential artefacts consist in particular of cores with negatives of fine blades, by which they are very similar to small obsidian cores from the Moravian Painted Ware culture sites. Further on this work only specifies the localities, in alphabetic order, with finds documented either by drawings or by photographs, or possibly with a known deposition. Nevertheless, it is probable there are other chipped moldavites among the collectors. In the Neolithic period, Dukovany and Mohelno-Boleniska may be considered reliable localities with chipped moldavites where several moldavite artefacts have been discovered independently by a number of collectors.

Dukovany, 27 km SE of Třebíč

The first find of a small conical core with about ten negatives of chipped off small blades was described and photographically documented by Dvorský (1898, 72, Tab. 1). A drawing reconstruction was carried out by Vokáč (1999) who moreover described his own find of yet another small core comprising about eight negatives of small chips from the so-called Oulehla's Field. Kovárník (1992, Fig. 1, 2) has carried out a drawing documentation of further, at least five, artefacts (but he refers to up to 20 possible items in total). He designates them as scrapers, side scrapers (?), burins, small cores, and chips. At the crossing of the road from Dukovany to Skryje and Heřmanice a moldavite artefact was documented by Přichystal (1991, 13); the artefact is deposited in the author's collection. "A small nucleic specimen of moldavite, possibly prehistorically chipped", from the Mejtnice locality, was recorded by Skutil & Oulehla (1961). This was to originate from the area of local Palaeolithic station.

Mohelno-Boleniska (Bolenska, Na boleniskách), 6 km north of Dukovany

Two artefacts from this locality, famous both for its natural occurrence of moldavites and for archaeological finds (Palaeolithic station of the Bohunician, or Szeletian, as the case may be, settlement of the people with the Moravian Painted Ware, as well as younger prehistoric finds), were described by Oliva (1996). The first one originates from R. Klíma's collection. It is a small core (13 x 8 mm) with more negatives of fine blades. The second artefact is a thick chip with the traces of previous preparation. It was found by J. Mikulášek and it is deposited in the Anthropos Institute under the ID No. 53506. Further chipped artefacts are mentioned and depicted by Vokáč (1999): a flat chip from the gatherings by P. Dočkal, a quarter of an originally rolled piece with three negatives of micro-blades (private collection in Moravian Krumlov), a core-like shape with five negatives of small chips from the West-Moravian Museum in Třebíč (ID No. 4585). He mentions yet further seven possible moldavite artefacts; three of them would come from the cadastral area of Lhánice, into which a part of this locality intervenes. Another possible artefact from Mohelno is depicted by Kovárník (1992, Fig. 1, No. 9).

Approximately from the centre of Boleniska, Mrázek & Herzán (1989) have described a find of a glass bead with the dimensions 25.6 x 12 mm and the weight 10.18 g which they assume to have been refined and drilled of moldavite. This interpretation seems to be very improbable as from Boleniska come also other finds, similar in dimensions and shapes (handed over by M. Trnka to the author), one of artificial glass, also with a fine sculpturing, another one made of stone. Moreover, in wider surroundings of the first find were detected ceramic pieces and a whorl from the La-Tène Period (Vokáč 1999, 135). All this indicates that even in the mentioned "moldavite bead" we have to do with a man-made glass object. It should also be taken into account that drilling of moldavites represents a very difficult kind of working, due to their overstress, which was documented by a present test in a masonry enterprise when a moldavite has broken during drilling.

Other localities in western Moravia

Furthermore, Mrázek & Herzán (1989) mention another moldavite, possibly drilled in the prehistory, from Slavice (collection of the Moravian Museum, ID No. T 14). Kovárník (1992) shows chipped artefacts also from localities Slavětice, Suchohrdly, Lhánice, Dalešice, Slatina, Rouchovany and Kordula.

Southern Bohemia

In Bohemia, the last critical assessment of chipped moldavites (Červený & Fröhlich 1990) showed that even here they were used exceptionally, possibly even less than in Moravia, as due to their heavily sculpted shapes they are less suitable for chipping than the Moravian ones. In particular as regards the Pre-Neolithic settlement at the Řežabinec Pond, a number of references in the specialized literature induce a notion it was used there.

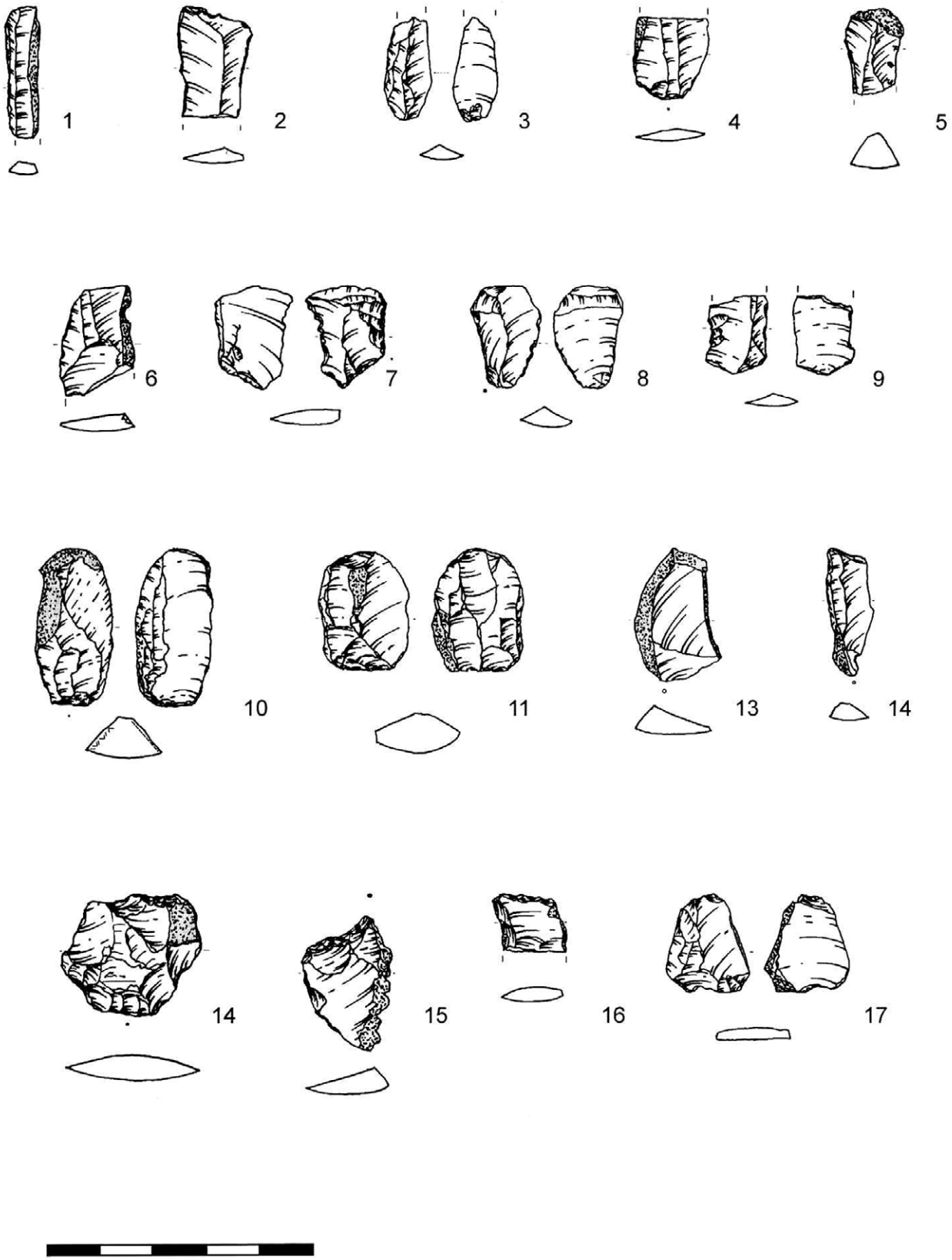

Fig. 87. Chipped moldavites from Lipí in southern Bohemia. Collection of M. Trnka. Drawn by Z. Nerudová.

In fact only a single find of a non-worked moldavite has been described, which was picked up by J. Michálek at the north-east edge of the pond, in the Putim cadastral area, in 1962. Originally it was reasoned about its having been brought by a prehistoric man as a potential raw material but Červený & Fröhlich (1990) rightfully tend rather towards its natural incidence. On the examination of many thousand artefacts from the Pre-Neolithic localities, not only from the surroundings of Řežabinec Pond but also from other South-Bohemian archaeological sites, not a single moldavite artefact has been found in the recent years (Přichystal in Vencl et al. 2006). The same was stated by Mazálek (1954, 378) in respect of the collection of nearly 7,000 artefacts acquired by the excavation in the Řežabinec area carried out by the Institute of Archaeology of the Czechoslovak Academy of Sciences between 1950 and 1953.

Červený & Fröhlich (1990, 42) are of the opinion that in southern Bohemia several fine-shaped moldavite artefacts from the Dobrkovská Lhotka, Milíkovice, Nesměň and Třísov sites apparently will be of the Mesolithic age. From the viewpoint of the moldavite use, the locality Milíkovice-Křemenička Field seems to be the most interesting; a few moldavites bearing possible traces of intentional chipping off come from there, and several chipped stone artefacts from other raw materials were also ascertained. The natural moldavite incidences are located at a 100 to 150 m distance only. At the Na packu site in the cadastral area of the same municipality one moldavite artefact was found, and another of a black silicite. A chisel made of a moldavite drop originates from Nesměň (Žebera 1969, Fig. 2), a blade and a core of moldavite were found at Třísov (Beneš & Vencl 1966). The artefacts are mostly deposited in private collections and, unfortunately, their depictions have been published only exceptionally. Adamovská & Adamovský (1973, 9) considered some moldavites from Besednice and Radomilice to have been worked by prehistoric man, nevertheless the photographic documentation does not indicate this. Přichystal (2004) described an apparently chipped moldavite from the surroundings of Lhenice near České Budějovice.

In present time the author of this monograph has obtained probably the best assemblage of 65 chipped moldavite artefacts that was possible ever to collect (Fig. 87; Supplement/Photo 195). They are a part of M. Trnka's collection deposited in Brno and their Mesolithic age can be supposed. According to a personal communication of the owner, the chipped moldavites were both from an unknown lady and they come probably from Lipí near České Budějovice (site "U chat"), it has been possible to obtain no more data.

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II.5. Clastic siliceous rocks

II.5.1. Quartzites (orthoquartzites)

Quartzites are sedimentary, fragmental (clastic) rocks composed prevalently of quartz grains that are firmly bonded together by siliceous cement. Especially the fine-grain types feature a conchoidal fracture similar to silicites; therefore these were rather frequently used for the manufacture of chipped artefacts in prehistoric times. Besides quartzites of sedimentary origin (orthoquartzites in the English geological dictionaries) it is necessary to distinguish a metamorphic rock composed also mainly of quartz and usually formed by the metamorphism of quartz sandstone (this is called metaquartzite). Because of well-developed metamorphic foliation it is not suitable for chipping and its use for prehistoric chipped tools is exceptional.

II.5.1.1. Ordovician quartzites of the Barrandian

General Overview: Several Ordovician formations in the Barrandian and even in the territory of Prague contain important beds of quartzites. It is possible to mention mainly the Skalka quartzite within the framework of Dobrotivá Formation and the Řevnice quartzite within the Libeň Formation. The Skalka quartzite has obtained its name according to the Skalka Hill near Mníšek and the Řevnice quartzite after the village of Řevnice near Prague. Both quartzites can reach a thickness up to a few tens metres (for example in Prague-Motol), even a pseudokarst cave has been developed in the Řevnice quartzite on the Babka Hill near Řevnice. Beds of Ordovician quartzites occur often in the Libeň and Letná Formations just in Prague where they built conspicuous knolls or ridges (Vítkov, Hradčany, and Vyšehrad).

The Ordovician quartzites have usually light grey or yellowish grey colour and tubular to vermiform trace-fossil structures that are assigned to the "genus" *Skolithos*. Round pieces and pebbles of Ordovician quartzites can be gathered in terrace gravels of the Vltava River; they have a darker colour because of weathering and as a consequence of strong wind activity in the Pleistocene they form often ventifacts (Supplement/Photo 196).

According to Žebera (e.g. 1970), pebbles of Ordovician quartzite from the fluvial gravel terraces were used already in the Lower and Middle Palaeolithic in Bohemia (Přezletice NE of Prague, Chyňava in the area of Beroun). An extensive use of the Ordovician quartzite is referred from the Neolithic site of Kosoř (Šreinová, Šťastný & Šrein 1997). Based on the thin section investigation, the rock contains besides prevalent quartz grains also hematite pigmentation, insignificantly fedspars and both micas. Rutile, zircon, tourmaline and titanite represent accessory heavy minerals.

II.5.1.2. Quartzite of the Lipnice type (southern Bohemia)

Background: Quartzites were chipped also at Pre-Neolithic localities in South Bohemia. From this point of view, an exceptional position is held by the Putim-Ražice

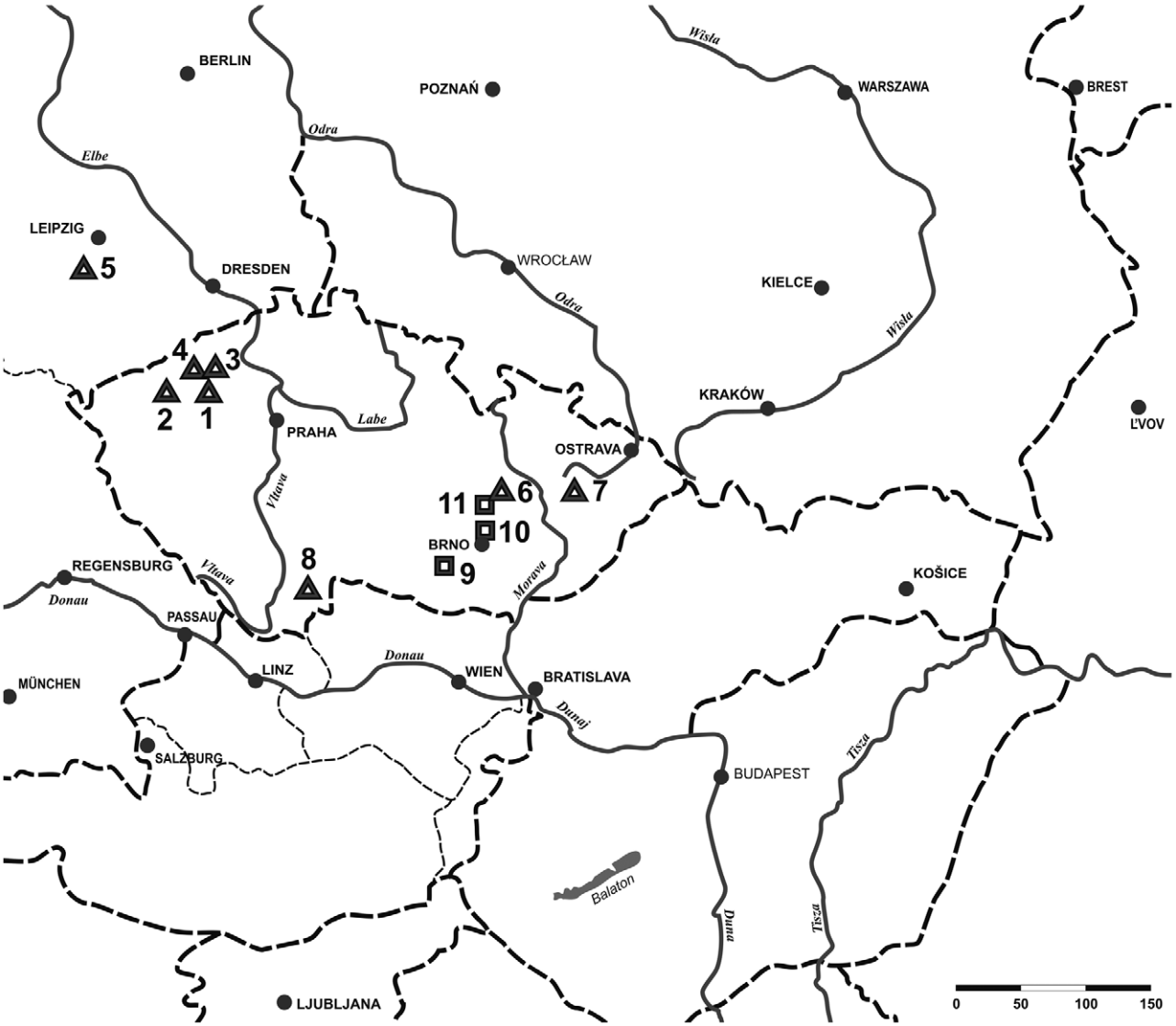

Fig. 88. Some important occurrences of quartzites and chert breccias in eastern Central Europe. Quartzites: 1 – Bečov, 2 – Tušimice, 3 – Skršín, 4 – Kamenná Voda, 5 – Profen, Zauschwitz, Pegau, 6 – Otaslavice, Ondratice, Určice, 7 – Hlinsko near Lipník, 8 – Lipnice south of Třeboň. Chert breccias: 9 – Vedrovice and Moravský Krumlov, 10 – Brno-Líšeň, 11 – Olomučany in the Moravian Karst.

complex of sites, where, apart from sporadic incidences, quartzite industry has occurred more frequently in the plot No. 762 on the southern slope of Pikarna knoll, and in 1949 even a workshop for processing of this raw material has been discovered here (Dubský 1950, 36–40). He ascertained more than 150 quartzite artefacts around a granite plaque. Unfortunately, the author has not provided any closer statement to the characteristic and origin of the raw material; he has only specified a "white quartzite". In a monograph from the previous year he characterized this raw material from the workshops on the rise near the Řežabinec Pond by the words "both grey-white and yellowish quartzite, granular". As regards the provenance, he assumed this was a Tertiary ganister quartzite brought in from the Drahany Highland in Moravia (Dubský 1949, 60). The same author also mentioned a quartzite Mesolithic station near Střezmíř in the Tábor area. The plentiful incidence of quartzite at the prehistoric settlements of the Putim-Ražice area indicates this is a local resource, hitherto not considered in the archaeological literature. During a systematic research of raw materials connected with the Pre-Neolithic settlement in south Bohemia, Přichystal (2006) came to the conclusion that it was used a South-Bohemian quartzite and he designated it after the type natural occurrence as the Lipnice type quartzite.

Location: The village of Lipnice lies about 10 km south of Třeboň. The best pieces of quartzite were found at the local deposit of heat-resistant ganister sands. The mining works were finished there in the half of the 20th century

and the mining pit has been filled up, so it is very difficult to obtain any quartzite sample nowadays. Analogical quartzites are present also at other natural finding places especially in the Třeboň Basin (Veselí nad Lužnicí, Kardašova Řečice, Smržov, Hrutov, Pecák, Mlaka near Stráž nad Nežárkou); only one locality (Vlhlavy u Netolic) is mentioned from the České Budějovice Basin. Other natural occurrences as denudation relics are even out the basins – Bechyně, Komárov near Bechyně, Písek, Smrkovice near Písek.

Geological Setting: Similarly to NW Bohemia, a horizon of quartzites appears in sedimentary rocks of the Lower Tertiary (Oligocene) age in south Bohemia as well. It is referred to as a part of the Lipnice Formation (Bouška & Slánská 1961); that is why the author of this book started to use the Lipnice type quartzite. It is necessary to take into consideration the South-Bohemian basins had originally substantially larger areas as is manifested by occurrences of isolated boulders of quartzites in the surroundings of Písek, Bechyně and Tábor.

When seeking for the provenance of the quartzite artefacts in the South-Bohemian Pre-Neolithic localities, another complication is the presence of quartzites in the relics of Tertiary sediments in western Bohemia, i.e. at about half of the way to the known resources in the Most surroundings. Such quartzites are mentioned, without a closer specification, e.g. by Šípek (1965, 19) from Lažany near Černošín east of Tachov.

Macroscopic Appearance: Upon the macroscopic observation, the quartzite from Lipnice is characterized by the alteration of pale yellowish and brown yellow parts, sometimes even bands (see for example specimens in the exhibition or the documentary sample No. 1381/75 in the South-Bohemian Museum in České Budějovice). Several samples have brown red parts or smudges. By its properties, the quartzite used at Putim-Ražice is partly reminiscent of the Bečov type (a plentiful representation of relatively big quartz grains), but partly also the Tušimice type (a marked presence of a yellowish fine-grained groundmass) – Supplement/Photo 206.

The quartzite horizon corresponding to the Lipnice Formation was originally probably very variable as it follows from the occurrences of quartzites outside of the Třeboň Basin. For example the nearest natural quartzite source to Putim-Ražice lies in the Poušť forest NW of Bechyně where the denudation relic of a quartzite bed have a thickness up to 1–1.8 m and A. Malecha (in Vrána et al. 1989, 27) has believed it was an analogical quartzite to that of the Lipnice Formation. From macroscopical point of view the local homogeneous white grey quartzite differs from the classical occurrence at Lipnice.

Another boulder of quartzite with dimensions 30 x 20 cm and weighting about 5 kg comes just from the town of Písek and it is deposited in the Prácheň Museum in Písek. Krejčí (1925, 63) described numerous pieces of dark grey quartzite near Smrkovice south of Písek. Similar isolated occurrences of quartzite boulders are common in the northern surroundings of the South-Bohemian basins. At random it is possible to introduce a find of ganister quartzite ventifact at Komárov SE of Bechyně (Žebera 1975, 284).

Stereomicroscopic Appearance: Small fragmental chips of translucent quartz up to 1 mm, in places partly rounded bigger quartz grains with diameter up to 5 mm, are spread in the yellowish to greyish pink groundmass (Supplement/Photo 207). The bigger grains are very often milky clouded, sometimes almost translucent. Opaque minerals are present only exceptionally.

Thin Section: Psephitic to psammitic texture with sharply angular (rarely partly rounded) quartz grains is typical (Supplement/Photo 208, 209). The quartz grains usually about 1–2 mm show complicated intergrowths with marked undulatory extinction. There is no doubt they have the origin in the underlying crystalline rocks of the Moldanubicum. They also contain numerous needle-like inclusions (sagenite?). The groundmass consists of fine-grained quartz detritus and there are missing silicified clay galls we know from some quartzites of the NW-Bohemian provenance. Small lamellae of muscovite, grains or elongated crystals of zonally coloured tourmaline, irregular grains of epidote, and rounded zircons have been ascertained as accessories. According to Bouška & Slánská (1961, 262), the quartzites from Smržov and Pecák have also contained kaolinized potassium feldspar (the quartzite from Pecák additionally also magnetite); in the quartzite from Kardašova Řečice they have described fine grains of andalusite, and disintegrated pyroxene in the sample from Lipnice.

Other Analyses: The following contents of studied elements have been ascertained by a portable gamma-spectrometer (values from three measurements): K = 0.0 %; U = 2.2 to 6.8 ppm; Th = 4.9 to 6.5 ppm.

Prehistoric Use: Chipped tools made of this quartzite have been already mentioned for example at the Pre-Neolithic localities near Putim-Ražice. It does not mean the raw material comes undoubtedly from the type locality at Lipnice because in the surroundings of the archaeological sites they could be boulders of an analogous quartzite that was worked for chipped artefacts by the prehistoric hunters.

II.5.1.3. Bečov quartzite (NW Bohemia)

Background: It was probably Žebera (1955, 25) who noticed a sugar-like white and fine-grained quartzite of the NW-Bohemian origin that was chipped during the Mesolithic in Bohemia. Later, he located outcrops of the quartzite in the vicinity of Bečov (district of Most) in the Krušné hory piedmont area and he described even prehistoric mining at the source (Žebera 1966). Following investigations of prehistoric chipped artefacts in Bohemia have shown the Bečov quartzite was one of the most important raw materials especially at the end of the Palaeolithic. Fridrich (1972) carried out an archaeological excavation of the natural finding site.

Location: The quartzite crops out on the Písečný vrch Hill (317 m) and the Verpánek or Bečov Hill (356 m) near the village of Bečov about 10 km SSE of Most. Both natural finding sites were famous by unusual morphological formations in the white quartzite (stone "herds", small gate

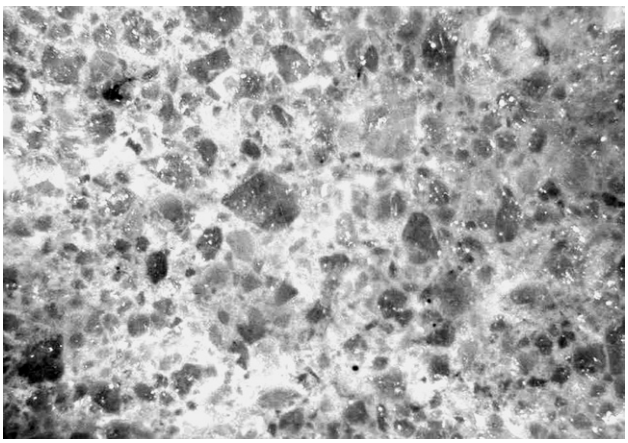

Fig. 89. Bečov quartzite in water immersion under the stereomicroscope. Most of the partly rounded quartz grains (dark) reach a size of 1 mm, bigger grains up to 2 mm. Photo by the author.

in a quartzite block, quartzite needles and pseudocaves) that had to increase the attractivity of the source in prehistoric times. Unfortunately, these unique rock formations on the Písečný vrch Hill were destroyed as a consequence of a vast commercial quarrying during World War II and on the Verpánek Hill in 1958. Their appearance we know thanks to the description and photographic documentation of Váně (1963).

Geological Setting: The profile on the Písečný vrch Hill is usually interpreted as a relic of Tertiary maar (crater produced by an explosive volcanic eruption) in which the central vent formed by volcanic breccia is preserved. The surface ring of ejected material and upper filling of the crater have been denudated. Irregular crusts of quartzite occur in a roughly 10 m thick group of kaolinite sand and sandstone beds – probably sediments of a maar lake that have been later hydrotermallly silicified. The sands are fine- to medium-grained, almost loose and without any visible layering (Váně 1963, 17), in places they are changed to solid sandstone. Well-rounded small pebbles of quartz can reach rarely above 1 cm. Above the group of beds with quartzite there have been deposited basaltic volcaniclastics (volcanic breccias and tuffs) and pieces of the quartzite are present as xenoliths in the volcaniclastics as well.

Macroscopic Appearance: The Bečov quartzite is a fine- to medium-grained rock (Supplement/Photo 198), usually with a shining white colour (2.5Y 8.0), less often with a light or bluish grey colour (2.5Y 7.0–2.5Y 6.0). As a consequence of weathering it can obtain also brown or rarely purple hues and the quartzite concretions have a conspicuous zonal colouring. The surface is rough to the touch with a several cm thick non-cemented sandy crust. Comparing the already mentioned raw material from southern Bohemia and the Tušimice and Skršín quartzites from NW Bohemia, the Bečov quartzite differs because of the colour and of bigger quartz grains that are visible with the naked eye.

Stereoscopic Appearance: Quartz grains (usually between 0.5 to 2 mm) are 5–20 times bigger comparing those in the Tušimice quartzite. Angular grains prevail but it is possible to find half-rounded grains as well (Fig. 89; Supplement/Photo 199). The quartz fragments are predominantly dissolved at the edges and their margins are indicated only by different stage of clouding. They are well visible on gently patinated artefacts when the chalcedony cement has patinated in white colour while the quartz grains stay grey.

Thin Section: The quartz clasts have prevalently homogeneous or only slightly undulatory extinction, in any case without distinctive signs of deformation. Intergrowths of quartz grains are usual. It seems to probable the quartz grains originated by weathering of post-tectonic Variscan granitic rocks. The siliceous cement has a radial fibrous texture with characteristic chalcedony filaments.

Prehistoric Use: Fridrich (1982) has believed the raw material was used probably since the Lower Palaeolithic. The Magdalenian period represented an important stage in its use because several workshops and settlements were situated on the SW promontory of Písečný vrch Hill in that time (Fridrich 1972) and the raw material was transported as far as 150 km to the west or south-west and to the south-east (Brno-Maloměřice, Borky I; Valoch 1963). Evidence on the mining in the Neolithic, Eneolithic and Middle Bronze Age has been ascertained in the area of Písečný vrch Hill. A detailed evaluation of prehistoric mining and distribution of the Bečov quartzite can be found in a comprehensive publication of Malkovský & Vencl (1955, 19–24).

II.5.1.4. Tušimice quartzite (NW Bohemia)

Background: The first information corresponding to the raw material nowadays called the Tušimice quartzite appeared in a chapter by K. Žebera in the book "Synoptical history of the Czechoslovak mining" where he has written: "A light grey-yellow ganister quartzite, massive, fine- to medium-grained, often with conspicuous isolated bigger quartz grains was chipped at fortified strongholds of the Řivnáč culture in Bohemia" (Žebera 1955, 25).

Location: The quartzite source lies at Tušimice, Rokle and Krásný Dvoreček in the eastern surroundings of Kadaň. When the Tušimice thermal power station was built in 1962 there were found tens of prehistoric mining features such as pits, shafts up to 4 m deep and a few meters long horizontal galleries in the area 50 x 75 m (Neustupný 1963, 1966). Based on the found pottery, some of them (wide open shafts) were sunk by the people with Stroked Pottery culture; more developed mining works correspond to the Eneolithic (two undecorated potsherds belonging to the Řivnáč culture and probably the Funnel Beaker culture according to the C^{14} dating of a charcoal from the shaft No. 5). Unfortunately, the mining features are not accessible nowadays.

Geological Setting: Silicified Upper Cretaceous sandstone is supposed to be the host rock of the Tušimice quartzite (Malkovský &Vencl 1995, 13). The quartzite forms discontinuous beds, blocks or big nodules and it originated probably in the Lower Tertiary.

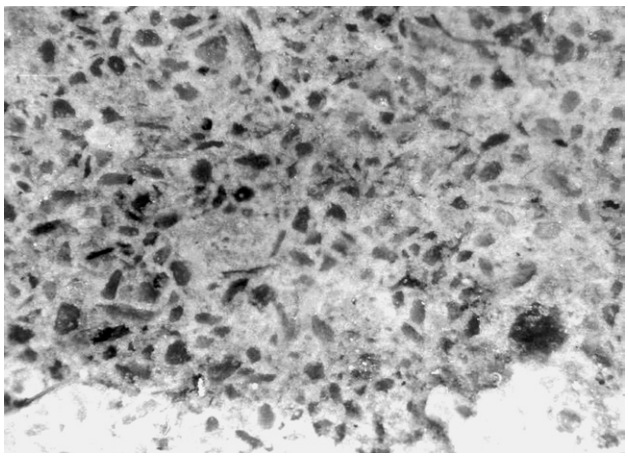

Fig. 90. Tušimice quartzite in water immersion under the stereomicroscope. The sharp-edged quartz sherds (dark) vary about 0.1 mm. Photo by the author.

Macroscopic Appearance: The raw material has a perfect conchoidal fracture and yellowish hues of various intensity (usually 5Y 7/2), which is connected with finely dispersed TiO_2 in the cemented siliceous groundmass (Supplement/Photo 200).

Stereomicroscopic Appearance: Figure 90 or Supplement/Photo 201 show the quartzite in the water immersion under the stereomicroscope. Markedly angular grains to splinters of quartz with stable dimensions around 0.1–0.2 mm (bigger grains occur only rarely) represent a typical sign of the Tušimice quartzite. Because of this granularity it is possible to distinguish it from the Skršín quartzite: using a suitable inclination of the Tušimice quartzite artefact the observer can see hundreds of small reflections on the quartz grains while the Skršín quartzite has a dull lustre similarly as silicites.

Thin Section: The rock is composed of quartz splinters or partly rounded quartz grains with roughly similar dimensions; bigger rounded quartz grains up to 1 mm are present only rarely. They show prevalently homogeneous extinction and they do not include other minerals. Some quartz grains display characteristic bay-shaped corrosion, so they are probably of volcanic origin. Microcrystalline siliceous mass clouded by dispersed TiO_2 forms the cement among quartz grains. Small rounded zircon was ascertained as only one of the accessory minerals. As is the genesis of the Tušimice quartzite concerned, it represents a pedogenic silcrete, so called F-type (Richterová 2007).

Other Analyses: The Tušimice quartzite contains high values of TiO_2 (about 2.5 %) and SiO_2 (more than 96.5 %). Other oxides (MgO, CaO, MnO, Na2O, K_2O, P_2O_5) are under 0.03% or between 0.1–0.3% (Al_2O_3, Fe_2O_3). The loss of ignition is low (0.2%).

Prehistoric Use: According to Žebera (1972), the Tušimice quartzite was chipped already in the Middle Palaeolithic; its small occurrence has been noted in chipped industries of the Late Palaeolithic and Mesolithic in Bohemia. It was frequently used for chipped tools in the period of Linear Pottery culture and Stroked Pottery culture especially in NW Bohemia but it appeared also in western Moravia or Central Germany at that time (Malkovský & Vencl 1995, 26–28). The Tušimice quartzite was popular in the Eneolithic as well (i.e. in the Řivnáč culture, Corded Ware culture and Bell Beaker culture).

II.5.1.5. Skršín quartzite (NW Bohemia)

Background: Vencl (1971, 93) introduced it to the archaeological literature and in compliance with its maximal occurrence in chipped collections in the area of Žatec he proposed to call it preliminary the Žatec type quartzite. Later the raw material was found identical with the quartzite deposit at Skršín.

Location: The quartzite deposit was situated in a small area of the Vrbka rise (345–360 m) north of Skršín village, district of Most. As a consequence of the Pleistocene frost weathering and solifluction, quartzite blocks originated not only on the rise but they appeared even a few hundred metres far of the deposit on the slopes. The boulders were prevalently destroyed because of the agricultural activity and the deposit was intensively mined as a source for the ganister brickwork in blast furnaces in the period 1945–1955. So only a depression with bushes has stayed on the rise topical part but it is possible to pick up chips of quartzite in the neighbouring fields.

Similar quartzites are to be found also at other outcrops in the surroundings of Most, for example at Zámecký mlýn near Most-Chanov, in the valley of Bílina River, between Zaječice and Stránce and elsewhere (see Malkovský & Vencl 1995, 8).

Geological Setting: Vachtl (1952) has described geological situation of the quartzite deposit. Massive quartzite formed a bed 0.3–2.5 m thick with a smooth but undulated surface in the Tertiary sedimentary rocks. A layer of red tuffite was just above the quartzite bed; downwards it was gradually changed to whitish sandy quartzite or kaoline sand. Stocks of the quartzite were estimated for 250 000 tons in 1951. Malkovský & Vencl (1995) have considered the age of the host rock (kaoline sand) as the Upper Cretaceous even though no paleontological evidence was found at the mining place but the quartzite originated by silicification probably in the Lower Tertiary.

Macroscopic Appearance: The raw material is very fine-grained to aphanitic, so it resembles silicites by its qualities. Bigger quartz grains up to 1–3 mm occur only rarely but whitish lumps are common. The prevalent colour is yellowish light grey with rose or red spots, schliers and veinlets as a characteristic sign (Supplement/Photo 202). The quartzite has a perfect conchoidal fracture.

Stereomicroscopic Appearance: Clastic structure is not well visible even using the stereomicroscope and only in places it is possible to find clusters of small quartz grains. Whitish lumps and illuvial structures with dimensions up to 5 mm are conspicuous (see also description of thin section). Red schliers and veinlets crossing each other are typical for some varieties (Supplement/Photo 202).

Thin Section: The siliceous groundmass prevails above small quartz grains (usually between 0.05–0.4 mm). As a typical sign for the Skršín quartzite there is

an occurrence of so called illuvial structures, it means rhythmic alternation of concave bended laminas with various content of iron and titanium oxides. They are arranged in the form of narrow elongated formations. Using plane-polarized light, cloudy accumulations of iron oxides-hydroxides and veinlets intensively pigmented by iron compounds are conspicuous.

Prehistoric Use: The prehistoric use has been described in detail by Malkovský & Vencl (1995). Probably the oldest artefacts manufactured from this raw material were ascertained at some Late Palaeolithic sites of the Federmesser group in north Bohemia, within the 30 km radius area around the source (Komořany, Sebuzín). Artefacts of the Tušimice quartzite are abundant at Early Mesolithic settlements in northern Bavaria about 80 km far from Skršín (Schönweiss 1993). Its distribution at the Bohemian Mesolithic sites is low because of prevalence of the Bečov quartzite. The maximal utilisation seems to be in the Early Neolithic when it was substantially chipped at all important localities with the Linear Pottery not only in the larger surroundings of the source but also in Central and eastern Bohemia. It was distributed in the period of the Stroked Pottery culture as well but its occurrence was not so high. Inventories of the Eneolithic cultures in Bohemia (Funnel Beaker culture, Řivnáč culture, Corded Ware culture) have also yielded chipped tools made of this quartzite type.

II.5.1.6. Kamenná Voda quartzite (NW Bohemia)

Background: Vencl (1986, 488) mentioned the raw material in the archaeological literature for the first time when he studied chipped artefacts from a Neolithic site at Žichov in the Teplice area. In addition he added a footnote that M. Malkovský proposed the name of quartzite in a prepared publication at that time.

Location: The quartzite has or had outcrops again in the southern surroundings of Most, for example between Postoloprty and Obrnice west of an abandoned valley of the Ohře River, northwards to Střimice, near the Osek vineyards and in the vicinity of extinct villages Stránce, Židovice and Kamenná Voda (Malkovský & Vencl 1995).

Geological Setting: The mentioned authors have described a bed of this quartzite east of Srpina. Its thickness reaches up to maximally 1.4 m with kaolinite sand and Upper Cretaceous marl as the underlayers. Green or red tuff and tuffite followed by a basalt lava flow and a small Tertiary coal basin between Skyřice and Polerady lie above the quartzite bed.

Macroscopic Appearance: Grey (N6) to yellowish grey (5Y 7/2) quartzite is fine-grained, very well cemented, without any possibility to distinguish individual quartz grains. Yellowish schliers and spots up to 1 cm are conspicuous (Supplement/Photo 204).

Stereomicroscopic Appearance: To distinguish individual quartz grains in the grey groundmass is almost impossible even using the stereomicroscope. Yellowish schliers and spots are more interesting because their structure resemble that of the Tušimice quartzite. They contain bigger angular grains or splinters of quartz cemented by an aphanite siliceous mass (Supplement/Photo 205).

Prehistoric Use: The Kamenná Voda quartzite was not so popular in the prehistoric times as the previous NW-Bohemian quartzites. It has been ascertained in a minor occurrence at some Neolithic settlements in the surroundings of the source. Vencl (1986) mentioned it at Žichov (a settlement with the Linear Pottery culture) and at Hrobčice (a workshop of the older phase of the Stroked Pottery culture).

II.5.1.7. Profen-Zauschwitz quartzite (Saxony and Saxony-Anhalt)

Background: The raw material is well known to the experts from Landesamt für Archäologie Sachsen because it was chipped at the important Neolithic site of Zauschwitz and at other archaeological localities in the surroundings of natural outcrops. Elburg (2001) described in detail the quartzite including its natural finding places and information in this book is based on this source. There are other natural occurrences of quartzite in Saxony towards the border with the Czech Republic; German geologists designate it as "Knollensteine" or "Braunkohlenquartzite". According to the explanations to old geological maps there are natural places with similar quartzite also in the territory of the Czech Republic (between Huntířov and Ludvíkovice east of Děčín)

Location: The best accessible samples are on the stripping of a vast brown coal at Profen in Saxony-Anhalt., roughly 20 km south of Leipzig, or at the archaeological finding site Zauschwitz, district of Borna, Saxony.

Geological Setting: The quartzite is a part of sands and gravels between so called "Böhlener Oberflöz" and "Thüringer Hauptflöz"; the last one is of the Upper Eocene age. So the quartzite is believed to be of probably the Eocene age as well.

Macroscopic Appearance: The rock has prevalently a white to light grey colour (N9–N7), a darker variety (10YR 4/1) can also appear (Elburg 2001). It partly resembles the well-known NW-Bohemian quartzite of the Bečov type because of its sugar-like appearance. Individual quartz grains are well distinguishable. In addition the quartzite contains up to several cm big schliers of brown or ochre colour. Some pieces have a whitish cortex with a darker stripe just under it.

Prehistoric Use: According to Elburg (2001), the Profen-Zauschwitz quartzite is occasionally found at Neolithic settlements, especially it is mentioned the archaeological site between Zauschwitz and Großstorkwitz situated only several hundred metres from a natural source. It was chipped together with erratic flints especially but the Tušimice and Skršín quartzites, Bavarian platy chert and even two pieces of obsidian occurred as well.

II.5.1.8. Quartzite to quartz conglomerate called sun boulder (Bohemia, Moravia, Lower Austria)

General Overview: Relics of siliceous weathering crusts in the form of quartzite or quartz conglomerate boulders (often also as ventifacts) have been referred from many places in the Bohemian Massif, not only in Bohemia and Moravia but also in Lower Austria. From the geological point of view it was Spitzner (1901) who

drew our attention to their occurrences in the Drahany Highland. Originally he considered them as erratic boulders. Paper of K. Absolon dedicated to so-called "quartzite Aurignacian" in the Drahany Highland (Absolon 1935) attracted notice of archaeologists. In addition, mineralogist V. Rosický and geologist K. Zapletal wrote a chapter on used lithic raw materials in his paper. Conspicuous light colours (yellowish, white grey, reddish) of the quartzite boulders deposited on the dark coloured Lower Carboniferous rocks caused the Czech name "sluňák" (sun boulder) and the supposed mysterious origin of the boulders in the beginning of the 20th century.

A few years later Žebera (1939) described natural occurrences of similar quartzites from the area of Kladno and Koutek (1940–1941) published a list of their localities in Bohemia. Pelíšek (1977) informed about their finding sites in the Bohemo-Moravian Highland. Unfortunately, almost all remarkable quartzite boulders in the Drahany Highland (Moravia) were destroyed during World War II; on the other hand some occurrences in Bohemia still attract our notice, for example the Kounov Stone Rows or the Devil's Stone at Mutějovice (in the Natural Park Džbán, the Rakovník area).

It is evident the quartzites could originate on various underlying rocks with content of quartz, i.e. sandstone, arkose, greywacke, granitic rocks etc. The mother rocks underwent an intense weathering in the tropical climate in the Lower Tertiary, namely in the Oligocene. The timing of the quartzite origin is based on the occurrence of quartzite pebbles and fragments in the Lower Miocene (Eggenburgian – Ottnangian) gravels in southern Moravia but they have not been described from conglomerates of the autochthonous Palaeogene in the Nesvačilka Trough.

Macroscopic Appearance: The raw material is possible to determine usually with the naked eye. The boulders and natural fragments have characteristic glossy surfaces with small shallow and rounded depressions. The colour is always light – yellowish grey to yellow, reddish, and greenish. The granularity is prevalently well visible because the rocks are classified as silicified coarse-grained quartz sandstones or fine-grained quartz conglomerates. Natural chips and fragments of the quartzite are often similar to small human or animal sculptures (Supplement/Photo 210, 382). Fossils in the quartzite have been found very rarely (Supplement/Photo 211).

Prehistoric Use: The raw material was chipped especially in the Palaeolithic in Moravia and in Central Bohemia. In younger prehistoric periods it was used only in the vicinity of natural finding places, very often as rider for saddle quern.

II.5.2. Chert breccia

General Overview: As we are aware from the geological history of the Bohemian Massif, its prevailing part, not covered by the sea, has gone through a very intense weathering process in the subtropical climate during the Cretaceous and Lower Tertiary (Palaeogene). According to which rocks were weathering, various types of weathering crusts (duricrusts) were created on their surface, or in a certain zone under the surface. In fact, these are special cases of paleosol usually hardened (cemented) either by sesquioxides of iron (ferricrete) or by silica (silcrete); naturally, even other duricrust types exist. The then youngest rocks – Jurassic limestones with cherts – were the first that underwent this intense subtropical weathering. Indeed, these are currently known at the eastern margin of the Bohemian Massif only as small denudation relics in the area of the Brno city, and in the depressed part of the Moravian Karst, laying in the continuation of the Blansko trough; nevertheless, we may entirely rightfully expect their substantially larger aerial distribution. These considerations are confirmed by the existence of the Rudice Formation preserved just in the surroundings of the denudation relics of the Jurassic in the above-mentioned depressed part of the Moravian Karst. The Rudice Formation is considered to be continental fluvio-lacustrine and proluvial deposits, probably of the Lower Cretaceous age, in the composition of which a significant part is played by only shortly transported decalcified residues of Jurassic limestones. These remnants of Jurassic limestones represent their most resistant parts – cherts and clastic quartz grains that emerge as a part of the Rudice Formation in the form of chert gravels or quartz sands. The accumulation of the chert fragments in depressions, their natural chipping to numerous fragments in forceful periodic water streams, the migration of silica due to temperature differences, all of this led to the gradual formation of the silcrete layers. Their creation could have proceeded in several stages; however, according to all results it seems most probable that their genesis has occurred first of all in the Lower Tertiary (Palaeogene). Within this period the silcretes originated on the Bohemian Massif rocks were represented either by silicified quartz sandstones (the so-called Drahany orthoquartzites or "sun boulders") the relics of which are known, for example, also on the granites of the Czech-Moravian Highland, on the Lower Carboniferous rocks of the Drahany Highland etc., or by chert breccias originating in the vicinity of partially or fully denuded Jurassic

Fig. 91. A boulder of chert breccia with dimensions 1.7 x 1.5 m found during construction of the housing estate Brno-Líšeň, Zikova street, in 1983. Photo by the author.

relics. Jaroš (1965) pointed out the geological significance of chert breccias at the eastern margin of the Bohemian Massif and Přichystal (1979) introduced them in the archaeological literature as an important raw material for prehistoric chipped tools.

Location: In two cases we are aware of these chert breccias occurring in the proximity of Jurassic limestones: the area of Josefov-Olomučany in the Moravian Karst and Brno-Líšeň, (Fig. 91; Supplement/Photo 213); nevertheless, their most extensive incidences are right in the area of the Krumlovský les Highland, west of Vedrovice and Pravlov and in the adjacent part of the Boskovice Furrow between Rakšice and Oslavany (Jaroš 1965). It is indubitable that just in the latter territory a total destruction of Jurassic limestones with cherts occurred and the chert breccias are a proof of their existence. A part of these breccias lay *in situ* as relic blocks directly on the rocks of the Brno Batholith (for example east of the forester's lodge Stavení; on the Réna Hill near Ivančice), or on Permian rocks of the Boskovice Furrow south of Budkovice; a part of them was redeposited later in the Miocene sea. The all mentioned chert breccias originated from the Jurassic or Cretaceous cherts. The author found an extraordinary chert breccia in the uppermost floor of Lesní lom (Forest quarry) in Brno-Líšeň (Supplement/Photo 212); this one is composed of fragments of the Upper Devonian to Lower Carboniferous chert.

Geological Setting: Chert breccias occur on various underlying rocks – granitoide rocks of the Brno Batholith in the Krumlovský les Highland, Devonian to Lower Carboniferous limestones in Brno-Líšeň, Permian sedimentary rocks of the Boskovice Furrow, Jurassic limestones in Brno and the Cretaceous Rudice Formation in the central part of the Moravian Karst. They form both isolated boulders on the older rocks or redeposited fragments to pebbles in younger Upper Tertiary or Quaternary sediments.

Macroscopic Appearance: From the petrographic point of view, these are not silicites but clastic rudaceous (psephite) rocks in the structure of which angular fragments of cherts take the prevalent part (Supplement/Photos 214, 215). However by the side of them even well rounded, small quartz pebbles may appear. This rudaceous fraction (it means 2 mm and more) is cemented by a whitish-yellow, markedly yellow, or brown-red siliceous groundmass. On a number of chert breccias it may be seen that in this case the brecciation of cherts did not happen due to shattering in the course of transportation, but rather *in situ*, by splitting as a result of intense temperature variations. The shapes of chert fragments often perfectly interlock; they are shifted only by several millimetres and separated by thin layers of the siliceous groundmass. Chert breccias in the area of Olomučany and Klepačov (Moravian Karst) contain Jurassic quartz geodes as well; in a boulder of chert breccia at the path from the Líšeň housing estate to the Lesní lom quarry the author found a silicifed solitary coral of probably Jurassic age (Supplement/Photo 213).

Unlike the Krumlovský les type cherts that underwent river transportation first and, upon transgression of the Lower Miocene sea, the fluvial sediments with their pebbles were partially eroded and redeposited in the sea (Nehyba 1997), the chert breccias underwent mostly a minimum or practically no transportation at all, as shown by their fragments for example from the trench I-4–1 in the Krumlovský les mining area. In some cases a dark desert varnish may be observed on fragments of cherts in the breccias (trench II-2–1.); sometimes we may observe fragments of already older breccias. This gives evidence in favour of the concept that the origin of chert breccias should be laid most probably to the end of Palaeogene, i.e. to the Oligocene stage.

Stereomicroscopic Appearance: Chert fragments in the breccias from Krumlovský les show the same properties characteristic particularly for the Krumlovský les chert, variety I (spicules of sponges, phantoms after silicified quartz clasts, bluish grey to dark grey colour). In an absolute majority the space between the fragments of cherts is filled by fine angular chips of clear quartz (substantially fewer of cherts) with the size below 0.1 to 0.2 mm that are bonded by aphanite yellow substance. In the district VII in the Krumlovský les mining area there were found chert breccias containing fragments of Jurassic geodes. In other cases the occasional presence of fragments of opal substance and greenish chalcedony clasts would correspond to the views of Dlabač (1976) that in the creation of the chert breccias a partial share could have been taken even by weathering products of the West-Moravian serpentines (opal, plasma); laterite weathering products of serpentinites rich in iron have then caused the deep red colour of the groundmass of some chert breccias.

Prehistoric Use: Chert breccias from the Krumlovský les area appeared among raw materials for chipped artefacts already in the Upper Palaeolithic. Their use in the Neolithic and Eneolithic cultures is summarized in a paper by Oliva, Neruda & Přichystal (1999). Surprisingly, chert breccias were used mostly in the Old Bronze Age (the Únětice culture, the Věteřov group) when they were significantly worked at the settlements in the vicinity of Krumlovský les (Budkovice, Kubšice, Šumice; Supplement/Photo 214) and the tools (so-called segments) were exported for a long distance (for example they were found at the stronghold of Zelená hora, district of Vyškov). The author together with J.Bronowicki ascertained a segment of the Kubšice type chert breccia even at a locality of the Únětice culture (with influence of the Maďarovce-Věteřov group) in Radłowice near Oława, SE of Wrocław, south Poland. The artefact is exhibited in the City Museum in Wrocław. Another segment made of white grey chert breccia coming from Krumlovský les was found during an excursion at a Věteřov stronghold Waidendorf-Buhuberg in Lower Austria.

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II.6. Other rocks

II.6.1. Porcellanites and hornfelses (Fig. 92)

By their appearance and properties, porcellanites (formerly also incorrectly called porcelain or basalt jaspers) are rocks resembling porcelain. Their definitions substantially differ in various dictionaries; for example Allaby & Allaby (1991, 291) characterize porcellanite as a highly siliceous sedimentary rock with a dull lustre, porous texture, and conchoidal fracture, similar in general appearance to porcelain. According to them, porcellanites include certain biogenic, siliceous, deep-sea sediments and some fine-grained, recrystallized acid tuffs. However this is contradictory to the definition of porcellanite in Central Europe and elsewhere. Therefore in this monograph only contact (thermally) metamorphosed, fine-grained sediments (marlstone, mudstone, siltstone, and limestone) with a compact (porcelain) appearance and conchoidal fracture are designates as porcellanites. The terms porcelain and basalt jaspers seem unsuitable and misleading – see above the definition of jasper as a siliceous filling of vugs and dykes in volcanic rocks. Due to a distinct granularity, contact metamorphosed sandstone may also be well distinguished and, moreover, it has own special name – buchite. The source of the contact metamorphosis is either a body of a volcanic rock (most often basalt or andesite), or a naturally burnt-up coal bed. According to Fediuk (1987, 98) we are able to distinguish both genetical types of porcellanite: the porcellanite originated at the contact of volcanic rock does not contain glass while the porcellanite from the vicinity of burnt-up coal deposit has variable presence of glass.

The colour of porcellanite may be very variable, from a pale greenish grey through red speckled, brown striped, deep brown, yellow, bluish grey. In addition to that, the intensity of the thermal metamorphosis falls down quickly around the source, so that classic porcellanite gradually merges into only partly thermally metamorphosed mudstone or marlstone. The porcellanite differs by its higher hardness (steel needle does not scratch porcellanite), or possibly by the absence of $CaCO_3$. When verifying the hardness, it is necessary to take into consideration that porcellanite artefacts acquire a relatively thick, light patinated surface that is soft and it is scratched by the knife or steel needle. Porcellanite occurrences are rather plentiful in Central Europe, and we are aware that a number of them were used as raw materials for chipped tools in prehistoric times.

II.6.1.1. Porcellanites from the Bohemian Cretaceous Basin

There are many localities within the extensive area of the Bohemian Cretaceous Basin where sediments of the Cretaceous age are intruded by Tertiary basaltic volcanic rocks, around which porcellanites could have been formed. When solving the provenance of porcellanite artefacts, particularly in the Mladá Boleslav and Jičín surroundings, it has to be taken into consideration that they need not originate from the famous Kunětická hora Hill near Pardubice in every case. For example, upon investigation of No. 3855 Jičín 1: 75 000 map sheet, Pacák (1957) has found out 53 incidences of basalt eruptive rocks in the environment of Cretaceous sediments, and on No. 3854 Mladá Boleslav sheet he has found even 112 of them (Pacák 1947). Their exact record is nearly impossible as it depends on the status of the momentary exposure; in addition to it a number of them have been affected by medieval extraction. On the other hand, not each of them featured conditions suitable for the creation of porcellanite. From the Jičín sheet, the above author mentions porcellanites (in his text "basalt jaspers") from Dílecká Horka SW of Železnice, from Čeřovka (the spotted type), and from Šibeňák near Jičín. On the Mladá Boleslav sheet, he has recorded them at Loreta, 1.3 km NW of Velíš, on the western end of the municipality Hubojedy, at Horka near Zámostí (the latter two sites are located in the Prachovské skály Rocks area), on the Kamenná Horka Hill near Březka, and on the Malá hora Hill near Střeleč. He characterizes them as compact, non-stratified rocks of grey-white, grey-green, but also of black colour with a smooth, conchoidal fracture, faint or slightly matt lustre, and with the hardness between grades 6 and 7. Sometimes they may still contain relics of $CaCO_3$ or fine pores. Skutil (1952, 37) estimated about 210 possible localities of porcellanite in the Bohemian Cretaceous Basin. The most important source of porcellanite is situated on the Kunětická hora Hill near Pardubice.

Porcellanite from the Kunětická hora Hill near Pardubice

Location: This striking morphological elevation (307 m) overtops the surrounding flat landscape by more than 80 m and it lies about 7 km NNE from the centre of Pardubice. The Labe River flows in a wide bend around the hill in the north, east and south. The castle of the same name was built on the hilltop in the Middle Ages. A big quarry for the volcanic rock has been dug in the south slope; the mining was in progress up to 1916 and it caused destruction of a part of the castle fortification.

Geological Setting: The Kunětická hora Hill obtained its striking appearance because a Tertiary volcanic rock intruded the soft Cretaceous sediments and as a more resistant rock formed the elevation as a consequence of weathering. The classification of volcanic rock in geological papers was repeatedly changed, according to the last geological map 1: 50 000, sheet 13–24 Hradec Králové (Straka, Valečka & Shrbený 1986), it is a coarse-grained natrolite-sodalite trachybasalte with nepheline. The volcanic rock thermally metamorphosed marlstones of the Březno

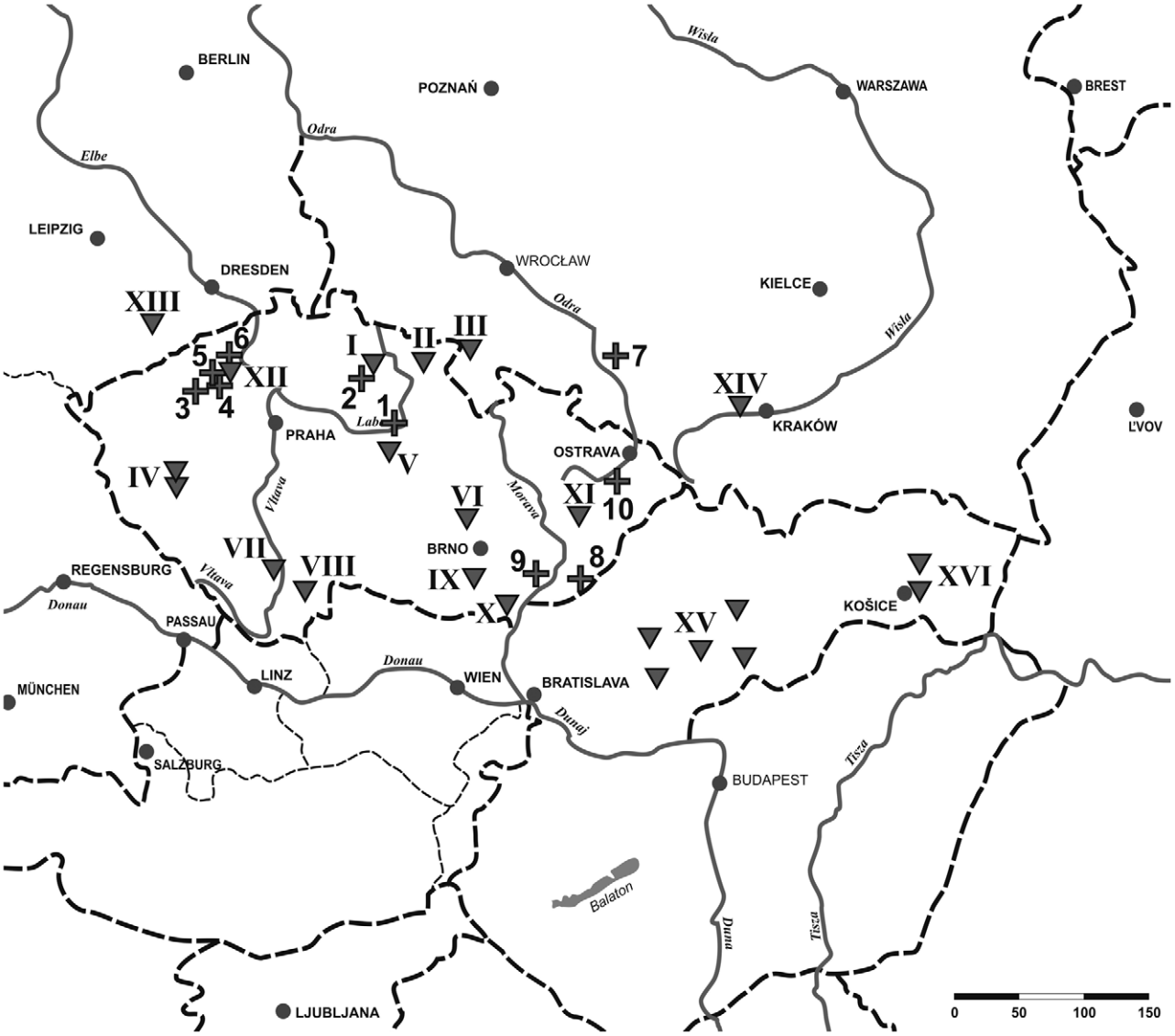

Fig. 92. The most important natural sources of porcellanite and silicified wood in eastern Central Europe. Porcellanites (crosses): 1 – Kunětická hora Hill near Pardubice, 2 – Čeřovka near Jičín, 3 – Čermníky and Březno NW of Žatec, 4 – Nečichy near Louny, 5 – Dobrčice near Most, 6 – Želénky south of Teplice, 7 – Góra Sw. Anny Hill SE of Opole, 8 – Bučník Hill near Komňa, 9 – Medlovice near Uherské Hradiště, 10 – Hončova hůrka Hill near Příbor.
Silicified woods (triangles): I – Nová Paka and Pecka in the Krkonoše Piedmont Basin, II – Radvanice in the Broumov area, III – surroundings of Nowa Ruda, IV – Chotíkov and Líně near Plzeň, V – Kraskov in the Železné hory Mts., VI – Bořitov, VII – surroundings of České Budějovice, VIII – southern surroundings of Třeboň, IX – Žabčice, X – Břeclav-Poštorná, XI – Hlinsko near Lipník, XII – the area of Most, XIII – Chemnitz in Saxony, XIV – Kwaczala and Regulice W of Cracow, XV – area of Central-Slovak neovolcanics (Cígeľ E of Nováky, Ľubietová E of Banská Bystrica, Veľký Ďur W of Levice, Lupoč NW of Lučenec, Nevoľné), XVI – northern part of the Slanské vrchy Mts. (Zámutov E of Prešov), southern part of the Slanské vrchy Mts. (Čakanovce E of Košice).

Formation (the Lower to Middle Coniacian) and porcellanites originated at several places: in the northern side it is so called Žlutá skalka (Yellow Rock) with a roughly two-meter thick porcellanite deposit (Fig. 93), followed by an occurrence at "U studně na baště" farther to the NE, and a big block of porcellanite (6 x 40 m) is also closed in the volcanic rock at the southern side, in a steep broken-off quarry wall under the castle tower (Pacák 1946).

Macroscopic Appearance: Massive rock, usually grey yellowish green (5GY 7/2) or light bluish grey (5GY 6/1–5B 7/1). We know also varieties with dark grey green (5G 4/1) or dark yellowish green (5GY 5/2) colour. The knive does not scratch it and the rock does not react with the diluted HCl. Occasionally a system of almost parallel thin smudges can be seen on the fresh surface. Spotted or banded porcellanites (Supplement/Photo 217) originated probably in a bigger distance from the contact with the volcanic rock. Neolithic porcellanite artefacts underwent an intense patination (Supplement/Photo 216).

Stereomicroscopic Appearance: The rock is very fine-grained and to distinguish individual mineral particles it is necessary to use the magnification more than 40x. Dry

Fig. 93. Kunětická hora Hill, eastern Bohemia. In the foreground the flat outcrop of porcellanites. Postcard, 1930.

sample shows many tiny reflexes on the fracture surface but substantially lesser comparing quartzite. The groundmass contains lighter bluish schliers with accumulations or isolated grains of pyrite up to 1 mm. A thin black edge occurs around the pyrite grains or crystals.

Other Analyses: Magnetic susceptibility with values 0.11–0.21 x 10^{-3} SI is only slightly higher or the same as that of the non-metamorphosed marlstones. A detailed x-ray investigation of the porcellanite from Kunětická hora carried out by D. Všianský has shown a high content of quartz, occurrence of newly formed feldspars and pyroxenes, than calcite, Fe-dolomite, probably even rutile, and cristobalite.

Prehistoric Use: There is no doubt on the use of porcellanite from Kunětická hora for prehistoric chipped tools; according to Vokolek (1993, 8) the raw material was ascertained for example at Svobodné Dvory (a Gravettian site in east Bohemia) already in 1899 or porcellanite artefacts were found just in a natural pseudocave on the slope of Kunětická hora Hill (Šnajdr 1909, 64).

Vokolek & Vencl (1961) wrote a detailed study concentrated on the use and distribution of the porcellanite from Kunětická hora. They have published a schematic map with porcellanite occurrences at archaeological localities in the Palaeolithic, Mesolithic, Neolithic, and even the younger prehistoric periods. The region of Pardubice was the principal area of the porcellanite distribution, for example at a Mesolithic station in Pardubice it forms 27 % of chipped artefacts (Vencl 1965). A relatively rich porcellanite workshop connected with the Šárka stage of the Linear Pottery culture was found at Úhřetice on the other side of the Labe, about 12 km far from the natural source. They were processed porcellanite pieces up to 25 cm big, quarried probably at Žlutá skalka (Yellow Rock) on the Kunětická hora Hill. Numerous porcellanite artefacts were found at a settlement with the Stroked Pottery in Pardubice-Hůrka.

II.6.1.2. Porcellanites from the Krušné hory Piedmont Basins (NW Bohemia)

General Overview: There are many occurrences of porcellanites in the Krušné hory Piedmont Basins, namely in the Most Basin it is registered about 65 localities of pyrometamorphic rocks: buchites, slags and paralavas can be found besides typical glassy porcellanites (Žáček, Skála & Dvořák 2010). The porcellanites originated as a consequence of the thermal metamorphosis of Tertiary clays or claystones around naturally burnt-out deposits of brown coal. The well-known porcellanite sources lie for example in the area of Želénky-Zabrušany, at Dobrčice near Skršín, in the surroundings of Bílina or at the extinct village of Čermníky (Tschermich) near the Ohře River.

The porcellanites are very variable and usually macroscopically different from the porcellanites of the Bohemian Cretaceous Basin. They have very often conspicuous colours – light red (5R 6/6), light yellowish orange (10YR 8/6), medium yellowish brown (10YR 5/4). On the other hand, some samples have a typical porcelain appearance with light bluish grey colour (5B 7/1). This type containing plant relics burnt-out in red colour is very attractive and suitable for making of jewellery (Supplement/Photo 218, 219).

Magnetic susceptibility is very variable from 0.04–0.15 x 10^{-3} SI (grey, yellow, bluish porcellanites) to 0.5 x 10^{-3} SI (red slaggy porcellanite).

The NW-Bohemian porcellanites has been used since the Lower Palaeolithic (a single find of handaxe), the maximal utilisation for chipped tools was probably in the Mesolithic.

II.6.1.3. Porcellanites from southern Moravia

Porcellanite from the Bučník Hill near Komňa

Location: The sedimentary rocks of the Magura Group, Carpathian Flysch Belt SE of Uherský Brod, are penetrated by dykes, sills, and subvolcanic bodies of the Miocene trachybasalts to trachyandesites, around which porcellanite deposits up to 5 m thick were created by the contact metamorphosis. Kruťa (1966) specifies them from eight localities: Bystřice pod Lopeníkem, Komňa, Krhov near Bojkovice, Nezdenice, Ordějov, Starý Hrozenkov, Suchá Loz, and Záhorovice. The most significant occurrence is represented by the quarry on the Bučník Hill near Komňa where porcellanites occur in such volume and quality that they are polished as gemstones under the name "Moravian moss-stone".

Geological Setting: The local porcellanites originated by pyrometamorphosis of a subvolcanic body (laccolith) composed of biotite-amphibole trachyandesite, in addition influenced by hydrotermal process called propylitization (Přichystal 1974).

Macroscopic Appearance: Mátl et al. (1983) have classified macroscopically seven varieties of porcellanite in the quarry on the Bučník Hill. Apart from simply coloured porcellanites (pale grey, grey-green, blue-grey to black) also olive grey with a laminar texture (laminae around 1mm thick) and schliers are present. Brecciated porcellanite consisting of roughly one centimetre long grey-green fragments that prevail over the dark green grey fine-grained cementing substance is especially attractive (Supplement/Photo 220). Furthermore, porcellanite

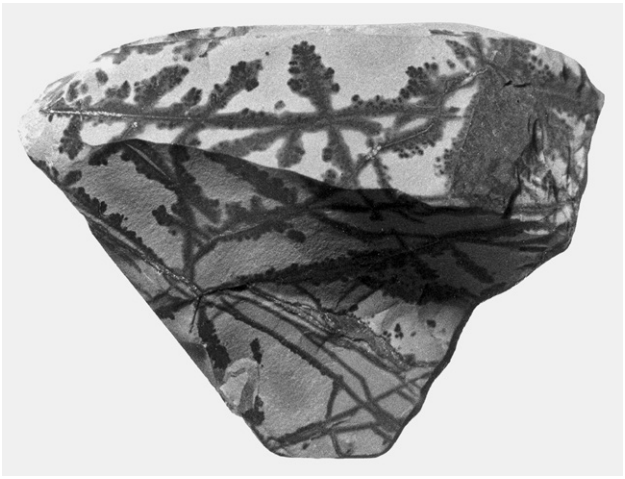

Fig. 94. Porcellanite with numerous dendrites, Bučník Hill near Komňa, SE Moravia. Photo by the author.

with globular structure has been ascertained, as well as chocolate brown variety with white veinlets and, finally, again very impressive grey-green porcellanite with black dendrites (Fig. 94). Irrespective of the cracking it is no problem to acquire up to 10 cm big pieces.

Stereomicroscopic Appearance: The groundmass of porcellanite is non-translucent and it has an aphanite (extremely fine-grained) texture. A frequent characteristic feature of porcellanite is the occurrence of ore minerals, in particular of pyrite and pyrrhotine in hair-thin cracks. The ore minerals have been observed especially in porcellanite with richly tree-like dendrites; these are considered as manganese hydroxides.

Přichystal (1974) studied mineralogical and chemical composition of porcellanite from the Bučník Hill. He mentioned also results of x-ray investigation. A contemporary x-ray diffractographic study carried out together with D. Všianský found newly formed pyroxenes and feldspars, in addition it confirmed quartz, calcite, pyrite and we could not exclude occurrence of vermiculite or chlorite, kaolinite and cristobalite.

Prehistoric Use: Porcellanite was ascertained at a few Palaeolithic sites in Moravia, but usually only several pieces. As is its provenance concerned, we cannot exclude it originates in some cases from the Bílé Karpaty Mountains, especially from the Bučník Hill. Its utilisation can be expected at Upper Palaeolithic (Aurignacian) sites in the Uherské Hradiště area, 30–35 km to the west from the natural source.

Porcellanite from Medlovice near Uherské Hradiště

Location: The village of Medlovice lies about 14 km west of Uherské Hradiště or 11 km to the southeast from Kyjov in southern Moravia. Geomorphologically, the region is classified as the Kyjov Hilly land.

Geological Setting: The locality is situated in the Vienna Basin. Porcellanite crops out at several places; the best one is a quarry south of the road from Medlovice to Osvětimany at the altitude 350 m (Supplement/Photo 221). A small brown coal seam together with calcareous clay originated in a bay of big lake in the Pannonian. After denudation the coal seam appeared on the surface and burned out – it was a natural phenomenon as a consequence of oxidation (or of a clap of thunder) probably still in the Tertiary. According to data of Klvaňa (1885), the porcellanite body has a length about 300 m and a thickness up to 10 m. Čtyroký & Novák (1978, 81) situated a borehole UH-20 just at the quarry wall in 1972. It found about 15 m of porcellanite and burned clay, but partly redeposited.

Macroscopic Appearance: Porcellanite disintegrates in small pieces or bigger boulders. It is a very varied rock from the viewpoint of colour: besides the prevalent brick red one can find various hues of ochre, orange, brown and grey colours (Supplement/Photo 222). The hardness of well burned grey or red porcellanites can reach up 6–7 of the standard scale. Novák (1947) introduced hyalite (a variety of glass-like opal) from cracks in the Medlovice porcellanite.

Prehistoric Use: Valoch (1985) described an Upper Palaeolithic station at Hostějov, only 1.5 km to the SW of the Medlovice porcellanite outcrops; other Upper Palaeolithic sites have been mentioned at nearby Stříbrnice or Buchlovice. No occurrence of chipped artefacts made of porcellanite has been noticed at these localities. Looking for porcellanite artefacts on the surface is very difficult because the Medlovice porcellanite was mined since the 19th century and used for building of roads. That is why the information of Valoch (1988, 73) on occurrence of brown yellow and brick red porcellanite in the layer 11 (the Middle Palaeolithic, Taubachian) in the Kůlna Cave is extraordinary; he supposes the source of porcellanite at Medlovice about 60 km distant from the Kůlna Cave as the most probable one.

II.6.1.4. Hornfelses at the contacts of the teschenite-picrite association in the Carpathian Flysch Belt

General Overview: In north Moravia, and in the Czech and Polish parts of Silesia, several dozens of incidences of the Lower Cretaceous teschenite-picrite rocks intruded sediments of the Silesian Unit of the Carpathian Flysch Belt. The most popular occurrences are concentrated around Nový Jičín (Žilina, Janovice, Kojetín, Palačov) or the Bušlín Hill near Milotice nad Bečvou, Choryně and the Hončova hůrka Hill near Příbor. Hornfelses originated by thermal metamorphism at contacts with the mentioned igneous rocks.

The best samples are represented by a mixture of cryptocrystalline quartz and chalcedony of green colours – dusky yellowish green 10GY 3/2 or greyish green 10GY 5/2 (Supplement/Photo 220). Illite, chlorite and pyrite were ascertained in thin sections under the polarising microscope (Matýsek 1984). Magnetic susceptibility measured by the portable kappameter is low, just above the detection limit (0.01–0.03 x 10^{-3} SI).

The prehistoric use of local hornfelses has not been described yet but we cannot exclude it especially in the surroundings of Nový Jičín and Příbor.

II.6.1.5. Porcellanite from the Góra Św. Anny Hill (Polish Silesia)

General Overview: The Góra Św. Anny Hill (406 m) is the highest point of the Wyżyna Śląska Highland. It lies about 25 km SE of Opole. The topical part of the hill is built of Triassic limestone that is penetrated by Oligocene nephelinite dated by the K–Ar method for 27 million years (Birkenmajer & Pécskay 2002). The unique geological situation is open to public here in the form of a natural trail. The porcellanite ("jaspis porcelanowy" in Polish) occurrence on the Góra Św. Anny Hill is represented only by a several metres long lens of a markedly granular, silicified rock, prevailingly of moderate brown colour (5YR 4/4), with a characteristic conchoidal fracture (Supplement/Photo 224). At first sight the rock resembles a silicified limonite iron ore. It has more or less distinct banding, the bands being distinguished by the brown colour hues. Sporadically, there are distinct pores to cavities filled by darker limonite. Porcellanite is resistant against scratching by the knife and it does not react with diluted HCl.

When observing the rock in thin section under the polarising microscope, it is visible a mosaic pattern of quartz grains with various intensity of brown colour, i. e. with various content of goethite. Small "islands" of clear quartz grains occur in places (Supplement/Photo 225). An x-ray investigation carried out by D. Všianský revealed beside prevalent quartz and goethite also small amounts of dolomite, pyrolusite, manganite, probably kaolinite and anatase as well.

This porcellanite is supposed to have been formed as a result of a reaction of hot hydrothermal solutions rich in SiO_2 with a marlstone attitude within the Triassic limestones. The original marlstone was decalcified and silicified upon the creation of a markedly parallel (fluidal?) structure with fine pores in places, somewhere with veinlets penetrated into the limestone.

Prehistoric Use: The morphologically conspicuous Góra Św. Anny Hill had to attract man in prehistoric times. The use of local nephelinite for polished tools is very probable, so we cannot exclude also the utilisation of porcellanite for chipped artefacts.

II.6.1.6. Hornfelses in Bohemia

General Characteristics: Dark grey to grey-black rocks, originated by thermal metamorphosis on the contact usually of plutonic or hypabyssal rocks with clayey shales or similar sediments are most often designated as hornfelses. Typically, they feature equidimensional grains with a mosaic (paving) texture and no preferred orientation. Czech topographical overviews of mineralogical occurrences include in hornfelses also rocks originated around volcanic rocks intruded Palaeozoic sediments in the Barrandian, so the definition towards the porcellanites is sometimes rather subjective. Distinguishing of hornfelses from porcellanites may often be impossible if we have found them only in the form of artefacts and we don't know geological circumstances of the origin. It is evident the group of hornfelses includes various rocks and it is difficult to characterize them together.

Location: Tuček (1970) have introduced 37 localities of hornfelses from the Central Bohemian Pluton, Barrandian, Železné hory Pluton, etc. in the book "Finding places of the Bohemian minerals and their references 1951–1965". Láznička (1964) dedicated his paper to hornfelses in so called "Islet Zone" (a belt of Proterozoic and Lower Palaeozoic sediments enclosed in granitoide rocks of the Central Bohemian Pluton).

Prehistoric Use: Žebera (1955, 33) has used the term hornfelses for the rocks formed by burning of Silurian graptolite shales at the contact with paleobasalts in the Barrandian, and he maintained that the chipped tools made of these hornfelses were common both at the surface stations and in the caves of the Bohemian Karst.

II.6.2. Fine-grained volcanic, subvolcanic and volcaniclastic rocks

Based on the published data, the fine-grained volcanic rocks were chipped especially in the Lower and Middle Palaeolithic. The use of fine-grained reddish Permian volcanic rocks formerly determined as quartz porphyries or porphyrites (paleorhyolites, ignimbrites or basaltic paleoandesites in the recent classification) for chipped tools has been described from a Lower Palaeolithic site at Bilzingsleben or a Middle Palaeolithic station at Weimar-Ehringsdorf (both are situated in Thuringia). Similarly, at a Middle Palaeolithic site Bojnice in Slovakia there were chipped pebbles of Miocene andesite from the nearby Handlovka River. Žebera (1972) informed about a find of heavy patinated fine-grained basalt artefact resembling handaxe roughly 1 km to the SE of Komorní hůrka Hill near Cheb and he regarded it as an Acheulian tool.

Following chapters are concentrated on the probably most important raw materials of this type: Permian acid subvolcanic rocks from southern Bohemia, Permian silicified banded tuff from Gnandstein in Saxony, and Triassic felsic metarhyolite from the Bükk Mountains in Hungary.

II.6.2.1. Permian acid subvolcanic rocks from southern Bohemia

Background: Upon an investigation of the raw materials of the Pre-Neolithic settlements in southern Bohemia, a new and unexpected finding was posed by the ascertainment of chipped acid subvolcanic rocks (Přichystal & Vencl 2001).

Location: Klečka (1984) described in detail natural occurrences of acid subvolcanics at Lásenice in the Jindřichův Hradec area; their veins continue towards the border with Austria and they crop out also in the Austrian Waldviertel. Other subvolcanic localities in Bohemia are known in the surroundings of Pelhřimov or in the area between Milevsko and Sedlčany (see a paper of Němec 1994).

Geological Setting: The dykes of acid subvolcanic rocks penetrate granites of the Moldanubian Pluton or rocks of its mantle. The length varies between 100–2000 m, the thickness from several dm to 10 m. The structure of the dykes is predominately zonal: at the contact with

country rock it is felsic microgranite or vitreous microgranite and the central part is formed by felsic granite porphyry. The vitreous microgranite was chipped especially. Rb-Sr whole rock isochron of 9 samples yielded an age of 295 ± 5 million years (Klečka et al. 1994), it means the Early Permian.

Macroscopic Appearance: The dusky green (5G 3/2) vitreous microgranite is without a recognisable granularity (i.e. aphanitic), usually with a distinct fluidal or banded structure (Supplement/Photo 232). The thickness of this originally glassy rock is up to 50 cm.

Thin Section: Small white spots composed of diminutive plagioclases or K-feldspars occur in the microcrystalline groundmass. Chloritized biotite, K-feldspar and volcanic quartz may occasionally be seen as phenocrysts (Supplement/Photo 234, 235). Volcanic quartz is surrounded by K-feldspars in places. Elongated apatite up to 0.2 mm and titanite in chloritized biotite phenocrysts represent accessory minerals.

Prehistoric Use: These rocks are most often represented in the complex of Late Palaeolithic and Mesolithic stations in the Putim-Ražice area (Supplement/Photo 233); usually only in several pieces they appear at the localities towards western Moravia (Hradišťko south of Dačice), or even in the Strakonice area (Strakonice 7). For the Pre-Neolithic stations in the Putim-Ražice area it will most likely be necessary to look for the resource probably around Milevsko.

II.6.2.2. Permian silicified banded tuff of the Gnandstein type (Saxony)

Background: In German geological papers the rock is usually called "Gnandsteiner Bandjaspis" or "Wolftitzer Porphyrtuff". It emerges in the surroundings of villages Gnandstein and Streitwald, in the wooded Leipziger Tieflandsbuch Hilly land between Leipzig and Chemnitz in Saxony. Basic data on this raw material are referred by Elburg & Kinne (2001) without accurate location of the source because they are afraid of its next devastation.

Geological Setting: According to published data, it is not entirely clear which exact petrographic type is in fact hidden under the collectors' name "banded jasper". Older works use the term quartz porphyry – "Wolftitzer or Rochlitzer Quarzporphyre" in German. Pietzsch (1962, 291) regarded the rock as a special variety of acid rhyolite tuff ("Wolftitzer Porphyrtuff") of the Permian age and he has used the designation fine-grained heavily silicified ash tuff.

Macroscopic Appearance: The very fine-grained to aphanitic rock is noted for its distinct banded structure in fine pastel green and red colours (Supplement/Photo 236). Under patination, the red stripes disappear and the entire rock acquires a grey-green appearance. The thickness of the bands varies from 1 mm to several cm. The silicification is so intense that the banding has no adverse impact on the chipping of the raw material.

Stereomicroscopic Appearance: Regular accumulations of biotite crystal fragments in the aphanitic groundmass are well visible in some bands. Thicker bands with chips of volcanic quartz or feldspar are present as well. Some bands have evident graded bedding supporting the opinion the rock is a tuff. The red brown colour is caused by uniformly distributed iron oxide pigmentation; it forms darker ventricular accumulations in places. Opaque minerals are not almost present. That is why the magnetic susceptibility is very low, just above the detection limit of the portable kappameter (0.01 x 10^{-3} SI).

Thin Section: The author's investigation of thin section revealed it is a silicified rhyolite tuff. The texture of groundmass is vitrophyric or crystal-vitrophyric in places. It is evident the original rock was an ash tuff with angular chips of volcanic quartz, biotite crystals, small crystals of K-feldspar and fragments of vitreous rock with microphenocrysts of K-feldspar. Almost parallel arrangement of biotite sheets bears evidence the rock should be classified as a tuff (Supplement/Photo 237).

Prehistoric Use: The utilisation of the raw material ("Gnandsteiner Bandjaspis") in prehistoric times has been known at least since the early 20th century. Apart from the production of chipped industry, it served mainly for the manufacture of polished axes in the Late Neolithic (Eneolithic).

II.6.2.3. Triassic felsitic metarhyolite ("quartz porphyry") from the Bükk Mts. (Hungary)

Background: The raw material is designated as felsitic quartz porphyry in the archaeological literature. In the eightieth of the 20th century the IUGS Commission for classification of igneous rocks accepted a recommendation not to use different names for Pre-Cenozoic volcanic rocks, so the rock from the Bükk Mts. has to be reclassified as a rhyolite and because of its metamorphic alteration the correct name is felsitic metarhyolite.

Location: The felsitic metarhyolite forms outcrops about 10 km west of Miskolc, in the vicinity of Bükkszentlászló and Bükkszentkereszt villages. From geomorphological point of view it is the eastern edge of the Bükk Mountains in NE Hungary. According to Simán (1986), the raw materiál sui-table for chipping crops out only above the first mentioned village.

Geological Setting: In the geological map of Bükk 1 : 100 000 (Balogh 1963), the rock (at that time designated as quartz porphyry) is a part of a larger body together with diabase, porphyrite and their tuffs. In the new geological map of Hungary 1 : 500 000 (Fülöp, ed. 1984), the volcanic rocks are classified in full conformity with the IUGS Commission proposal, it means metarhyolite, metabasalt, metaandesite and their tuffs. Triassic limestones form the south and north surroundings of the volcanic body. The age of volcanic rocks is believed to be the Middle Triassic, namely the Ladinian (Haas, ed. 2001, 92).

Macroscopic Appearance: The plane-parallel structure is a typical sign and on bigger pieces of the raw material it is possible to distinguish indication of psephitic vitrolithoclastic texture. The colour of the rock is medium grey (N5) on a fresh surface by fracture but chips are usually more or less patinated. More patinated lenticular parts with dimensions of about 2–3 cm are probably vitreous

lapilli particles (Supplement/Photo 238). According to information in some papers, the raw material can have also red grey colour and light brown cortex.

Stereomicroscopic Appearance and Thin Section: Non-patinated rock is translucent only partly, the patinated one is not translucent at all. Small accumulations of partly limonitized pyrite or lenses rich in quartz are elongated with the plane-parallel fabric. Phenocrysts of volcanic quartz can be found in thin section (Supplement/Photo 239).

Prehistoric Use: Simán (1986) followed the distribution of chipped artefacts made of this raw material. The felsitic metarhyolite was used already in the Middle Palaeolithic at the end of the Riss/Würm Interglacial or at the beginning of the Würm Glaciation. At that time they are numerous occurrences connected prevalently with the Bábonyiani culture in the radius of 25 km around the source. The same artefacts from the technological point of view are to be found about 80 km to the west in the Mátra Mts. or roughly 90 km to the north-east in the Hornád River valley. The Szeletian was another period of its large distribution when the Bükk metarhyolite reached to the Danube, the surroundings of Košice or the Váh River valley in western Slovakia. A Szeletian artefact from Ondratice (the district of Prostějov, Central Moravia) represents the westernmost find of this raw material (Valoch 1983). Only occasional small chips have been found in the area of about 30 km around the source in the Neolithic.

II.6.3. Silicified corals of the Příbor-Klokočov type

Background: Paleontological reports on finds of silicified corals in the surroundings of Příbor-Klokočov have been published since the beginning of the 20th century; Eliášová (1989) described them in detail. Diviš (2003, 28) drew our attention to prehistoric use of this unique raw material even if he originally considered it to be a silicified wood.

Location: The town of Příbor (district of Nový Jičín) lies roughly in the middle between Nový Jičín and Frýdek-Místek in the Podbeskydská pahorkatina Hilly land, near the northern part of the Moravian Gateway. Klokočov was an independent village till 1949 but in recent time it forms the NE part of the town. The silicified corals crop out as fragments on a grassy slope dipping to the south or south-east, about 400 m from the last building in the Lesní street. The area with finds is not probably too large. According to Diviš (2003, 28), the maximal raw material concentration is near the border of the pasture with the Osičina forest, almost at the hilltop.

Geological Setting: Geological map of the CSR 1: 50 000, sheet 25–21 Nový Jičín (Roth & Růžička 1989) shows rocks of the Sub-Silesian Unit of the Carpathian Flysch Belt in the finding place. They are represented namely by sandstones and conglomerates of the Strážek type having the Upper Cretaceous (Maastrichtian) to Lower Eocene age. Claystones and sandstones of the Třinec Formation crop out in the wider vicinity of the locality. How to explain the occurrence of big silicified coral pieces? The author proposes as the most probable explanation a layer rich in pieces of silicified corals within the conglomerates of the Strážek type. They have weathered out from the layer together with pebbles of quartz and metamorphic rocks.

Macroscopic Appearance: The silicified corals form angular fragments weighting up to several kilograms. The raw material has a dark brown and very rough surface, sometimes individual corals are weathered out on it. The central parts of big fragments have an appearance of brownish-banded chert with alternating brown and whitish bands thick a few mm (Supplement/Photo 226, 227).

Prehistoric Use: According to Diviš (2003), the raw material was intensively used during prehistory in the eastern surroundings of Příbor. It is documented by numerous chips, blades and cores with various stages of patination. A Late Palaeolithic station is situated just in the area of natural fin-ding place and in addition to it, J. Diviš supposes the raw material was used earlier (probably in the Aurignacian) and also possibly later in the Neolithic.

II.6.4. Silicified woods

General Overview: According to the current knowledge, in Central Europe silicified fossil woods originated especially in the course of two periods: towards the end of Palaeozoic in the Permian period, and during the Lower Tertiary, particularly in the Oligocene. The silicification is a slow process occurring only in an alkaline environment (this develops e.g. upon the chemical weathering of plagioclases) and with the access of air, rainfall water, and underground water with free circulation (Karásek 1997). Especially woods of the Permian age feature an excellent appearance after having been cut and polished, and are well-known to both specialists and collectors thanks to samples exhibited for example in Nová Paka and Turnov in northern Bohemia, or in Walbrzych in southern Poland.

Location: There are many occurrences of silicified wood both from the Permian and Tertiary period in eastern Central Europe (see Fig. 92). The most popular Permian silicified woods can be found in the Krkonoše Piedmont Basin (Purkyně 1927; Supplement/Photo 240, 241), in the Intra-Sudetic Basin (Žacléř Formation in the surroundings of Nowa Ruda; Sachanbiński 1979) or rarely in the Boskovice Furrow (Kruťa 1966). As is the Tertiary silicified woods concerned, we know them from the South-Bohemian Basins, from southern Moravia (Šmerda 1997; Supplement/Photo 242), from the Maleník Block in central Moravia (Záleský 1947; Supplement/Photo 243) and from the area of Slovak Tertiary volcanic mountains (Horáková 1977; Ďuďa 1996, 257; Ďuďa & Pauliš 2005). The Permian to Upper Carboniferous silicified woods crop out also to the west of Cracow (Kwaczała and Regulice).

Prehistoric Use: Grolich (1977) has mentioned three pieces of the Permian silicified wood found at the Palaeolithic (Late Micoquian/Szeletian?) station Horky (404 m) near Bořitov (western Moravia). The raw material comes from Permian deposits of the nearby Boskovice

Furrow. One fragment of Tertiary silicified wood was found at an Aurignacian site near Pavlovice u Přerova, central Moravia (Klíma 1980). Chipped artefacts from Permian silicified woods were ascertained also at some Bohemian localities, for example at a Mesolithic site in Hořín near Mělník (Přichystal 2000, 44) or three artefacts from an important settlement with the Stroke-ornamented Pottery at Mšeno, district of Mělník (Přichystal 1987).

Silicified woods were also found as solitary pieces at several South-Bohemian Pre-Neolithic localities: Milenovice II, Putim III, Týnec IV (Přichystal 2006). Nevertheless, they have obviously represented only occasional finds and have not played the role of a more important raw material anywhere. These are silicified woods of the Tertiary age (Oligocene – Lower Miocene). Their colour is usually yellow-brown or grey-brown, and their base horizon is the Oligocene Lipnice formation, but they were usually transferred to more recent, Upper Miocene or Pleistocene gravels (for an overview of the localities with the finds of silicified woods in South Bohemia, see Novák 1997, 2002).

A nice elongated piece of Tertiary silicified wood appeared in a feature of the Linear Pottery culture in Brno-Starý Lískovec during a rescue excavation by M. Přichystal. The wood texture is very well preserved and the piece has traces after test chipping.

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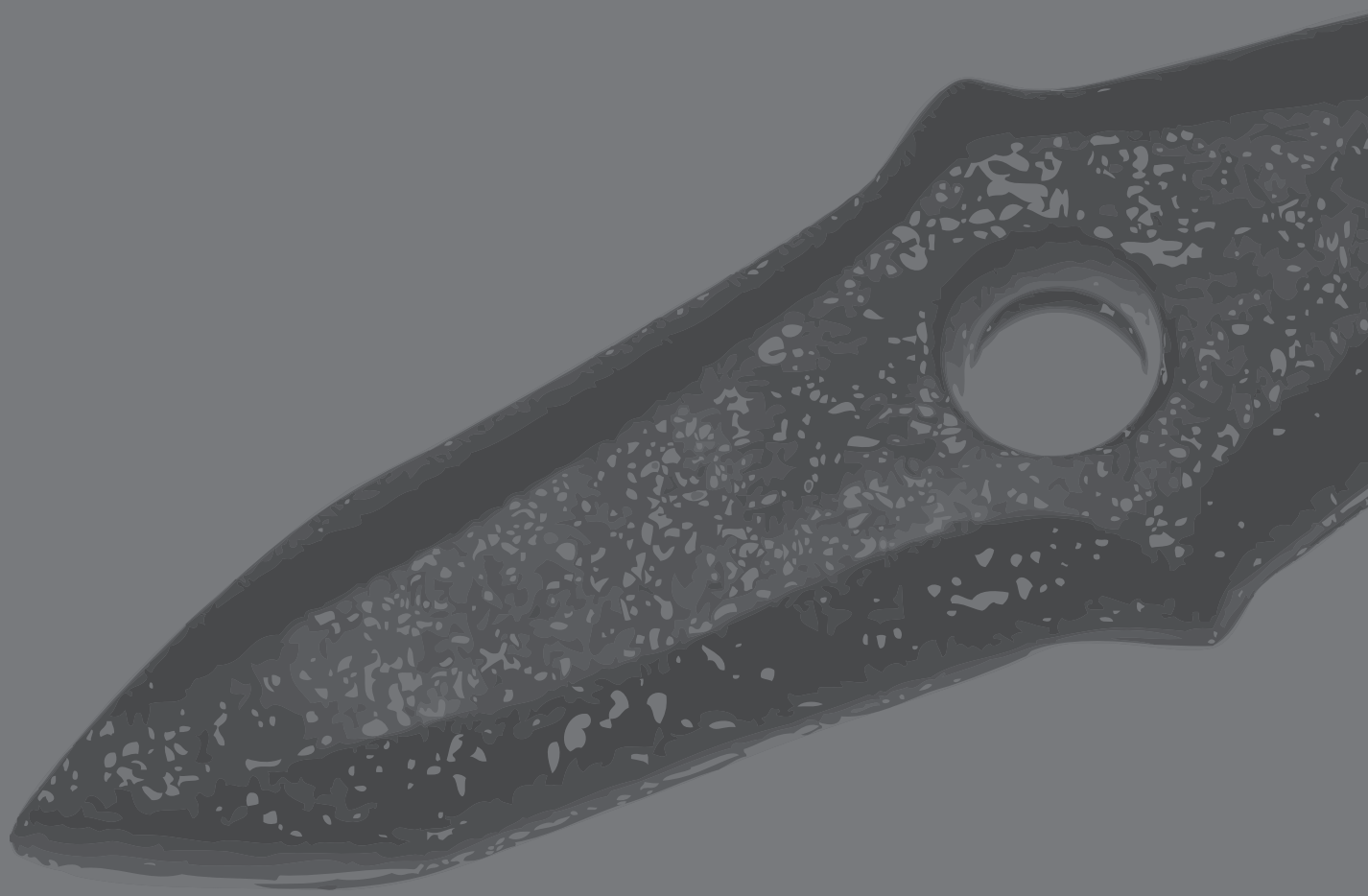
III.
RAW MATERIALS OF POLISHED STONE TOOLS



Stone tools and other stone objects that have been polished, smoothed, rubbed, or drilled during processing and finishing are classified as the polished or ground stone industry. Specific metamorphic, magmatic and sedimentary rocks were usually used for their manufacture, and these were markedly different from the raw materials chosen for chipped stone tools, even at the macroscopic level. The specific raw materials used, semi-finished artefacts, and related waste is also included in the polished stone industry, when assessing archaeological finds. We classify them as the polished stone industry whether or not there are obvious traces of working, and even when semi-finished products show signs of working that might be the same as those for the chipped industry. At some archaeological sites, for example, Moravian Painted Ware settlements in the vicinity of diorite sources near Brno, the flakes resulting from the preparation of semi-finished tools are themselves of such quality that their use as chipped stone tools is quite possible.

Finding the prehistoric sources and quarries for polished tool stone is much more difficult than finding silicite (flint) sources. In many cases "mining" was little more than cutting stone out of natural outcrops above river streams or collecting pebbles from river gravels, incidentally derived from older weathered conglomerates. During his time in Papua-New Guinea, Austrian traveller Heinrich Harrer took part in an aboriginal expedition to obtain raw material for polished stone axes, extracted from a particular site of rock located above a stream which they called the "Source of stone axes" (Harrer 1967, 87).

Special attention has been devoted to the interpretation of the function and social importance of polished stone tools, and the relationship between raw material and tool morphology, the utilization of stone which from our point of view are unsuitable, etc. In Czech archaeological literature Vencl (1960, 1979) and Oliva (1985) have taken clear positions in some of these matters.

Due to their conspicuous shape, stone axes and battle-axes quickly came to the attention of farmers who often found them in their labours, and who have felt the need to explain their origin. Interesting folklore has sprung up around stone tools, often labelled as "thunderstones" and used in folk remedies. In Stříbrnice near Buchlov, southern Moravia, a village teacher reports an explanation of their origin and use: "Thunder strikes high trees, teacher, and upon this the thunderstone falls down from a cloud and digs itself deep into the ground. Our grandma found such a thunderstone and keeps it hidden behind a beam in the room. She said the stronger the lightning, the bigger the stone. Some of them will rise to the surface of the ground on the seventh day, some as late as in the seventh year, so they say. Yet each has a healing power. When you have a pain somewhere on your body, you ought to rub it several times and the disease will disappear. Stomachache will stop when we stir a drop of wine on a little plate with a thunderstone and then drink it up. The disease will disappear as if by a magic" (Štěrba 1924). The "thunderstone" myth has been examined several times by J. Skutil (see for example Skutil 1932), and more recently by Sklenář (1999) who notes the basically identical pan-European nature of this folk tale and assumes it to have arisen in the deep past when they were considered rarities and objects of adoration as evidenced in Bronze, Iron, and Roman Ages graves. Thunderstones were well-known to ancient Greeks and Romans whose written accounts refer to them as keraunia or ceraunia found at the site of a lightning strikes, and who considered them to have magical properties. They used them as amulets to divert evil. Some European museums have examples of stone axes with magic formulas and other similar engravings (Figs. 146 and 147). The myth was encountered first-hand by J. R. Vávra, a Czech travelling amongst the Tuaregs in northern Africa, where these stone tools were still believed to be thunderstones (Vávra 1950, 9).

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III.1. Metamorphic rocks

III.1.1. Thermally metamorphosed metabasite and greenschist

For roughly forty years it has been accepted that the most common rocks utilized by earlier central European farmers to make polished stone tools (axes, shoe-last axes, shoe-last adzes) were amphibole-rich metabasites, with the macroscopic appearance of greenschists. On the basis of thin section studies under the polarizing microscope petrographers have identified actinolite,

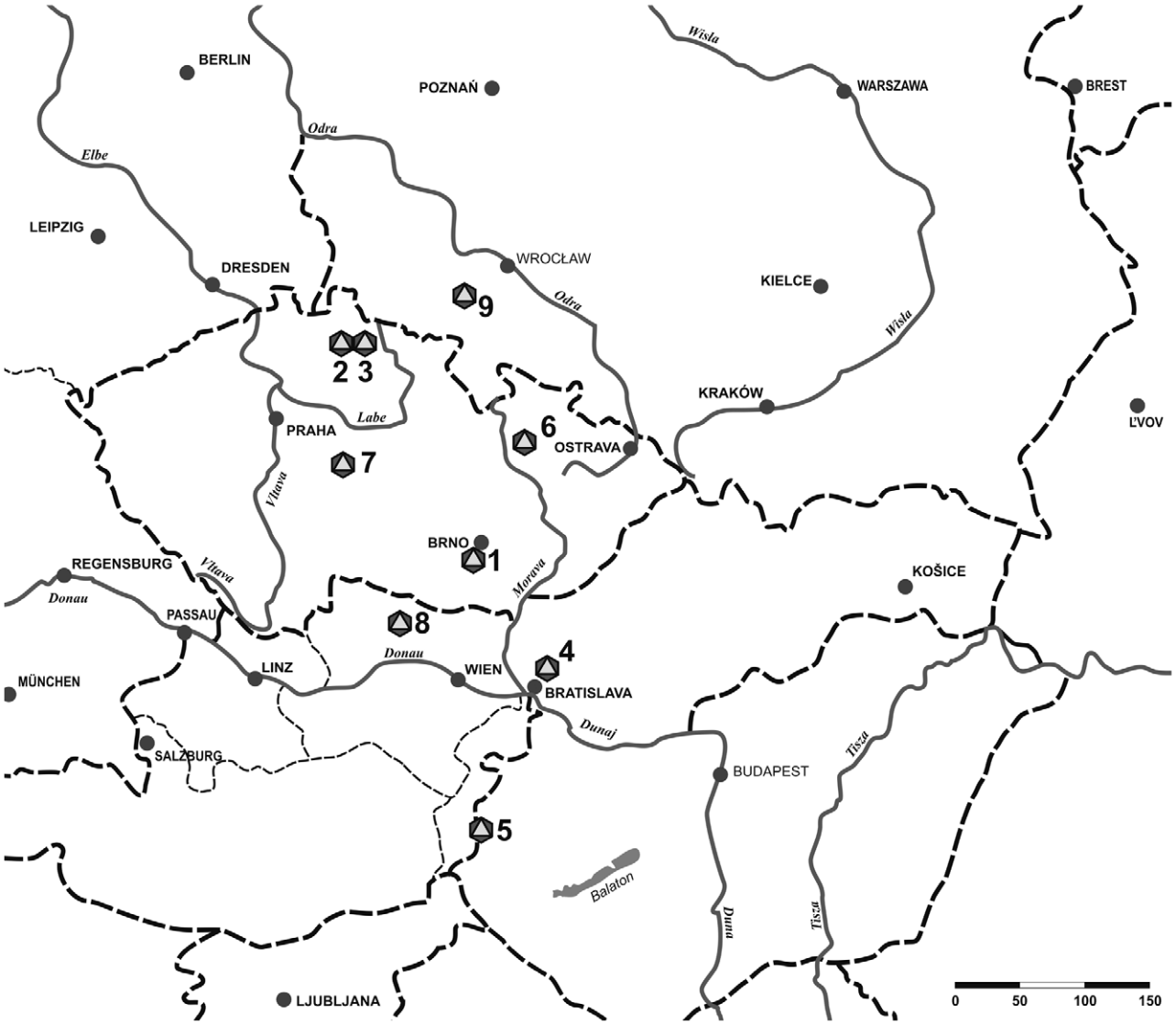

Fig. 95. The most important occurrences of thermally metamorphosed metabasites, greenschists and amphibolites mentioned in the text. 1 – Želešice near Brno, 2 – Jistebsko near Jablonec nad Nisou, 3 – Velké Hamry near Tanvald, 4 – Pernek in the Malé Karpaty Mts. (Slovakia), 5 – Folsöczatár (Hungary), 6 – the area of Sobotín in the Hrubý Jeseník Mts., 7 – Rataje nad Sázavou, 8 – surroundings of Horn (Lower Austria), 9 – Pyszczyńska Góra Mt. east of Strzgom (Poland).

amphibole-actinolite, and actinolite-amphibole greenschists as the most common rocks (Štelcl & Malina 1970, 1975). It has gradually become apparent that this stone type is common not only at large Neolithic settlements connected with the Linear Pottery (Bandkeramik, LBK, Danubian I culture), Stroked Pottery and early phase MBK (Moravian Painted Ware, Lengyel I) in Moravia and Silesia (Bylany near Kutná Hora, Vedrovice near Moravský Krumlov, Mšeno near Mělník, Těšetice-Kyjovice near Znojmo), but also in the Neolithic of Slovakia (Hovorka & Illášová 2002, 130). The thick patina on these stone tools (Supplement/Photo 244) can lead to inaccurate macroscopic identification and it is possible that the ratio of this raw material in various collections of prehistoric artefacts could be even higher. Similar rock is presumed to exist at Neolithic settlements in Lower Austria, such as at Schletz, an Early Neolithic site west of Mistelbach, where the author had an opportunity to review some polished stone tools.

German researchers Schwarz-Mackensen & Schneider (1986) supported the importance of this rock when they ascertained that 90 % of the several hundred Early Neolithic artefacts found in the northern foothills of the Harz Mts. are made from it. As this type of rock has no known source in Germany the researchers posited its source lay to the south-east and visited the former Czechoslovakia in 1982. Together with the author they tried to find outcrops of the raw material in the crystalline units of Hrubý Jeseník and Rychleby Mts. in northern Moravia and Silesia, which J. Štelcl presumed was the source. We sampled also metabasite rocks from the Letovice and Kutná Hora Crystalline Units. Unfortunately,

the raw material had not been found in the Bohemian Massif at that time, so the German colleagues concluded that the Western Carpathians or more probably Bulgaria was the source.

It has been recently determined that most tool rock used in the Early Neolithic was amphibole-rich metabasite that had undergone thermal metamorphosis in contact with a large plutonic body (Přichystal 2009). Probably the most important such source lies in the Jizerské hory Mts. (northern Bohemia, Czech Republic). Another rock with a similar geological background, and also intensively used in the manufacture of polished stone artefacts, is a metabasite from the Brno Batholith with outcrops at Želešice south of Brno. Aside from these two major centres lithic exploitation a third source of similar stone exists in the Pezinok-Pernek Group in the Malé Karpaty Mts., western Slovakia. Utilisation of other metabasites (typical greenschists with albite; amphibolites) without thermal overprint has been reported but these are considered secondary. Examples include a greenschist from Felsöcsatár in west Hungary, the Hrubý Jeseník and Rychleby Mts. in north Moravia and Silesia, and a greenschist from the Pyszszyńska Góra Mt. in southern Poland (Fig. 95).

III.1.1.1. Amphibole-rich metabasite from the Jizerské hory Mts. (northern Bohemia)

Background: Until a number of years ago it was thought that an extensive mining centre for amphibole-rich metabasite (called amphibole-actinolite greenschist in that time) existed in northern or north-eastern Bohemia (Přichystal 1991, 31). This was later located with more precision in the Železný Brod Crystalline Unit (Přichystal 2000). The author relied on the work of Vencl (1975), who described a concentration of polished stone tool depots in eastern Bohemia. Bukovanská (1992) pointed out that basically identical rock have been found at the southern exocontact of the Krkonoše-Jizera Pluton, at Černá Studnice, Maršovický Hill near Jablonec, Zahájí, Zbytky and Loužnice. From the geological point of view this is the area of contact between the Pluton with the rocks of the Železný Brod Crystalline Unit. For this reason the author started to survey the Kamenice River valley, a north-south running tributary of the Jizera River, which crosses the Železný Brod Crystalline Unit containing a huge complex of greenschists (metabasites). The almost all greenschists in the Kamenice valley contain carbonates and disintegrate along schistosity planes. This makes them unsuitable for stone axes. In 2001 the author found the right rock in the riverbed between Návarov and Velké Hamry (Přichystal 2002, 212). Its concentration in the riverbed increased moving up to Velké Hamry-Svárov, 2 km south of Tanvald (Supplement/Photo 245). At this point the author discovered an extensive prehistoric mining site on the slope above the Kamenice River (Přichystal 2002a). The site contains dozens of shallow pits with debitage, and semi-finished axes and shoe last adzes. A basaltoid mallet and a block of thermally metamorphosed phyllite bearing probably signs of tool polishing were found on the surface (Supplement/Photos 250 and 319).

At the same time a group of Prague geoscientists under V. Šrein had been looking for the tool stone in the Jizerské hory Mts. At the "21st workshop on the Neolithic and Eneolithic in our lands" (Hradec nad Moravicí, September 2002) they announced the discovery of a prehistoric mining site of this rock at Dolní Černá Studnice, Jistebsko cadastre (Šrein et al. 2002). Surface survey revealed a high volume of metabasite debitage, and semi-finished artefacts prepared for transport (Fig. 97; Supplement/Photo 251). Further localities with raw material sources in the area between Jistebsko and Velké Hamry were discovered by detailed survey of Šída (2007). This supports the conclusion that the Neolithic mining of thermally metamorphosed metabasite at this site is one of the most important in Europe, supplying raw material to local people and into Germany, Poland, Moravia, Slovakia, Hungary and Austria.

Location: From a geomorphological point of view the metabasites rise on the southern border of the Jizerské hory Mts., particularly on the slopes of Černá Studnice Ridge. The area containing the rocks in question lies on the east-west axis and it is bounded by the villages of Jeřmanice to the west and Světlá to the east. The larger city of Tanvald lies approximately 2 km north of Velké Hamry and Jablonec nad Nisou is about 3 km north-west of Jistebsko. The most significant mining areas identified are near Jistebsko (Šrein et al. 2002), and Velké Hamry (Přichystal 2002a). Other mining areas discovered during a systematic survey conducted by Šída (2007) include: Maršovice, Paseky nad Jizerou, Bílá Skála, Zásada, Zadní Zbytky and Šumburk nad Desnou.

Geological Setting: Small bodies of thermally metamorphosed metabasite occur along the line of contact between the Krkonoše-Jizera Pluton (more precisely its southern part built of the Tanvald granite) and the extreme northern part of the Železný Brod Crystalline Unit. The latter includes the Early Palaeozoic (Ordovician to Lower Devonian) Poniklá Group (Klomínský and Kachlík 2005), in an older idea of Chaloupský et al. (1989) the group was believed to be of the Proterozoic age and called the Velká Úpa Group. The prevailing rocks are sericite, chlorite-sericite and graphitic phyllites containing intercalations of quartzite, dolomitic marble and metabasite. The phyllites near granite have changed into biotite-cordierite-andalusite hornfels. Basic rocks (originally probably fine-grained tuffs or tuffites) were initially affected by regional metamorphosis and then by contact metamorphosis. This explains why the process of naming these rocks was so complicated. Gränzer (1933) compared the rock with nephrite, whereas Watznauer (1934) rejected the term and suggested "aktinolithfels". Similarly, Hejtman (1962) used the term actinolite schists for foliated types or actinolite fels for varieties with massive structure, as did Bukovanská (1992), who preferred the term actinolite schist (hornfels). Klomínský et al. (2004) conducted the most recent detailed study and used the term amphibole-plagioclase hornfels. Considering the complicated history of the stone's name and usually evident schistose structure it is best to simply call them

Fig. 96. Shoe-last celt from the eastern slope of the Velký Kosíř Hill, district of Prostějov, central Moravia. Very probably metabasite from the Jizerské hory Mts., the Linear Pottery culture. Photo by the author.

thermally metamorphosed amphibole-rich metabasite in artefact analysis. Necessity demands shorter names and the author of this book prefers the term "Jizerské hory metabasite" (see also Šída 2006). This simplification does not imply doubt about the term amphibole-plagioclase hornfels. It is essential to note that two different terms exist in English, for a sedimentary fine-grained to cryptocrystalline siliceous rock (chert) and for a massive, fine-grained, granoblastic contact metamorphic rock commonly displaying also conchoidal fracture and splintery debris (hornfels; see for example Allaby and Allaby 1991). Similarly in the first half of the 20th century, there was a different term in Czech for contact metamorphic stone of cherty appearance – "rohovcovec" (Otto's Encyclopaedia 1904, Masaryk's Encyclopaedia 1932), and for rock of organogenic sedimentary origins – "rohovec". Unfortunately, later the term "rohovec" (chert) has been applied to a wide range of aphanitic stone of different origins (sedimentary, weathered and contact metamorphic).

Macroscopic appearance: In the mining area we find uneven fragments and oblong prismatic examples over 30 cm long. These were ideal for the preparation of large and long shoe-last adzes. Patinated rock is dirty bright green-grey (5GY 6/1–5Y 6/1), and black-green to green-black (5G 3/2–5G 2/1) on a fresh fracture. Bluish varieties are found in the Kamenice riverbed. The patina is 2–3 mm thick on some artefact fragments. The majority of rocks found in both the Jistebsko and Velké Hamry mining areas have obvious foliation and often alternating light and dark strips (Fig 96). Their mineral composition is so fine-grained that naked-eye identification of minerals is usually impossible. Šída (2007) divides the rocks into three groups: a) fine-grained metabasite with tiny phenocrysts of amphiboles and some plagioclases; b) porphyritic metabasite and c) contact metamorphic tuffitic phyllites.

Stereomicroscopic appearance: The stone is non-translucent. It is possible to recognize occasional microphenocrysts of dark green isometric minerals (amphiboles) and whitish rectangular feldspars on its surface. Small amphibole needles, sometimes gathered into leaf like aggregates, are marked on cross section to foliation. The amphiboles have a nearly perfect cleavage, and can show sometimes a light or almost whitish appearance (especially on the patinated artefact surface).

Thin Section: A nematogranoblastic to nematoblastic texture prevails, in which marked leaf like or radial assemblages of acicular amphiboles occur (usually 0.1–0.3 mm), together with xenomorphic feldspars. In laminated varieties from Velké Hamry these strips are richer or poorer in dark and light minerals. Opaque minerals have an uneven or slatted shape and given the rock low magnetic susceptibility it is obvious that mainly ilmenite is present. It can be spread unevenly or accumulates rather in feldspar rich strips. Microphenocrysts are comprised largely of feldspar (0.5–1 mm), and to a lesser extent by pieces of older amphiboles (to 0.5 mm), usually replaced by an accumulation of acicular amphiboles. Acicular amphiboles usually grow diagonally and crosswise to the foliation, which undoubtedly contributed to the improvement of the strength of the rock (Supplement/ Photos 248, 249, 252, 253).

In higher quality exploited rock, amphiboles comprise 60 %, plagioclases 30 % and opaque minerals about 10 %. Along with ilmenite we also find a smaller amount of magnetite, pyrrhotite, quartz and chromite as accessories. In some pebbles from the Kamenice riverbed, sphene is concentrated in a pupa-like mass.

Several researchers independently conducted microprobe studies of the constituent minerals, both in artefacts thin sections and from natural outcrops (Šrein et al. 2000, Přichystal 2002a, Klomínský et al. 2004, Šída 2007). Only the findings related to main rock-forming minerals will be presented hereafter. All the researchers concluded that this rock has surprisingly calcium-rich plagioclases of labradorite (Velké Hamry) or bytownite (Jistebsko-Dolní Černá Studnice) character. Even though more Na-rich plagioclases of andesine character were discovered in outlying bodies, these more Na-rich cores

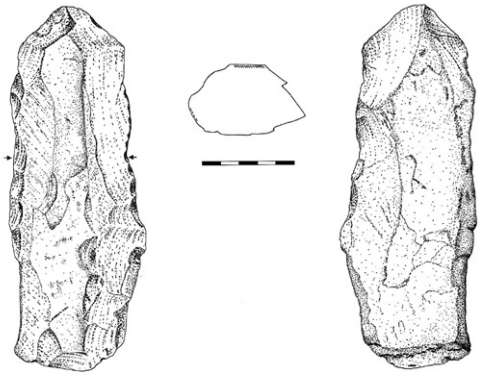

Fig. 97. Semifinished shoe-last celt from the prehistoric mining locality of Velké Hamry near Tanvald, northern Bohemia. Metabasite of the Jizerské hory. Drawing by Z. Nerudová.

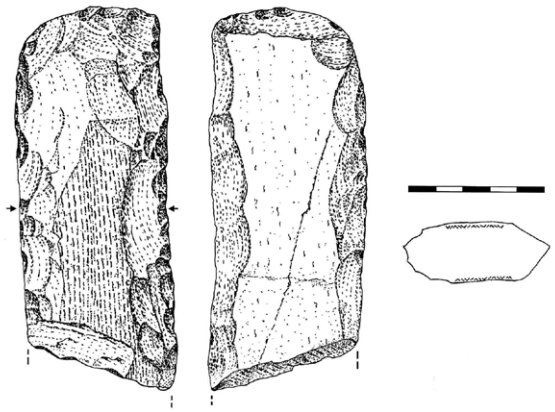

Fig. 98. Semifinished axe from the prehistoric mining locality of Jistebsko near Jablonec nad Nisou, northern Bohemia. Metabasite of the Jizerské hory. Drawing by Z. Nerudová.

grew with more Ca-plagioclases in the margin (Šída 2007, 47). Two opaque phases were found with the microprobe in the rock from Velké Hamry. Ilmenite was the prevalent component, with smaller amounts of magnetite, than chlorites, epidote-zoisite, apatite and quartz as accessories.

Author's microprobe analyses of amphiboles of semifinished artefacts from Velké Hamry show that they can be divided into calcic and magnesium-iron groups. Šída (2007, 38) came to the same conclusion in a study of metabasite samples from natural outcrops or exposures. Calcic amphiboles cover the spectrum from actinolite, actinolitic hornblende to ferrohornblende. Magnesium-iron group includes cummingtonite.

Other analyses: Magnetic susceptibility of semifinished products from the mining area at Velké Hamry ranged from 0.6 to 1.3 x 10^{-3} SI. Higher values were measured on surfaces parallel with foliation and lower values found perpendicularly to it. Similarly, the samples from Jistebsko provided values between 0.65 to 0.85 x 10^{-3} SI. Based on the author's experience, quality samples from Maršovický Hill approaching partly nephrite had relatively low magnetic susceptibility 0.25 to 0.5 x 10^{-3} SI. Semi-finished products with values up to 8 x 10^{-3} SI were found only exceptionally at Velké Hamry. It is necessary to note that even higher levels of magnetic susceptibility have been found very rarely on some natural outcrops, however, they are not characteristic and do not appear within the lithic assemblage.

The rocks were also studied geochemically (Jistebsko for example by Šída 2007, Velké Hamry by A. Přichystal). Polished artefacts found in Germany and compared with those from Jistebsko in Jizerské hory were analysed by Christensen & Raminger (2004) and Christensen et al. (2006). In the Total Alkali – Silica (TAS) diagram the Jizerské hory metabasites are classified as sub-alkalic rocks (except for metatuff and metatuffite, see Šída 2007, 63). In the AFM diagram (A = Na_2O+K_2O, F = FeO+ Fe_2O_3, M = MgO) they have clear tholeiitic differentiation trend. Strictly speaking researchers agree that in discrimination diagrams based on few immobile trace elements, such as Nb, Ti, Zr, Ta, Hf, Y, the rocks from the source area including the semi-finished artefacts (along with some artefacts from Germany) are found in the field of within plate basalts. Another characteristic sign is the total iron content (expressed as Fe_2O_3) being normally twice as high as MgO. Where FeO and Fe_2O_3 are identified, FeO is markedly higher. TiO_2 is strongly present as well. In semi-finished products from Velké Hamry it fluctuated between 2.68 to 2.81 %. Pebble of metabasite from the Kamenice River near Návarov contained 3.47 % TiO_2 and a semifinished product from Jistebsko contained 4.1 %. Similar results were found in comparative samples from Jistebsko (Christensen et al. 2006). Only in Šída's analyses (2007) TiO_2 was found always as low as 2.4 % (usually even under 2.2 %), though this is possibly a laboratory error. P_2O_5 content is agreed by all authors to be relatively high as well, at 0.4 to 0.5 %.

Prehistoric Use: Till the discovery of prehistoric mines in the Jizerské hory Mts., there was known only a few occasional finds of the Neolithic – Eneolithic stone tools in the whole mentioned area (Brestovanský & Stará 1998). Recently we have obtained many semifinished stone artefacts in the both mining areas at Jistebsko and Velké Hamry (Figs. 97 and 98). Archaeologist P. Šída studied prehistoric mines near Jistebsko. Charcoal from the site provided uncalibrated radiocarbon dates of 6120±35 BP and 6035±35 BP (5150–4900 BCcal, Šída 2007, 109–110) According to Šída these dates correlate with the transition of the Linear Pottery culture to Stroke-ornamented Pottery culture. Preliminary archaeological research in the mining area at Velké Hamry was conducted by Vondroušová (2005) as part of her master thesis, and subsequently by Šída (2006a). Charcoal extracted by Šída was dated at the VERA laboratory in Vienna and the obtained result VERA-4477 is 335±40 BP that represents 1460 ADcal – 1650 ADcal (95.4%). It is noteworthy that Šída (2007a, 148) has published a similar datum from the locality Jistebsko: VERA-2982 is 325±30 BP (1480–1650 ADcal, 95.4%). The obtained results yield evidence on early Post-Medieval activities at the both sites in the similar time.

Current knowledge of the distribution of this tool stone indicates that it was mainly used by the Linear Pottery and Stroke-ornamented Pottery peoples. It is the totally predominant material in the well-known Neolithic site at Bylany near Kutná Hora. One of the main distribution networks cut across eastern Bohemia. This is well documented by the extensive processing sites as for example at Hněvčeves (Supplement/Photo 256), Gbelnice, Labouňov, see J. Kalferst (1995), but also by the huge semifinished product depots found at Čístěves and Lípa (Supplement/Photos 254, 255) in the surroundings of the spot height Chlum (336 m, made notorious in 1866 during the battle near Hradec Králové). Magnetic susceptibility of shoe-last

adzes, semifinished products and raw material from the Lípa depot, at 0.6 to 1.11 x 10^{-3}, precisely corresponds to values for the stone raw material at its source in the Jizerské hory Mts. The tool rock from Jizerské hory than continued through the Boskovice Furrow depression to Linear Pottery culture site at Vedrovice (Přichystal 2002a) and Moravian Painted Ware site at Těšetice – Kyjovice (Vokáč's preliminary results 2007, Přichystal & Valová 2010). It may have also moved eastward to the Hornomoravský úval Graben, the districts of Zábřeh, Mohelnice, Prostějov and Olomouc (Supplement/Photo 257). Research in Hungary has shown that the metabasite from Jizerské hory reached as far as north-western and central Hungary, as evidenced by artefacts of this type from the Mihály assemblage in Veszprém (Szakmány et al. 2001), and by more than 300 pieces found in an extensive assemblage of the Ebenhöch collection from the surroundings of Györ (Friedel et al. 2008).

Another distribution wave moved along the Elbe River through Saxony and perhaps as far as Harz (Schwarz-Mackenzen & Schneider 1983), Thuringia, northern Bavaria (Christensen et al. 2006, 2008) and Hessen (Ramminger 2007, 329).

Though it has not yet entered the Polish archaeological literature, according to our investigation of polished lithic assemblages deposited in Silesian musea (Racibórz, Opole, Katowice, Wrocław) it is evident that this tool stone has been identified in south-western and southern Poland (modern Silesia and Lesser Poland). Because of strong patination, the metabasite from Jizerské hory was often incorrectly described as phyllite – see for example synoptic data on used raw materials connected with the Linear Pottery culture in Polish Silesia (Cholewa 2004, 38–39). Godłowska et al. (1987) described polished stone tools from LBK and Lengyel sites around Kraków, Nowa Huta and Pleszów. All the axes and shoe-last adzes are dated to the Music-note phase of the Linear Pottery culture, and according to M. Pawlikowski (Godłowska et al. 1978, 138) they are made of amphibolite. It is the author's opinion that this stone, called usually greenschist or metabasite (or amphibolite) in the Czech Republic, can be compared to the Jizerské hory metabasite. Differences in rock terminology are compounded by classification problems in every country. Polish researchers emphasize that no "amphibolite" processing sites were found anywhere in Lesser Poland and that therefore the rocks arrived in the Cracow area as finished products. When the high number of Cracow-Częstochowa Jurassic silicites (largely variety A) in East-Bohemian Neolithic sites is accounted for, it is tempting to posit long-distance exchange. At the famous Neolitic settlement of Bylany for instance the Polish Jurassic silicite forms 46 % of the middle or later LBK phase (I. Pavlů and A. Přichystal in Přichystal 1985). Quality tool stone for the chipped industry from the Cracow area may have been exchanged for quality tool rock for the polished stone industry from Jizerské hory in northern Bohemia. The metabasite from Jizerské hory was easily accessible to farmers at Bylany and it is the dominant tool rock in that area.

III.1.1.2. Metabasite from Želešice (southern Moravia)

Background: Polished stone artefacts from this magnetite-rich raw material were described in the early 80's at more Moravian Painted Ware (Lengyel) sites in southern Moravia (Přichystal 1981, 1984). That is why the author has supposed its prehistoric quarrying to the west of Želešice village, where the Bobrava River flows through a metabasite body. The characteristics of this rock, obtained from the current Želešice quarry, caught the attention of J. Malina, who used it to experiment with polished stone tool production (Malina 1973).

Location: Želešice village is situated 10 km south of Brno near the road to Vienna. Metabasite rises up west of the village and in prehistory were easily accessed in the Bobrava River valley, where there are more outcrops. Currently, there is a modern open quarry in the metabasite on the left bank of the river (Fig. 20), and an old quarry on the right bank where the metabasite is thermally influenced by a granite of the Brno Batholith.

Geological Setting: The rock is a part of the metabasite zone of Brno Batholith. Within its western metadiorite strip bodies of ultramafic and ultrabasic rocks are also found. An extensive outcrop between Želešice, Nebovidy and Hajany is marked as hornblendite in the Geological map of Czechoslovakia in the scale 1 : 200 000, sheet Brno (Kalášek et al. 1963). However, detailed petrographic investigations have shown that the body underwent

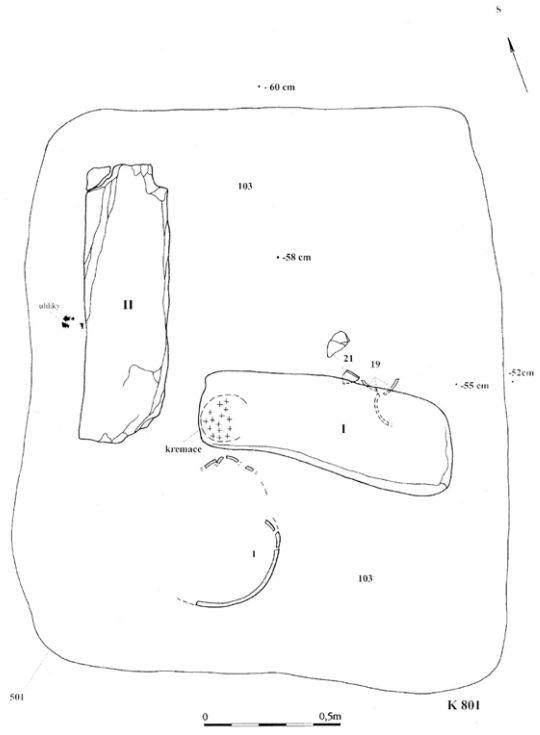

Fig. 99. Modřice-Sádky near Brno, excavation of P. Kos from the Institute for Archaeological Heritage Preservation in Brno, 2003. Unique stone stelae found at a cremated burial of the Horákov culture were made of the Želešice metabasite (II) and Tertiary algal limestone (I). In the both cases the raw materials were transported at a distance of a few kilometres.

regional metamorphosis and that the majority of rock has a significant plane-parallel structure, and a crystalloblastic texture prevails in thin sections. Gregerová et al. (1986, 109) defined the Želešice rock as fine-grained to compact amphibolite, epidote amphibolite and actinolite, chlorite-actinolite and chlorite greenschists.

Buriánek (2005) is the latest researcher to study the metamorphic evolution of local rock. The oldest Proterozoic metamorphosis corresponds to amphibolite facies (>5 kbar, 550–650°C). Afterward, the rock underwent contact metamorphosis because of granite intrusion of the Brno Batholith western part in the Late Proterozoic. During the Variscan orogeny the metabasite was intensively deformed and metamorphosed in the greenschist facies (ca 2 kbar, 450–530°C). General metamorphic development led to the formation of stone with characteristics suitable for producing polished stone tools.

Macroscopic Appearance: Rock used for polished stone tools is dusky green (5G 3/2) on a fresh cut and usually has visible metamorphic foliation. In comparison with metabasite from the Jizerské hory or Malé Karpaty Mts. (see below) they have markedly greener shade. The colour changes to a markedly brighter grey-green (10GY 5/2) after weathering. Whitish or darker green streaks or small veins are common, lengthened with foliation or situated perpendicularly. Sometimes it is possible to see larger magnetite crystals or pyrite with the naked eye (Supplement/Photo 260).

Stereomicroscopic Appearance: Alternating thin bright and dusky green streaks, which differ in the amount of feldspars and dark minerals, are visible on the patinated surface. Cubic or octahedron shaped brownish-black magnetite metacrystals are found up to 1 mm, with a metallic lustre (Supplement/Photo 265).

Thin Section: Texture of the rock is granonematoblastic to nematolepidoblastic. Occasional bright streaks are formed by xenomorphic feldspar, epidote, acicular amphibole, and sometimes quartz (Supplement /Photos 266, 267). Opaque magnetite developed into bigger crystals around which pressure shadows are created. The prevalent groundmass is built of very fine scaly chlorite, leucoxene and plentiful tiny partly crystallized opaque magnetite. Striated formations with more noticeable interference colours indicate the relics of amphiboles. These striated formations are sometimes finely folded. Through microprobe analyses it is possible to class the amphibole relics usually as magnesiohornblende. Acicular actinolite is common on their edges or in plagioclase rich streaks (see also Buriánek 2005, 84). In a roughout from Modřice, actinolite creates extensive sheaf accumulations up to 1 mm long. Feldspars include a wide range of plagioclases in the body from Želešice. They usually have an andesine to labradorite character, but albite and K-feldspar (on the younger small veins) were identified as well. The opaque mineral is a very pure magnetite containing up to 0.3% TiO_2 and about 0.4% V_2O_5 (Supplement/Photos 261, 262).

Other analyses: One of the most important characteristics of the Želešice tool rock is its high magnetic susceptibility, which was measured for the first time using kappameter KT-5 on polished artefacts from the Jevišovice culture site at Brno-Starý Lískovec (Přichystal 1994). The outcrops around the Bobrava River valley and in the new Želešice quarry were measured at 122 points. There was an average value of 45 x 10^{-3} SI with the dispersion from 10.1 to 80 x 10^{-3} SI. An extensive assemblage of semifinished products from manufacturing sites around Želešice provides similar results. Values for raw or semifinished products from Brno-Nový Lískovec ranged from 41 to 46 x 10^{-3} SI. As a consequence of the artefacts thinness from the site with Linear Pottery and Moravian Painted Ware in Brno-Holásky, the measured values of magnetic susceptibility of semifinished tools and raw material (10 to 35 x 10^{-3} SI SI) were partly lower comparing the data obtained on natural outcrops.

Prehistoric Use: Metabasite raw material from Želešice was widely used since the Old Neolithic in the Brno area, for example in the early Linear Pottery culture period Ia in Brno-Starý Lískovec and Brno-Holásky. It is widespread in the Moravian Painted Ware culture, with the expansion of Želešice raw material in the Brno area (inclusive of Brno-Holásky, Brno-Bystrc, Brno-Žebětín, Brno-Kníničky, Popůvky near Brna, and Střelice; see Supplement/Photo 263) across the Krumlovský les Highland (Jezeřany-Maršovice) to the modern Austrian border. The raw material is found in the Vyškov area (Opatovice) to the north-east, and on up to the Prostějov and Olomouc area (e.g. in the parts of Velký Kosíř Hill called Tři duby and Vápenice). The Želešice metabasite polished tools are also found in the inventory of the Jordanów (Drnovice and Radslavice, Vyškov district), Jevišovice (Brno-Starý Lískovec) and Bell Beaker cultures. The use of Želešice metabasite for stelae in the Hallstatt period is also remarkable (Supplement/Photo 264). Přichystal (2000) and Kuča & Vokáč (2008) published distribution data for this raw material. It is probable that the Želešice metabasite will be found at some Lengyel sites in Lower Austria. According to Friedel et al. (2008), 34 pieces of the Želešice metabasite were found in the Ebenhöch collection, which comes from the Györ area in north-west Hungary.

The find of stone stelae made from the Želešice metabasite (Fig. 99, Supplement/Photo 264) in a Horákov culture cremation (Hallstatt period) at Modřice-Sádky is very important (research of P. Kos from the Institute for Archaeological Heritage Preservation in Brno, 2003). As with the Krumlovský les chert, this find shows that Želešice metabasite was at the centre of prehistoric interest also in later periods, not only in the Neolithic and Eneolithic. Both mentioned prehistoric mining sites were probably conspicuous still in the Hallstatt period, perhaps delimited by stone monoliths (see finds of M. Oliva in the Krumlovský les mining area – Supplement /Photos 58, 59).

III.1.1.3. Greenschist from Felsöcsatár (western Hungary)

Background: During research into the provenance of actinolite greenschist tools found at the Bicske-Galagonyás Neolithic site, 30 km west of Budapest, Szakmány (1996,

226) started to suppose that Felsöcsatár greenschist could be used for Neolithic polished stone tools. Based on the distribution of rare earth elements and lithology, Nikl et al. (2002, 780) concluded that the stone artefact No. 30 from a Neolithic assemblage obtained in the Tolna district (southern Hungary) must have originated in Felsöcsatár (see sample No. 30, Nikl et al, 2002, 780).

Location: Felsöcsatár is located in western Hungary on the border of the Austrian Burgenland, 12 km west of the town of Szombathely. Other greenschist outcrops can be found near the village of Bozsok and the nearby town of Markt Neuhodis in Austria. From geomorphological point of view this area belongs to the Eastern Alps.

Geological Setting: Greenschist from Felsöcsatár and other nearby localities is a part of the Penninicum, the deepest tectonic element of the Central Eastern Alps. In the mentioned area it is represented by the Köszeg-Rechnitz tectonic window along the Austria-Hungary border being built from fragments of oceanic crust and deep-ocean sediments of Jurassic and Early Cretaceous age. The oldest Penninic rocks in Hungary are the Köszeg quartz phyllites lying under the Velem calcareous phyllites with lenses of the Cák metaconglomerates. These rocks are covered by the Felsöcsatár Greenschist Formation, representing remnants of an older ophiolite suite with a thickness more than 500 m (for more details see T. Szederkényi in Haas, ed., 2001, 30–33).

Macroscopic Appearance: The rock is greyish green on a fresh fracture (5G 5/2). Short but relatively thick whitish lenses over 1 cm long in the light greyish green groundmass are well visible on patinated tools as a characteristic sign. The lenses are extended along a conspicuous metamorphic foliation. The rock is aphanitic, so the individual minerals cannot be distinguished with the naked eye (Supplement/Photos 268, 269).

Thin Section: The greenschist has a mematoblastic texture (Nikl et al. 2002, 780). Apart from the dominant actinolite it contains albite, quartz, epidote and opaque minerals. In comparison to the above mentioned metabasites from the Bohemian Massif, the section at the disposal of the author has higher visible content of bright minerals (feldspars, quartz). S-shaped lenses with diagonally arranged feldspars and indications of pressure shadows were marked. Older amphibole from the original rock and ilmenite were distinguished in the thin section.

Other Analyses: Magnetic susceptibility is low compared other greenschist and metabasite, ranging from 0.2 to 0.4 x 10^{-3} SI, with a maximum at 1.07 x 10^{-3} SI. Contents of rare earth elements are low and their distribution curve normalized on chondrite is totally flat without enrichment with light REE.

Prehistoric Use: Hungarian researchers believe the Felsöcsatár raw material was used mostly for local production. In addition, its occurrence in polished stone tool assemblages doesn't exceed 10 % (G. Szakmány's verbal communication). The greenschist was also identified as isolated pieces at farther archaeological sites. It appears especially in Lengyel assemblages.

III.1.1.4. Metabasite from the Malé Karpaty Mts. (western Slovakia)

Background: When establishing the provenance of an extensive Neolithic assemblage of polished tools from northern Harz Foreland, German researchers Schwarz-Mackensen and Schneider (1983, 313) posited that metabasite from the Malé Karpaty (Little Carpathians) Mts. in Slovakia could be one of possible sources. However, current knowledge clearly supports the provenance in the prehistoric mining centres in the Jizerské hory Mts. in northern Bohemia. Hovorka and Cheben (1997, 216) believe the Pezinok-Pernek Group in the Malé Karpaty Mts. is the nearest possible source for polished artefacts from the Neolithic locality of Bajč (SW Slovakia). Raw material artefact research with a microprobe basically supports this theory (Méres at al. 2004), although traces of prehistoric mining in the Malé Karpaty Mts. have not yet been found.

Location: The Malé Karpaty mountain range represents the westernmost core mountains of the Western Carpathians, between Bratislava and Nové Mesto nad Váhom. Metabasite crops out in the southern part of the range between Pezinok and Pernek and north of the village of Modra.

Geological Setting: Variscan granite rocks that penetrated into Lower Palaeozoic rocks and thermally metamorphosed them form the core mountains Malé Karpaty. Basic volcanites and their volcaniclastics were also originally a part of the volcano-sedimentary sequence. Initially they were metamorphosed to amphibolite and greenschist and later underwent contact metamorphism in the area around the Bratislava granite and Modra granodiorite massifs. Their evolution is similar to the above-mentioned sources found in the Bohemian Massif, i.e. metabasites from Jizerské hory and Želešice. In the geological map of Malé Karpaty, scale 1 : 50 000 (Mahel & Cambel, 1972), these rocks are classified as fine to medium-grained amphibolite, coarse-grained and spotted amphibolite and amphibolic rock with a substantial presence of pyroclastic material.

Macroscopic Appearance: The rocks are dark grey-green on a fresh fracture. It is not possible to distinguish them from the Jizerské hory metabasite by colour. Spotted varieties are frequent with dark green 1–1.5 cm spots elongated with foliation at gabbroamphibolite or by contrast little whitish rectangular shaped spots (up to 2 mm) in crystaloclastic tuffs. Metamorphic foliation is always well developed (Supplement/Photo 270).

Thin Section: Méres et al. (2004) examined tool rock from the Bajč Neolithic site, thought to have originated in the Malé Karpaty Mts. They identified amphibole schist (Supplement/Phtoto 271), amphibole schist with antophyllite, phlogopite-antophyllite schist and antophyllite schist with spinel and corundum. They found zoned amphiboles with actinolite nuclei and boarders created by magnesiohornblende and tschermakite in amphibole schist. Clinozoisite appears in zoned amphiboles nucleus. Plagioclase is zoned as well, having An_{38} core and An_{56} rims. Quartz, Mg-chlorite, clinozoisite, phlogopite and opaque minerals can be present in amphibole schist with

antophylite. Light-sized needles up to 0.5 μm represent antophylite. Basicity of plagioclases varies in wide range (An_{2}-An_{98}). Cordierite was also identified in phlogopite-antophyllite schist. Plagioclase is represented by anorthite. Antophylite dominates in antophylite schist, green spinel and corundum is situated in places of what was likely originally orthopyroxene. Other minerals were identified as clinozoisite, phlogopite, Mg-chlorite, muscovite, quartz and opaque minerals. The plagioclase is practically pure anorthite (An_{99}).

Other Analyses: Magnetic susceptibility ranges from 0.3 to 0.55 x 10^{-3} SI, lower than the mentioned metabasites of the Bohemian Massif.

Prehistoric Use: At this time the tool rock has been described from the Middle Neolithic site at Bajč, south of Nové Zámky and about 90 km far from the source in the Malé Karpaty Mts.

III.1.1.5. Greenschist from Pyszczyńska Góra Mt. (SW Poland)

Background: Greenschist (amphibole schist) from Pyszczyńska Góra Mt. is supposed to be identified as the possible source used for polished stone tools found at the Neolithic site at Kostomłoty some 9 km north-east of the source (Wójcik & Sadowski 2006).

Location: Pyszczyńska Góra Mt. (273 m), sometimes also called Góra Byczyna, is located south of the Pyszczyn village, 36 km south-west of Wrocław, north-west of the Imbramowice railway station. Pyszczyńska Góra is a part of the Vzgórza Imbramowickie geomorphological unit which itself is within Przedgórze Sudeckie.

Geological Setting: Pyszczyńska Góra massif is formed by Lower Palaeozoic greenschists (Grocholski et al. 1969). They were affected by contact metamorphism with Late Variscan granodiorite of the Strzegom Massif, which crops out nearby. From that point of view small occurrences in the vicinity of Domanice would be ideal. According to a geological map greenschists to amphibolites are directly in contact with igneous granodiorite.

Macroscopic Appearance: The author collected samples of greenschist on the path from Imbramowice to Pyszczyńska Góra. The rock is non-calcareous and in comparison with metabasites from the Jizerské hory Mts. and Želešice, its colour is clearly lighter (pale green 10 G 6/2) and the rock is less compact. Magnetic susceptibility of samples from Imbramowice ranges from 0.4 to 0.65 x 10^{-3} SI.

Thin Section: According to H. Fabin (in Sokolowski et al., eds., 1968, 172) Pyszczyńska Góra greenschist consists of uralite, plagioclase relics, chlorite, epidote, prehnite, fibrous amphibole and titanite. Metamorphosis corresponds to epidote-amphibolite facies more than to classical greenschist facies. Reference samples taken by the author from nearby Imbramowice have in thin section a sharply different appearance to samples from the Jizerské hory Mts. The rock has an abundance of epidote and chlorite but needle amphiboles are missing.

Prehistoric Use: As mentioned above, Polish petrographers at the nearby Neolithic site at Kostomłoty expect the use of Pyszczyńska Góra greenschist. With the help of A. Wójcik the author was in a position to study thin sections of two polished artefacts (W/23/05 and W/52/05) from Kostomłoty, which were classified by Wójcik & Sadowski (2006) as amphibole-feldspar-quartz schist. The raw material has a granonematoblastic texture with an abundance of needle amphiboles of actinolite character when the texture is formed by sheaf to radial aggregates mostly arranged roughly parallel to foliation but also growing diagonally. Relics of older hornblendes with amphibole specific cleavage and sharp blue-green to light yellow-green pleochroism are preserved in the middle of these aggregates. Perpendicular needle-like amphiboles grow within quartz-feldspar lenses to strips, which protrude between the strips, rich in amphiboles. Accumulations of fine-grained opaque mineral, possibly ilmenite, are arranged parallel to the foliation. Feldspar is xenomorphic to hypidiomorphic with rare lamellae. Quartz is xenomorphic with undulatory extinction.

It is obvious that the Kostomłoty Neolithic tool raw material differs greatly from the Pyszczyńska Góra greenschist (epidote and prehnite are absent), as published by H. Fabin, and in comparison to the sample collected by the author. It seems probable they have been made of the thermally metamorphosed metabasite from Jizerské hory in northern Bohemia.

III.1.2. Amphibolites

General Characteristics: Amphibolite is a kind of metamorphic rock formed by common hornblende and plagioclase, with other minerals such as epidote, garnet, pyroxene, biotite, titanite and quartz. Plagioclase usually corresponds to oligoclase and andesine or even more calcium-rich feldspars. The rock is usually medium grained and may have a well-developed planar or linear alignment of elongate hornblende crystals, which is less clear with coarse-grained varieties. It originates by metamorphosis of basic extrusive or intrusive volcanic rocks, their tuffs or tuffites, respectively.

Fig. 100. Markovice near Čáslav, the Kutná Hora Crystalline Unit. Amphibolite quarry in the seventhies of the 20th century. The fine-grained amphibolite could be probably used for polished artefacts in prehistoric times. Archives of the author.

Background: Amphibolites represent rocks long associated with polished stone tools in the lands of the Czech Crown. Amphibolite used for a celt from Mařatice near Uherské Hradiště in Moravia was identified through petrographic thin section already in the 1880s (Klvaňa 1887). By the end of the 19th century amphibolite was being identified in Bohemian and Moravian stone tools by Matiegka (1894) and Niederle (1894). It ranks in first place in Niederle's list. Žebera (1955) thought amphibolite to be the diagnostic Neolithic tool stone. He posited that it represented some 90 % of Czech sites with the Linear Pottery, Stroke-ornamented Pottery and Jordanów cultures. He believed that flat pebbles from the area of middle and lower Sázava River was the source of raw material.

Natural Occurrences: Only some of the most important amphibolite occurrences in the Bohemian Massif, probably used as prehistoric sources, can be mentioned. A large area of amphibolite bodies is exposed by the Jihlava River in western Moravia between Moravský Krumlov and Jasenice, to the north of Náměšť nad Oslavou, with amphibolite cobbles in the river terrace gravels. Neolithic man also very probably extracted amphibolites found at Rehberg in Lower Austria. Fine-grained amphibolite from Markovice near Čáslav (Fig. 100) and amphibolite bodies in the central part of Hrubý Jeseník Mts. may also have been used.

Geological Setting: Amphibolite is plentiful in strongly metamorphosed crystalline units of the Bohemian Massif and Western Carpathians. In the first place it is necessary to mention the Varied Group of Moldanubicum in the Bohemian Massif, with natural outcrops in the Moravian, Strážek and Waldwiertel Moldanubicum. Amphibolite bodies are also widespread in the Český Krumlov and Chýnov – Ledeč belts of the Varied Group in the Bohemian Moldanubicum. In the Central Bohemian Region amphibolites crop out in its western part, i. e. in the Domažlice Crystalline Complex and the Mariánské Lázně Complex. To the east they are present in the Letovice Crystalline Unit. The Jeseník and Sobotín amphibolite massifs occur in the Silesicum. The Staré Město and Nové Město Crystalline Units fall into the main geological units with amphibolites in the Czech part of the Lugicum. In the Polish part of Bohemian Massif amphibolites protrude from the north-east slopes of the Ślęża Mt.

In the Central Western Carpathians they are present in crystalline parts of all main geological superunits – Tatricum, Veporicum, Gemericum. The largest amphibolite body in the area of Tatric core mountains is in the Branisko Mts., but smaller occurrences are found in all the others. Suitable amphibolite pebbles are common in the gravels of all the larger Slovakian rivers: the Danube, Váh, Hron and Nitra (Supplement/Photo 275).

Macroscopic Appearance: Typical amphibolites (i.e. from the Moldanubian Varied Group or from Tatric core mountains) are evidently grained, usually with full-grown metamorphic foliation. This may be absent in coarse-grained types and than they have a confining structure. Some are sharply striped with light strips rich in feldspar, and dark strips rich in amphibole (Supplement/Photo 272). The colour is dark green or spotted green-grey in coarse-grained types. Fine-grained varieties may be distinguished from greenschists only in thin sections under polarizing microscope, or even after feldspar microprobe analyses in some cases.

Fig. 101. Brno – Šlapanice, faceted battle-axe made of coarse-grained amphibolite. Length 20.6 cm, Corded Ware culture. Deposited in the Moravian museum in Brno. Archives of the author and L. Šebela.

Stereomicroscopic Appearance: Both main minerals, dark green elongated hornblende and whitish plagioclase can be seen, along with red garnet in garnet amphibolite types (Supplement/Photo 273).

Thin Section: Because of the wide variability the thin section description is generalized. The texture is usually granonematoblastic with elongated grains of amphibole (hornblende) that is pleochroic, green or green-brown. This mineral has a mostly hypidiomorphic or allotriomorphic shape and is arranged parallel to the foliation. Plagioclases have a largely andesine composition and are allotriomorphic. Garnet, pyroxene, biotite, epidote and others may be present. Small amounts of titanite, magnetite, ilmenite, pyrite, pyrrhotite, apatite, and rarely rutile and zircon are found.

Other analyses: Magnetic susceptibility is low and usually similar in spite of measuremenst at sources. Fine-grained Moldanubian amphibolite from the vicinity of Horn in Lower Austria (Supplement/Photo 274) has values from 0.32 to 0.56 x 10^{-3} SI. Cobbles of coarse-grained Moldanubian amphibolite from the Jihlava River gravel at Hrubšice are characterized by only slightly higher magnetic susceptibility at 0.37 to 0.42 x 10^{-3} SI. Rather higher values of 0.5 to 0.55 x 10^{-3} SI were obtained on amphibolite samples from the Letovice Crystalline Unit at Bohuňov. Amhibolite from the quarry at the village of Markovice near Čáslav fell from 0.44 to 0.5 x 10^{-3} SI. Amphibolite cobbles from the Váh River gravel near Pruské in western Slovakia had values from 0.31 to 0.33 x 10^{-3} SI. A potential amphibolite source in the Ślęża Massif, Polish Silesia (south-east of the Wieżica Mt.) had values of 0.5 to 0.7 x 10^{-3} SI. Sharply higher magnetic susceptibility

was measured only on amphibolite artefacts from the Linear Pottery culture site near Vedrovice, southern Moravia: part of a mace-head measured 2.15 x 10^{-3} SI and a modified cobble 1.87 to 2.0 x 10^{-3} SI. Amphibolites from the Sázava region, central Bohemia (outcrops at Samopše and Sázava) have a high magnetic susceptibility in the range of 1 to 4.6 x 10^{-3}SI.

Prehistoric use: In Moravia, used amphibolite cobbles are found in the cadastral part "Široká u lesa", a Linear Pottery culture settlement at Vedrovice (Znojmo district). They come from the gravel of the nearby Jihlava River that runs over several amphibolite bodies of the Moldanubian Varied Group. Amphibolite is found in a small amount at a number of locations with the Moravian Painted Ware culture (see Plaveč u Znojma; Štelcl 1967), especially those located near amphibolite bodies in western Moravia. Amphibolite appears also at some West-Moravian Eneolithic sites, for example at Hradisko near Křepice that corresponds chronologically with the Retz-Křepice group or the hillfort of Jevišovice culture „Na hrádku" near Lhánice (see Přichystal 2000). Dohnal (1971) described a perfectly worked Funnel Beaker axe hammer from Horní Ves near Fryšták, Zlín district, which was identified as made of amphibolite by mineralogist R. Sládek. This material is absolutely unusual in the setting of local Carpathian flysch deposits. Amphibolite (Fig. 101) is often used for axes and faceted axe hammers in Corded Ware culture assemblages in Moravia and Silesia (Přichystal & Šebela 1992). Brus (1987) arrived at the same conclusion when he processed the polished stone industry of this culture from the area of Lomský brook in the Krušné hory Piedmont Basin, NW Bohemia.

Hovorka & Illášová (2002, 127–128) identified schistose and massive amphibolites as the tool rock used for different Neolithic and Eneolithic axes in Slovakia. They described an amphibolite artefact from Nitranský Hrádek-Zámeček in concrete. In general they supposed that the stone for these tools originated from the gravels of Slovak rivers.

According to Wójcik et al. (2000) amphibolites from Lower Silesia (southern Poland) form the bulk of tool rocks used for polished artefacts (56%) in Neolithic cultures during the Danubian period. The authors presume that the source is partly amphibolite from the Ślęża Massif, with some having origin from local erratic's. The rock source of 49 artefacts has not been found but A. Přichystal's view is that they are metabasites, formed by contact metamorphism, and likely originate from within the territory of the Czech Republic (Jizerské hory).

III.1.3. Metabasites generally

General Characteristics: The raw materials used for dark polished lithic tools are often identified through macroscopic study only as metamorphosed basic rocks (metabasites). If they still have relic forms of primary basic volcanic or volcaniclastic rock, the author prefers to call them also as metabasites. Rocks with full-grown metamorphic foliation are found as well. Microprobe analyses show that rocks believed to be greenschists on the basis of previous thin section studies under the polarizing microscope, do not have a typical greenschist plagioclase composition (i. e. albite). Specialists are not uniform in the classification of these tool rocks (see discussion about classification of different types of greenschist or fine-grained amphibolite). It is possible to avoid this problem with the use of the term metabasite generally (similar to the use of "silicite" for the raw material of chipped artefacts) and put in concrete terms adding the name of source (e.g. Jizerské hory metabasite).

Prehistoric Use: Metabasites generally are the most frequently used tool rocks in the Early Neolithic. They are also found in the Late Neolithic, as a proof of a link with earlier periods and a proof of the knowledge of old Neolithic mining centres. A typical sample of a metabasite artefact, is the semifinished axe found in Podstránská Street, Brno, made of a metabasite from the Brno Batholith (Přichystal 1984).

III.1.4. Serpentinites

General Characteristics: Serpentinite, from the Latin "serpens" (snake), is linked to the fact that some varieties resemble the colour of snake skin, or to the superstition about use of the rock as a snake bite antidote. It is a metamorphic rock of ultrabasic composition formed by minerals from the serpentine group (antigorite, chrysotile). It can contain other minerals, such as relics of the original igneous rock (olivine, pyroxene, amphibole, phlogopite, garnet) as well as other newly formed minerals (chlorites, opal, chalcedony, magnesite).

Background: Serpentinite was among the rocks favoured for drilled and polished stone tools, especially during the Eneolithic. It is amongst the first stones identified in the second half of the 19th century with the prehistoric manufacture of axe hammers within the area of present day Czech Republic (Matiegka 1894, 279). „Serpentine" hammer from "Čechy in Moravia" (now known as Čechy pod Kosířem, district of Prostějov, central Moravia) was a part of the collection of the Museum of the Czech Kingdom in Prague as early as 1857 (Hlavatý 1857, 185). This rock was often called serpentine in early petrographic research, but that term is now used only for the mineral (respectively the group of secondary minerals).

Geological Setting: In western Moravia, serpentinites crop out in the Moldanubian Varied Group. The largest occurrences are represented by the Mohelno and Hrubšice Massifs, an array of smaller serpentinite bodies in the Gföhl orthogneis in the vicinity of Jevišovice, and the body near Hrotovice. Most of these bodies are strongly impacted tectonically and their rocks are usually disintegrated to small pieces and unsuited to polished stone tool production. Serpentinized garnet peridotites are well-known in the Moldanubian zone of southern Bohemia in the area of Křemže south-west of České Budějovice. Tiny bodies have also been identified in the Kutná Hora Crystalline Unit (Kutná Hora, Malešov, Bečváry, Bořetice, Mladotice) and Zábřeh Crystalline Unit. Significant occurrences of

serpentinite are found near the Lugian-Moldanubian overthrust on the Moravian-Silesian Region in the Letovice and Staré Město Crystalline Units (eastern border of the Bohemian and Lusatian Regions). Some high quality examples are used as gravestones and for souvenirs (Skorošice). Additional potential serpentinite sources for prehistoric tools are found in the north-western Bohemia: Mnichov serpentinite within the metabasite complex at Mariánské Lázně and the tiny body of effloresced serpentinite further along, at the western foot of Doupov Mts., near the village of Lučina, are high quality sources.

In the north-eastern border of the Bohemian Massif, within the Lusatian area in Poland, there are three extensive serpentinite massifs: Gogolów-Jordanów (south of the town of Sobótka), Sklary and Braszowice-Brzeźnica. Serpentinite of the Gogolów-Jordanów Massif was beyond all doubt extensively exploited in prehistory.

In the Saxothuringian Region on the German (Saxon) side there is a body of excellent quality near Zöblitz.

Serpentinite in the Central Western Carpathians is mainly found in small bodies, and appears in hard to reach areas of the Slovak Ore Mts. For these reasons Slovak researchers look outside of Slovakia for tool stone sources for serpentinite artefacts found in Slovakia. They focus on the eastern border of the Bohemian Massif (Hovorka & Illášová 2002, 130). Easily processed serpentinite also crops out near Bernstein, in Burgenland, Austria, along the last spurs of the Eastern Alps above the Little Alföld (Kisalföld).

Macroscopic Appearance: Though metamorphic rocks, serpentinites usually have only slightly developed metamorphic foliation and even frequently confining structure. Fresh cut they are black-green or dusky green. High quality varieties are sometimes translucent in thin edge chips. However, artefacts made of them, especially those related to the Corded Ware culture, succumbed to intensive patination and are found in bright green, greenish white-grey or bluish white-grey. The original black-green colour is found only on damaged places. The surface of such patinated tools is usually high gloss, in which dark patches or veining are visible, or with several millimetre deep abrasions. The presence of chrysotile veins with their characteristic lustre and filamentous structure is a typical feature especially of such patinated artefacts. Unfortunately, these are usually rare.

Thin Section: Because these rocks were formed by serpentinization of ultrabasic precursors rich in olivine, secondary minerals from the serpentine group (such as, antigorite, lizardite, chrysotile) are dominant. They are ordered in a characteristic lattice-like or looped texture. Alongside these minerals it is possible to find relics of the original minerals, such as rhombic and monoclinic pyroxenes, amphiboles, and sometimes olivine. Their original phenocrysts are often accompanied by opaque minerals, especially magnetite or its decay products. A high magnetic susceptibility is therefore characteristic for serpentinite, usually in the range of 25 to 70 x 10^{-3}.

Spinel and garnet can occur as well. Minerals associated with the process of serpentinization or other alterations such as carbonates (especially magnesite), SiO_2 (chalcedony or opal) and vermiculite are also found.

Prehistoric Use: The Savignano sul Panaro Venus (near Modena, Emilia, Italy) is a unique Upper Palaeolithic female sculpture probably made of serpentinite (Böhm et al. 1950) or a stone similar to steatite (Mussi 2002, 263). Neolithic polished lithic artefacts made of serpentinite are rare, but occur as early as the Linear Pottery culture in the eastern part of Central Europe (e. g. Bylany). They include disc-like, circular and a two shouldered maceheads, and are assumed to have had meaning beyond their obvious working function. Vokáč (2008, 168) has gathered data about such Early Neolithic artefacts in SW Moravia. Mass use of serpentinite appears only during the Eneolithic for perforated polished stone tools. These are associated with the Corded Ware culture, whose graves in Moravia and Silesia are found to commonly contain serpentinite axe hammers, the raw material for which came mainly from prehistoric extraction pits in the Gogolów-Jordanów Massif, in southern Poland. Altogether twenty two Neolithic and Eneolithic serpentinite artefacts had been found in the western part of the central Silesia (Skoczylas et al. 2000). The authors have supposed the raw material coming from the Gogolów-Jordanów serpentinite Massif. All obtained results (Přichystal & Šebela 1992, 34) have shown that the main stream of distribution ran along the Odra River across Upper Silesia, to the Moravian Gateway, and on into Moravia. One hundred and thirteen serpentinite battleaxes were identified within this study of Corded Ware polished stone artefacts.

The serpentinite sources, whose prehistoric use is proven, or which are potential sources due to their tool stone quality, are described in detail in the following chapters.

III.1.4.1. Mnichov serpentinite (western Bohemia)

Background: This is one of only a few Czech serpentinite with small tectonic influence and as a result has been used for the production of art and souvenirs since the 19th century. The first Czech serpentinite grinding and processing facility was popularised by many famous visitors such as the Austrian Emperor and his wife in 1835, and the Bavarian and Greek kings, and Prussian crown prince a year later (Rybařík 1993). By the turn of the 19th and 20th centuries it is thought that about 30 m^3 of stone had been quarried including blocks of up to 2 x 1.5 x 1 m. Columns, cover plates, window sills and gravestones were made from this serpentinite.

Location: Mnichov (previous known in German as Einsiedl) is situated 9 km north-east from Mariánské Lázně in western Bohemia. The main quarry was situated at the south-east foot of Planý Hill about 800 m ESE from the spot height 861 m (a part called "V Boru" or formerly "Auf der Heide") or 500 m WNW of the closed Schöppl Mill. The Planý Hill state nature reserve was opened here in 1966. The entire excavation site lies in the protected zone within the Slavkovský les Highland.

Geological Setting: Serpentinite from Mnichov falls within the Mariánské Lázně Metabasite Complex, one

of the biggest concentrations of this rock type in the Bohemian Massif. Radiometric data support Cambrian age. The serpentinite body is a 1.3 km wide lens that runs 4 km on the south-west to north-east axis, between Vlček (Wolfstein, 833 m) and Pluhový bor (Pflugheide, 758 m). Serpentinites also occur to the NE of Mariánské Lázně and forms a belt running south of the village of Prameny, north of Sitiny and Mnichov, to Nová ves.

Macroscopic Appearance: Serpentinite has a few varieties in its appearance. It is usually dusky-green or black, although, dark-brown, brown-green or even bright-green colours are found. Its attractive appearance is caused by the presence of brighter green to whitish veins or patches, as well as, dark to black grains in the fine-grained green matrix.

Thin Section: The author has not had the opportunity to examine the Mnichov serpentinite in thin section. Fiala (1958, 33–34) described thin sections of serpentinites from nearby Prameny. They originated largely from dunite peridotites, comprised of the aggregates of fine-scaly antigorite, interlaced with veins and secretion of black ore pigment (magnetite and chromite). Ore minerals follow the edges of the original olivine grains or fill cleavage breaches. In some places pseudomorphs after olivine have been filled by a combination of serpentine group minerals, and chlorite. Green isotropic spinel and tiny rutile grains are also found, along with relics of altered pyroxenes and accumulations of steatite flakes.

Other Analyses: Magnetic susceptibility measured by the author using a portable kappameter KT – 6 on serpentinite outcrops along the Mnichov Nature Trial range from 24 to 55 x 10^{-3} SI. There is also great variation in physical characteristics, such as specific and volume gravity, absorbability, strength in tensile load, flexion or grindability (Rybařík 1993).

Prehistoric Use: Prehistoric use of this rock for polished tools has not been determined with certainty but is thought likely. The wide range of ground stone objects made from Mnichov serpentinite (also called "Edelserpentinite") during the 18th and 19th century evidence suitability. Additional examples of the use of this serpentinite include parts of the lateral altars in the Teplá Monastery Church, gravestones in the Vienna central cemetery, balusters of the main stair of the former Hypoteční Bank on Senovážná Square in Prague, and the more than 1 m high font in the Saint Petr and Pavel Church in Mnichov (for more details see Rybařík 1993).

III.1.4.2. Serpentinites from the Blanský les Mountains (southern Bohemia)

General Overview: Serpentinites lie in the Český Krumlov belt of Varied Group within the Moldanubian Region, and have been found in the Křemže area. They usually form small bodies, ranging from several to several dozen meters in length, only in the vicinity of Křemže they can be up to hundreds of meters long.

Prehistoric use: Poláček (1966, 27–28) recorded finding a serpentinite axe, eleven miniature axes and axe hammer with primitive borehole at the Bronze Age settlement at Dívčí Kámen, near the town of Český Krumlov. He assumed the miniatures were toys for boys, or beginner attempts at tool making. Although no petrographic analyses was conducted, it is almost certain that the raw material came from the vicinity, as the closest serpentinite bodies crop up only 1 km in west at the village of Holubov.

III.1.4.3. Serpentinite from the Jańska Góra Hill and the Gogolów-Jordanów Massif (Lower Silesia, southern Poland)

Background: Lower Silesian serpentinites found in the vicinity of Ślęża Mt. (or the town of Sobótka) were registered as raw materials for polished stone tools as early as the last quarter of 19th century. Typical axe hammers connected with the Corded Ware culture and made usually of serpentinite have been labelled even "Ślęża" and later also as "Sobótka"-type tools. A. Majerowicz conducted a modern petrographic analysis of serpentinite artefacts in Lower Silesia (e.g. Majerowicz et al. 2000); Wojciechowski (1983) published archaeological evidence about the prehistoric serpentinite mining at the Jańska Góra Hill.

Location: Jańska Góra Hill (253 m) is the highest point of the Wzgórze Łagiewnickie geomorphological unit and it lies 5 km NNW of Łagiewniki, and 4.5 km SSW of Jordanów Śląski. It is within the Ślężanski Park Krajobrazowy protected landscape in the vicinity of Ślęża Massif. The Jańska Góra Mt. is clearly visible from the Kłodsko to Wroclaw road because there are the ruins of so called Bismarck's Tower, actually a 19th century view-tower at its peak (Supplement/Photo 279). The hill appears only as a gentle inconspicuous elevation within the landscape because of the nearby three peaks of Ślęża massif: Ślęża at 718 m, Radunia at 573 m and Wieżyca at 415 m.

Geological Setting: The Gogolów-Jordanów serpentinite Massif is the lower member of the Ślęża ophiolite complex and includes amphibolite and metagabbro besides serpentinite. Amphibolite forms the north-eastern part of the massif, and metagabbro the basement of the

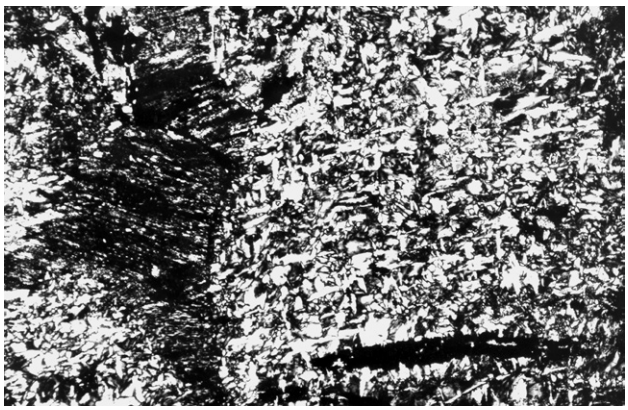

Fig. 102. Antigorite serpentinite with typical lattice texture of the groundmass and a relic of probably diallage phenocryst. Its cleveage is accentuated by opaque magnetite. Thin section, crossed polars, real dimensions of the picture are 2 x 1.3 mm. Battle-axe of the Corded Ware culture, Museum Prostějov. Photo by the author.

peak and south-eastern slope. Isotopic data indicate that the ophiolite complex is of Lower Palaeozoic age. From the regional geology viewpoint, the complex rises up in the eastern vicinity of the Sowie Góry Mt. gneiss block together with two other Lower Silesian serpentinite massifs: the Szklary and Braszowice-Brzeźnica serpentinite Massifs.

Macroscopic Appearance: It is possible to pick up samples of serpentinite in the fields on Jańska Góra Hill (Supplement/Photo 280). They appear as strongly weathered greenish white-grey fragments with limonitic patches. The rock structure is usually confining and tiny depressions coloured with limonite are usual on its surfaces. A high quality serpentinite crops out in the nearby nephrite quarry at Jordanów. It is patchy apple green-black-green and the arrangement of the dark streaks indicates metamorphic foliation. Magnetite grains sometimes shine with a metallic lustre in fresh fractures. Smooth planes as a consequence of tectonic movement are common. The hardness ranges between H 3 and 4 on Mohs' scale.

Stereomicroscopic Appearance: Relics of black-green minerals up to 0.5 cm with the characteristic pyroxene cleavage occur in the fine-scaled apple green matrix. Sometimes only tiny depressions are left after the relics, in which the grains of ore mineral have accumulated.

Thin Section: Petrographer A. Majerowicz (in Wojciechowski 1983) described eight serpentinite thin sections from the Jańska Góra Hill. Lepidoblastic and occasionally lepido-nematoblastic textures are typical. Antigorite is the prevalent mineral, appearing in the form of flakes and scales, which create irregular or lattice-like accumulated aggregates (Fig. 102). Thin chrysotile veins intersect the serpentinite. Sometimes, chrysotile aggregates create pseudomorphoses after diallage. In some pseudomorphoses, filled by isotropic groundmass, the fissile breaches of the original diallage are obvious. Compounds of iron, especially magnetite, highlight the appearance of the cleavage breaches. Tiny accumulations of Mg-chlorite (sheridanite) occur between flakes and tiny lenses of the serpentine group minerals. Large antigorite leaves have filled samples with more pseudomorphoses after diallage. Aggregates of carbonates, which are gathered in the veins and streaks, appear along the cleavage breaches of diallage in these samples. Carbonates also substitute chryzotile in some veins. Chromespinel is common in these samples. A. Majerowicz identified these rocks as antigorite serpentinites or serpentinites with carbonates. The process of serpentinization had been irregular in the Gogolów-Jordanów Massif, and minerals such are olivine, pyroxene and tremolite of the original rocks (various types of perioditite) had been preserved in some places.

Other Analyses: Natural serpentinite fragments from the Jańska Góra Hill, approximately as large as an axe hammer, were measured for magnetic susceptibility by the author using a portable KT-5 kappameter. Values ranged from 25 to 28 x 10^{-3} SI. Across the entire Gogolów-Jordanów massif magnetic susceptibility varies considerably, depending on the degree of serpentinization and weathering. The average value for serpentinite in Jordanów nephrite quarry is around 55 x 10^{-3} SI with dispersion from 40.3 to 64.9 x 10^{-3} SI. On the other hand, in Trzebnik, values ranged only from 17.4 to 28.7 x 10^{-3} SI, with an average of 25 x 10^{-3} SI. Přichystal & Gunia (2001) evaluated the magnetic susceptibility of serpentinites on the eastern boundary of the Sovie Góry block.

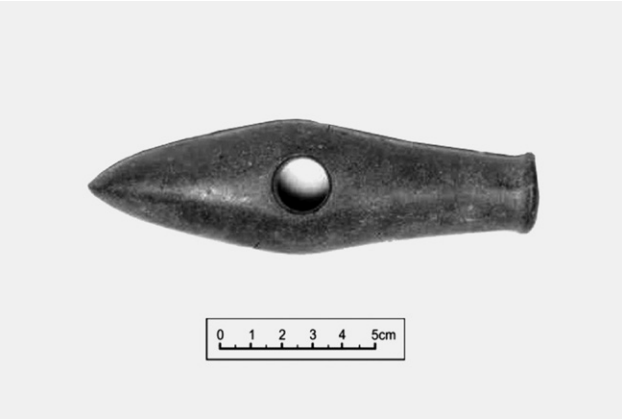

Fig. 103. Serpentinite battle-axe of the Ślęża type from Němetice, district of Vsetín. Length 14.6 cm, Corded Ware culture. Museum Olomouc. Archives of the author and L. Šebela.

Prehistoric Use: W. Wojciechowski, in cooperation with A. Majerowicz, studied the raw materials of typical Ślęża-type battleaxes and several varieties. They confirmed serpentinite as the most commonly used tool rock (Wojciechowski 1988). In a study of 670 Silesian Neolithic stone tools (polished artefacts and other industry), serpentinite (124 pieces) ranks as the most popular tool stone. Forty-nine pieces are affiliated with the Corded Ware culture. Přichystal & Šebela (1992) and Přichystal in Šebela (1999) conducted comprehensive analysis in Moravia and Czech Silesia. They described 113 serpentinite artefacts (mainly Ślęża-type battleaxe) imported into Moravia during the Corded Ware culture period, whose raw materials came prevalently from the Gogolów-Jordanów Massif (Fig. 103; Supplement/Photo 276).

Wojciechowski (1983, 1995) attributed the prehistoric quarrying of serpentinite from Jańska Góra Hill (the eastern part of the Gogolów-Jordanów Massif) to the late Funnel Beaker culture. The archaeological finds from this period are concentrated in the 10 to 15 km area around Ślęża. Considering the significantly higher number of Moravian Corded Ware period axe hammers made from local serpentinite, a significant increase in mining must be considered. The only nephrite source exists in the eastern part of Central Europe in the nearby Jordanów Śląski quarry and serpentinites from the quarry or its vicinity could serve as a suitable source. Aside from artefacts connected to the Corded Ware and Funnel Beaker cultures, Skoczylas et al. (2000) assert that serpentinite from the Gogolów-Jordanów Massif is the tool stone used for flat axes as early as the Danubian cultures that are found in Upper Silesia and the western part of the central Poland.

III.1.4.4. Serpentinite from Bernstein (Burgenland, Austria)

Background: According to data in the Felsenmuseum Bernstein, the local "Edelserpentine" (precious serpentinite) was mentioned for the first time in 1802. It has been used for producing decorative objects since 1860. It is also called "Burgenländische Jade" because of its beauty. The village has been named for an amber trade route that passed nearby in the Middle Ages.

Location: The village of Bernstein (619 m) is located 13 km NNE of Oberwart, the administrative centre of central Burgenland, 16 km west of the Hungarian border. Geomorphologically, it is situated on the northwest foothills of the Günser Gebirge Mts., which are partially in Hungary. In the village you can find a museum of mining history, minerals and things made of local serpentinite (Supplement/Photo 283) and amber as well. The museum is partly situated inside a mine tunnel.

Geological Setting: The local serpentinite body is a part of Penninic tectonic window, named after Bernstein. The Penninicum represents the deepest element of the Central Eastern Alps and occurs beneath the Austroalpine nappes (Unterostalpin).

Macroscopic Appearance: Common serpentinite is non-translucent and dark green (5G 3/2) with eye-catching split facet of pyroxene relics up to cm (Supplement/Photo 281).

The ratio of "Edelserpentine" to common serpentinite is 1 m^3 to 1000 m^3 (information in Felsenmuseum Bernstein). When wet it appears water-green to apple green (10G 6/2) and well translucent on its edges. "Edelserpentine" is rather soft (2– 3 Mohs) and greasy to the touch (Supplement/Photo 282).

Thin Section: Koller (1985, 87) provides a clear microscopic description of serpentinites (ultramafic rocks) from the Penninicum on the eastern border of the Alps. According to x-ray determination, lizardite and chrysotile, minerals from the serpentine group form the groundmass. Pyroxene relics, chlorite, tremolite and talc as well as chromite, magnetite and pyrite may be also present in the groundmass.

Other Analyses: Magnetic susceptibility of common Bernstein serpentinite has values from 16 to 30 x 10^{-3} SI, the decorative variety ("Edelserpentin") is 100 times lower at 0.24 x 10^{-3} SI.

Prehistoric use: An assemblage of 95 polished stone tools from the Thury György museum in the town of Nagykanisza (Zala region, south-western Hungary) contains 40 serpentinite pieces. Petrographic analysis was not conducted, but K.T. Biró identified the stone as serpentinite macroscopically (Biró & Szakmány 2000, 27). There is no doubt that the raw material was brought to Hungary, and one of possible sources could be Bernstein, which lies about 70–140 km away as the crow flies. But the mentioned authors also suppose that part of serpentinite artefacts comes from Slavonia (eastern Croatia). In the archaeological study of Miháldy's assemblage of polished tools at the Veszprém museum, Horváth (2001) has mentioned: "The serpentinite open-pit in Bernstein was used to produce axes". Support for this claim is absent and the museum in Bernstein has no proof of prehistoric mining. According to the museum exposition, the prehistoric settlement at Bernstein did not proceed the Roman period (Noric-Pannonian tumuli burials, 1st to early 3rd century AC). The author of this book saw a small private collection of polished stone tools at Bernstein Castle, including half-finished products. This could be a proof of Neolithic or Eneolithic settlement of the area and probably also the processing of local serpentinite though, unfortunately, there has not yet been an opportunity to study these artefacts in detail.

III.I.5. Jadeitite

General Characteristics: This attractive rock ranks among the most remarkable raw materials used for polished stone artefacts. Due to its macroscopic appearance that is similar to nephrite, the two are often confused, especially in popular literature, and the both are called "jade" in English and commercially. However they differ in petrography and genesis, and each is unambiguously defined by its mineralogical composition. Jadeite is an alkaline pyroxene and the rock composed of it predominantly is called jadeitite, while nephrite is mostly fibrous amphibolite, usually actinolite (tremolite). They also differ in their occurrence.

Background: In central Europe the provenance of jadeitite and nephrite polished stone tools (called "jadeite" in older literature) led to an extensive discussion in the second half of the 19th century, in which Moravian researchers play a significant part. In the first place it is necessary to mention Maška (1885), also J. Palliardi was active in the debate and the state of knowledge at the time was summarized by Červinka (1898). He concluded that the eight "jadeite" tools found in Moravia often have relics of pebble surface and they originated prevalently in riverbeds. He believed it was not possible that they could have been transported from as far away as western Switzerland or France. He sought a "jadeite" source in the Bohemian Massif, and especially in western Moravia. He did concede that only the source of nephrite was in the Eastern Alps where nephrite artefacts and natural pebbles had been found at that time.

The problem of provenance was taken up again by Skutil (1946). He reported already eighteen "jadeite" axes in Moravia, but only some of them were reliably identified by A. Arzruni or F. Berwerth in thin sections, and some identified as chloromelanite or jadeite only by naked eye. J. Skutil erroneously grouped "jadeite" axes together with nephrite artefacts and than wrongly concluded that the entire assemblage came from Polish Silesia where the only known source of nephrite (but not jadeitite) was found in Central Europe at the village of Jordanów (Jordansmühl, see Traube 1885). Jordanów lies about 35 km SSW of Wrocław.

Recent studies of jadeitite artefacts from western Slovakia include an axe from Sobotiště (Hovorka et al. 1998) and two fragments from a rondel near Golianovo

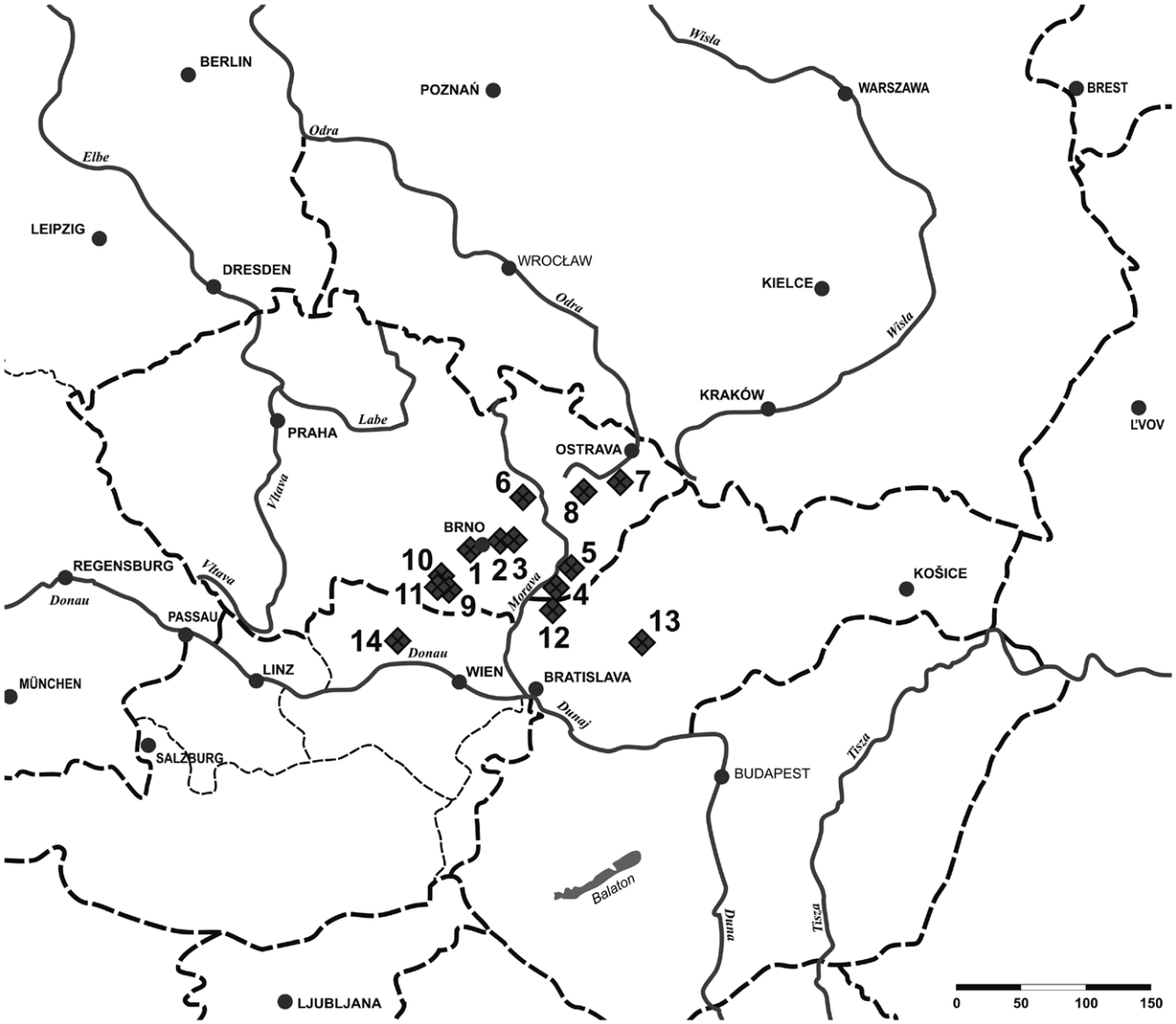

Fig. 104. Finds of jadeitite axes in eastern Central Europe (until 2009). Moravia: 1 – Brno-Žebětín, 2 – Brno-Líšeň, 3 – Tvarožná near Brno, 4 – Tvarožná Lhota SE of Strážnice, 5 – Jarošov NE of Uherského Hradiště, 6 – Pěnčín NW of Prostějov, 7 – Příbor NE of Nový Jičín, 8 – Velká near Hranice, 9 – Hodonice E of Znojmo, 10 – Křepice N of Znojmo, 11 – Hluboké Mašůvky; Slovakia: 12 – Sobotiště N of Senica, 13 – Golianovo near Nitra; Lower Austria: 14 – Kamegg near Gars am Kamp.

(Hovorka et al. 2006). They are connected with the Lengyel culture. Přichystal & Trnka (2001) identified the first jadeitite axe from Lower Austria only at the beginning of 21st century (Fig. 104). Pétrequin et al. (2010) confirmed the raw material determination and classified it more precisely as omphacitite from the Monviso area in the Western Alps. Jadeitite artefacts from Bohemia and Poland have not yet been reliably identified.

Location: There are no known sources of jadeitite in eastern Central Europe. The nearest ones are found in the Western Alps (the Beigua Massif, Liguria, and the Monviso Mt., Piemonte, north-western Italy). The area of Beigua Massif with 18,000 ha area became the "Beigua Regional Nature Park" in 1995, and is the largest regional park in Liguria. It lies between Genova and Savona and its southern promontory runs to the Liguria coast. Since 1993 especially C. D'Amico published several papers on the source and polished stone tools in northern Italy (D'Amico 1993, D'Amico et al. 1995, D'Amico & Starnini 2000).

The most important European source used in prehistory was found by French archaeologists P. Pétrequin and A. M. Pétrequin in May 2003 (large Neolithic extraction and working areas; Pétrequin et al. 2009, 6; Pétrequin et al. 2011, 245) and is situated on the slopes of the Monviso Mt. (also Monte Viso, 3843 m), the highest mountain of the Cottian Alps forming the border of France and the Piemonte Region of Italy. Five primary sources were mined at altitudes of 1,700–2,400 m during the Neolithic, including Barant, Alpetto-Murel, Bulë, Milanase and Porco (Pétrequin et al. 2007, Pétrequine et al. 2012). Secondary sources are also important. They are blocks that form

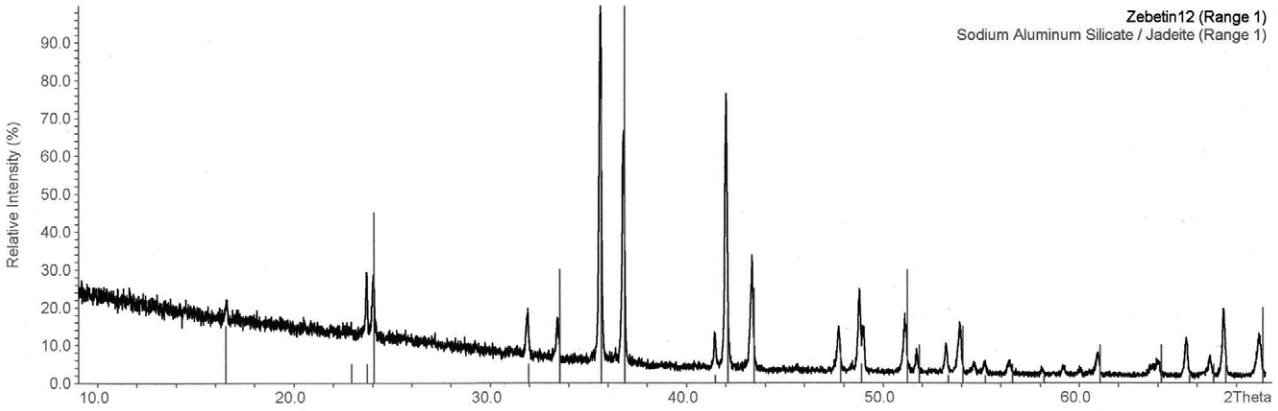

Fig. 105. X-ray recording of the jadeitite axe from Brno-Žebětín, Moravian Painted Ware culture. Determination by V. Vávra, Institute of Geological Sciences, Masaryk University in Brno.

part of moraine sediments of local mountain glaciation, or from boulder gravels of the upper Po River valley. The Po River spring is on the north-eastern slope of Monviso. According to Compagnoni et al. (2011, 334), the area is also well known to Italian mineral collectors since the summer 2002.

Geological Setting: Alpine-type ophiolite formed by a complex of metamorphic ultrabasic and basic rocks such as serpentinite, metagabbro, eclogite and jadeitite (the Voltri Group) crops out in the Beigua Massif. Oligocene trangressive conglomerates with numerous large pebbles of parent rocks (Supplement/Photo 284, 285) lie on top. It is expected that jadeitite for use as tool stone was acquired mostly from disintegrated conglomerates. Both half-finished polished stones and complete axes are found around conglomerate outcrops in the Sassello – Palo area. Jadeitites together with omphacitite, eclogite, serpentinite and gabbro are a part of the local meta-ophiolite group in the Monviso Massif as well. The Monviso meta-ophiolite complex is one of the largest in the Western Alps, a north-south trending body, 35 km long and up to 8 km wide (Compagnoni et al. 2011, 334).

Macroscopic Appearance: Colour of jadeitite axes can vary widely. The axe from Sobotiště in western Slovakia is light grass green. It has a fully polished surface with a high lustre in which small (1–1.5 mm) isometric crimps are distinguishable. The jadeitite axe from Kameg in Lower Austria is made of dark green (5G 3/2) aphanitic rock. Schmidt & Štelcl (1971) described the assemblage of eight Moravian jadeitite tools as rocks with different green tones (black-green to light green-grey), sometimes with yellow or brown shade. A newly found axe from Silůvky (15 km SW of Brno; Přichystal et al. 2011) is spotted yellowish grey-green (5G 7/2). The structures are confining and only the artefact from Pěnčín has a not too distinct plane-parallel structure.

Thin Section: Microscopic examination of Moravian jadeitite tools was conducted by Schmidt & Štelcl (1971) and Štelcl et al. (1973). The rocks are almost monomineral and compossed of colorless or light yellowish pyroxene. Titanite, zircon, opaque minerals and rarely epidote are present as accessories. Supplement/Photo 287 shows jadeite grains in thin section of newly found jadeitite axe from Brno-Žebětín.

Jadeitite axe from the Lengyel site at Kamegg is the first documented find of its type in Lower Austria (Přichystal & Trnka 2001). The rock is almost monomineral as well. Colourless, usually allotriomorphic pyroxene dominates. Sometimes it has a short columnar form elongated parallel to foliation. Its extinction angle ranges between 32–36°. Characteristic pyroxene cleavages or a zonal texture with a darker nucleus was observed in some grains. Microprobe analyses showed that the dominant pyroxene has a composition with about 13 to 15 % Na_2O and 2 to 3 % CaO. A high total iron content occurs in Fe-jadeites. A smaller portion of pyroxenes corresponds to omphacite or a mix between omphacite and jadeite. Allanite, zircon, rutile, and some rare xenotime were found as well (Supplement/Photo 286).

The mineral composition of jadeitite artefacts from northern Italy were investigated and reported on several occasions (e.g. D'Amico & Starnini 2000, 13–15). Petrographic characteristics of jadeitite and quartz-jadeitite rock from the Monviso meta-ophiolite has been described by Compagnoni et al. (2011).

Other Analyses: Jadeitite axe from Kameg has a very low magnetic susceptibility at about 0.14 x 10^{-3} SI. In 2001 the author measured for comparison artefacts from Sammardenchia using portable kappameter KT-6 (for more detailed archaeological data see Ferrari & Pessina, eds. 1999) or from Trentino in north Italy which were defined by C. D'Amico as jadeitites or Fe-jadeitites:

SAM 77/ 225 235, jadeitite: 0.10–0.12 x 10^{-3} SI;

SAM 103/1/463 270, jadeitite: 0.21–0.24 x 10^{-3} SI;

SAM 105/463 271, Fe-jadeitite: 0.35–0.48 x 10^{-3} SI;

MTSN 2451, Fe-jadeitite, Fe-jadeit >omphacite: 0.07–0.11 x 10^{-3} SI;

TN 1006, Fe-jadeitite: 0.25–0.28 x 10^{-3} SI;

TN 1003, Fe-jadeitite(?): 0.29–0.37 x 10^{-3} SI.

The magnetic susceptibility of the axe from Kamegg fits within the range of Italian jadeitite artefacts. Increasing of omphacite or garnet content and transition to eclogite, cause a higher magnetic susceptibility at around 0.5 x 10^{-3} SI. This was shown in measurements on the Monviso outcrops and current axe replicas made of raw materials from the Monviso area: jadeitite 0.29–0.33 x 10^{-3} SI, omphacitite at around 0.58 x 10^{-3} SI and eclogite at around 1.36 x 10^{-3} SI. Magnetic susceptibility of local serpentinite has profoundly different values at around 80 x 10^{-3} SI. Schmidt & Štelcl (1971, 143) measured the density of Moravian jadeitite artefacts to 3213 – 3413 kg/m^3. A newly found jadeitite axe from Radlbrunn in Austria (G. Trnka) has density 3241 kg/m^3.

Prehistoric Use: Moravia seems to be the richest area for jadeitite tools in the eastern part of Central Europe. At least eleven artefacts have been found. They are represented especially by axes with pointed back (Brno-Líšeň, Pěnčín, Tvarožná Lhota), all being connected with the Moravian Painted Ware, Lengyel culture (Skutil 1946, 155). An axe from Jarošov near Uherské Hradiště is the only one probably connected with the Linear Pottery culture (Štelcl et al. 1973). Slovakian jadeitite tools and the axe from Kamegg were found at Lengyel culture sites.

In the eastern part of Central Europe jadeitite artefacts are long distant imports from the Western Alps, likely the Beigua Massif near Genova, or the Monviso metaophiolite west of Torino, NW Italy. Radiocarbon dating indicates that the main period of mining in the Monviso area occurred between 5200 and 3700 BC (Pétrequin et al. 2009, 6). The second group of data beginning around 1300 BC may support the conclusion that Alpine pastures were used during the Bronze Age. Such long distance trade is not unusual because jadeitites from NW Italy are considered to be the source for the majority of jadeitite axes found in Great Britain (Smith 1965, D'Amico et al. 1995). The prehistoric use of natural jadeitite from the Greek island Syros (Bröcker & Keasling 2006) or from NW Turkey (Okay 1997) is not still reliably solved but there is no evidence about occurrences of jadeitite axe heads in both mentioned regions.

III.1.6. Nephrite

General Characteristics: "Nephrite" comes from the Greek "nefros", which means kidneys. It is related to the superstition that the stone protects the owner against kidney diseases. To medieval chemists it was known as "lapis nephriticus". Nephrite is basically a monomineral rock formed by filamentous amphiboles of the actinolite – tremolite group: $Ca_2(Mg,Fe^{2+})_5[(OH)\ Si_4O_{11}]_2$–$Ca_2(Mg)_5[(OH)Si_4O_{11}]_2$. Due to this it has outstanding mechanical properties, and is rigid and tough. Its strength, at 0.0225 joule/cm^2, is nearly twice as high as jadeitite at 0.0120 joule/cm^2 (Rost 1975).

Background: Together with jadeitite, nephrite falls into the group of first recognized rocks used for polished tools in Central Europe. At the beginning of the study it was thought of to be of Asian origin, but later some European sources have been identified.

Location: We know only a few nephrite sources in the world. The most famous Asian sources are in the Kuen-Lun Mts. in east Turkestan on the north border of the Taklamakan Desert. The nephrite is processed in the town of Hotan. Other Asian occurrences are in the Eastern Sajan Mts. near Lake Baikal, and a small outcrop in the south Ural Mts. Nephrite sources in New Zealand are world famous. The Maori used them to produce perfectly shaped axes and nephrite Tiki pendants with spiritual and symbolic meaning. Czech painter B. Lindauer captured images of the native people of New Zealand with these luxurious pendants in his paintings.

In Europe, there were no known nephrite sources and during the Middle Ages it was imported from Asia. Traube (1885) identified the first European nephrite deposit near

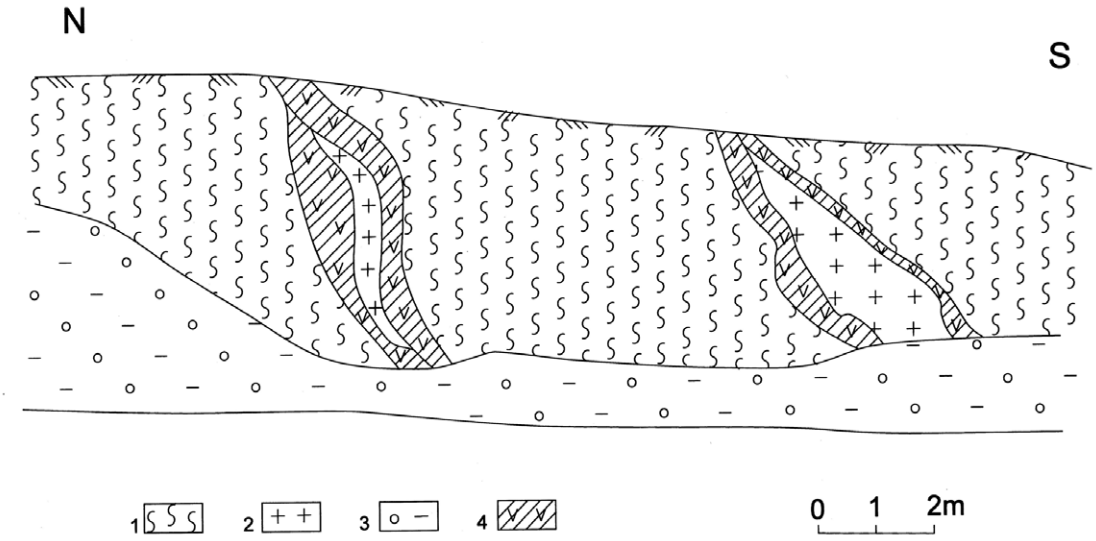

Fig. 106. Geological cross-section of the western wall of nephrite quarry at the village of Jordanów, Lower Silesia, Poland. After Gunia (2000). 1 – antigorite serpentinite, 2 – fine-grained plagiogranite (quartz-zoisite rock), 3 – stone debris, 4 – metasomatic reaction rim with nephrite lenses.

Jordanów (Jordansmühl) in Lower Silesia, about 30 km south of Wrocław. In the same time nephrite pebbles were found in gravels of the Mur River in Styria, Austria (Berwerth 1893). Fragments of nephrite were also found sporadically among erratic boulders in Germany and Poland (Linstow 1911). A number of nephrite sources are now known to exist across Europe, for example in the Swiss Alps (canton of Graubünden, Scortaseo and Val Faller), Italy (Val Malenco), Bulgaria (Kostov et al. 2012) and probably in other Balkan countries (Serbia, Macedonia, and northern Greece). But only the nephrite from Jordanów is considered the most probable source for prehistoric tools used in the eastern part of Central Europe (Fig. 106; Supplement/Photo 288).

Geological Setting: In term of the regional geology Jordanów lies on the north-eastern border of the Bohemian Massif. The serpentinite massif containing nephrite occurrences is a part of the Lower Palaeozoic ophiolite complex of the Ślęża Mt. Nephrite forms irregular small bodies, enclaves or pockets up to 2.5 m long and 0.4 m thick (Gunia 2000, 170) at contact zones around plagiogranite dikes that transect the serpentinite. Nephrite was mined as a raw material for jewellery and decorative objects in a small quarry in the second half of 20th century. The author visited it and procured samples there in 1971. Recently, the minig of nephrite in the quarry is closed; the locality is privately owned, and used as a depot for farm machinery.

Macroscopic Appearance: The rock has a streaked structure varying from light greyish yellow-green (5GY 7/2–10GY 6/4) to dark yellow-green (10GY 3/2). Dark green spots, up to 1 cm long appear in light green parts. The rock is translucent in the apple-green colour at the border (Supplement/Photo 289).

Stereomicroscopic Appearance: Within the better translucent light green streaks it is possible to observe under high magnification a structure made of fibrous mineral. Sometimes dark spots preserve pyroxene cleavage or show also a fibrous character with occurrence of opaque minerals.

Thin Section: Nephrite is almost monomineral, and comprised of Ca-Mg amphibole – tremolite (Supplement/Photo 290, 291). Apart from nephrite, quartz-zoisite or quartz-zoisite-tremolite rocks and talk or chlorite-talk schists occur in the contact zone (Gunia 2000).

Other analyses: Magnetic susceptibility is low in most samples and ranges usually between 0.23–0.57 x 10^{-3} SI.

Prehistoric Use: Nephrite and jadeitite tools were previously grouped together and authors overemphasised nephrite axes in Neolithic assemblages of polished stone tools in eastern Central Europe. Currently, nephrite artefacts are not as well documented as jadeitite artefacts in Moravia. Štelcl & Malina (1970, 54) described one from Plaveč near Znojmo based on the thin section. Another axe is known from Jemnice, Třebíč district (Košťuřík et al. 1986, 195). Based on macroscopic examination Mrázek (1996, 45) identified a nephrite axe and a small mattock from Prštice (Brno-country district, Moravian Painted Ware) and a discoid macehead from Popůvky (Brno-country district, Linear Pottery culture). Eisner (1933, 62) refers to a fragment of nephrite heart-shaped axe hammer from Maďarovce, Slovakia. Biró & Szakmány (2009, 29) noted only two polished stone tools from exotic nephrite in Hungary.

According to Gunia (2000, 170), nephrites are not frequent even amongst polished stone tools found in SW Poland, it is in the wide surroundings of Jordanów. This author considers it is a possibility that some nephrite axes come from other sources in Europe. Foltyn et al. (2000) studied a remarkable collection of 5 nephrite tools from the vicinity of the Odra River, in Upper Silesia, close to the Czech border. They are related to the Bell Beaker culture.

III.1.7. Eclogite

General Characteristics: Eclogite is one of the most strongly metamorphic rocks – in the terms of metamorphic facies the highest one is called the eclogite facies. It is assumed eclogites have been formed under high-pressure from basic igneous rocks when a slab of oceanic crust is subducted into the Earth's mantle. Its mineral structure is quite simple, including garnet with a high content of pyrope component and sodium-rich pyroxene omphacite. It also includes rutile, kyanite and other minerals, usually related to the rock transformation to lower metamorphic facies, such as hornblend, glaucophane, micas, epidote, plagioclase, titanite and quartz. A special type of eclogite is called griquaite, where omphacite is replaced by diopside or enstatite. If amphibole is significant then the rock is called amphibole eclogite. If omphacite has been replaced by amphibole and plagioclase the rock is called eclogitic amphibolite. It is possible to also see the term "Alpine type eclogites" in the professional literature. They are typically associated with jadeitites.

Background: In the eastern part of Central Europe the first mention of its use for polished stone tools appears in Velímský's (1969) master thesis about the polished stone industry at Bylany and in a publication of Štelcl & Malina (1970, 54). They linked it with two Neolithic axe hammers from Plaveč near Znojmo. The significance of this stone increased after D'Amico et al. (1995) concluded that eclogite with jadeitite were the predominant tool rocks for the polished stone industry within an extensive area of northern Italy and adjacent parts of Provence in France.

Location: Due to the character of the rock it is clear that it can occur only in the areas with strongly metamorphosed complexes. Tiny bodies are known in the Bohemian Massif, the west-Moravian and Austrian parts of Moldanubian Region, the Kutná Hora Crystalline Unit, Krušné Mts., the Saxonian Granulite Massif, Mariánské Lázně Metabasite Complex and Smrčiny Mts. (Fediuková 1989). Several meter long tectonic lenses are also found in the Lugicum. Probably the best-known eclogite sources crop out at Biskupice and Nové Dvory in the west-Moravian part of Moldanubian Region, Bečváry to the west of Kutná Hora and Mnichov, near Mariánské Lázně.

Geological Setting: Alpine type eclogites occur in Italian Liguria (Voltri Group). They are part of the metaophiolites

of the Western Alps together with jadeitite and other high-pressure metamorphites. Similarly, eclogites are substantially represented in the Monviso meta-ophiolite (for more details see the chapter on jadeitites). Eclogites in the Moldanubian Region of the Bohemian Massif are primarily found in the strongly metamorphosed Gföhl Unit.

Macroscopic Appearance: Contrary to most metamorphic rocks, they have an imperceptible foliation, are patchy red to black-green in colour and have the highest density of all silicate rocks (up to 3540 kg/m^3).

Stereomicroscopic Appearance: This rock is usually moderate to coarse grained, and the principal component minerals are easily recognisable. They include red or pink isometric garnets with vitreous lustre and fracture planes (the cleavage of garnets is generally imperfect) and greenish pyroxenes. Dusky green kelyphitic borders can develop around the garnets.

Thin Section: A detailed description of eclogite from two Slovak artefacts is provided by Spišiak & Hovorka (2005). These Slovak authors also conducted a microprobe analysis of pyroxene and garnet from eclogite, and amphiboles from symplectitic eclogite. A detailed mineralogical assessment of eclogites from north-western Italy was done by D'Amico & Starnini (2000).

Other Analyses: The magnetic susceptibility of eclogites and artefacts made of eclogite from north-western Italy is described in the chapter below about the eclogite from the Beigua massif. Eclogites from the Moravian Moldanubian Region (Bohemian Massif) provided similar or even higher values (Police-Kostníky 0.5 to 0.6 x 10^{-3} SI, Mstěnice 0.6 to 0.7 and 3.55 to 4.5 x 10^{-3} SI).

Prehistoric Use: In the Czech Republic eclogite artefacts were identified at the well-known Neolithic settlement at Bylany in central Bohemia, and at Plaveč near Znojmo (Supplement/Photo 293). In Slovakia, Hovorka & Illášová (1996) found symplectitic eclogite used for a Lengyel hammer at Nitriansky Hrádok. Spišiak & Hovorka (2005) identified almandine-omphacite eclogite used for a small axe at Svodín. The authors assume the former come from the Danubian gravels between Bratislava and Komárno (approximately 60–70 km to the south), because eclogite has not been found in the nearby Tríbeč core Mountains. They believe that the eclogite was transported in the Danube via the waterways of the southern (Austrian) slopes of the Bohemian Massif. As is the second eclogite concerned, the authors assume it was transported for a long distance, probably from the Mariánské Lázně Metabasite Complex in the western part of the Bohemian Massif. Eclogite artefacts had not been identified in Poland and Hungary to the present time (e. g. Prinke & Skoczylas 1980, Biró & Szakmány 2000).

III.1.7.1. Eclogite from the Beigua Massif (Liguria, north-western Italy)

Background: Jadeitite is highly likely to have been imported from NW Italy into Central Europe, making it impossible to exclude the possibility that eclogite tools found in Moravia or Slovakia could also have come from

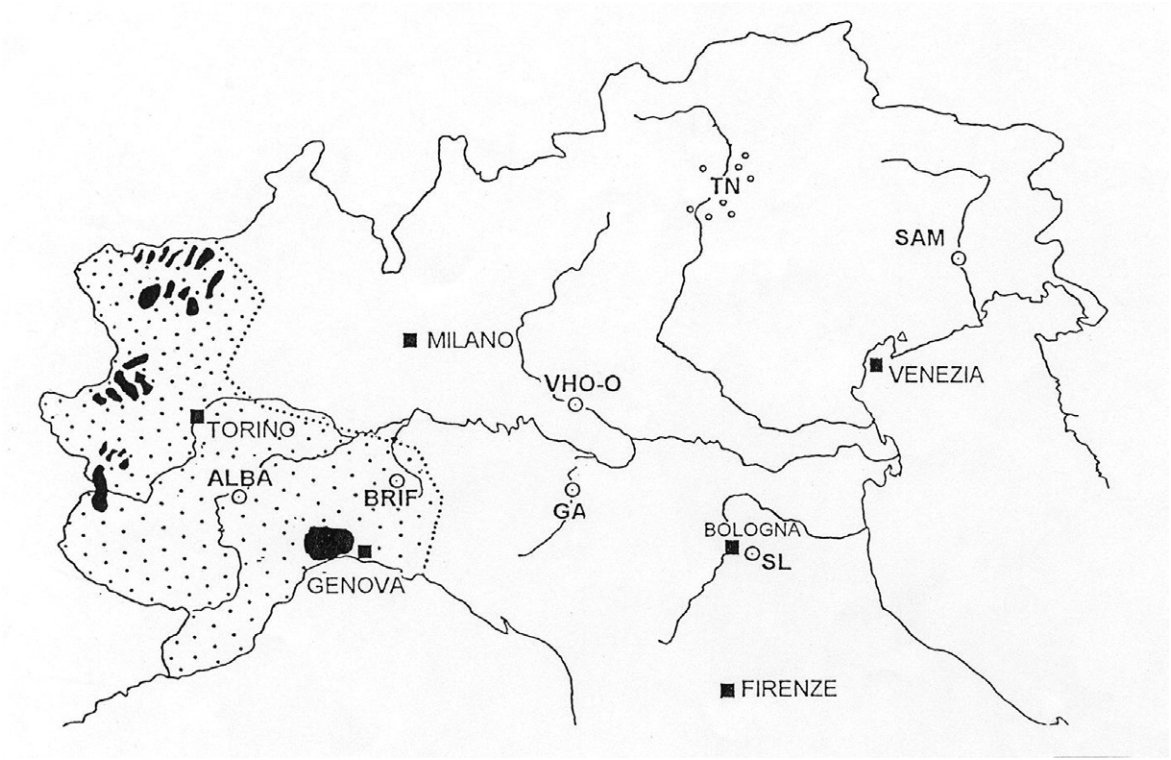

Fig. 107. Schematic map of northern Italy with outcrops of meta-ophiolite rocks including eclogites and jadeitites (black spots). Dotted area represents secondary occurrences of the raw materials in Oligocene conglomerates and younger alluvial deposits. Archaeological localities with substantial presence of eclogite and jadeitite polished tools: VHO-O = Vho and Ostiano, GA = Gaione, SL = San Lazzaro di Savena, TN = Trentino, SAM = Sammardenchia. After D`Amico & Starnini (2000).

there. Claudio D'Amico and his colleagues from the University of Bologna point to the extensive assemblage of eclogite polished stone artefacts found in northern Italy in the 1990's (D'Amico et al. 1995). They presume that eclogite cobbles released from Oligocene conglomerates by weathering of the source.

Location and Geological Setting: Eclogites crop out to the west of Genova in the Beigua Massif, the highest point of which reaches 1287 m. Other bodies are noted near the French border on the slopes of Monviso Mt. Further topographic and geological features of the Beigua Massif (Fig. 106) can be found in the chapter about jadeitite.

Thin Section: According to D'Amico et al. (1995, 32) the eclogite artefacts are built of 50–80 % sodic-calcic and Na-pyroxenes, 5–45 % garnet of calcic to magnesium almandine composition, 5–10 % Ti-minerals, up to 20 % chlorite and under 10 % of other minerals.

Other analyses: The magnetic susceptibility measured by the portable Kappameter on a garnet eclogite outcrop north of the village Vara Inferiore (9 km north-west of Voltri) ranges from 0.73 to 3.23 x 10^{-3} SI. The average value of 10 measurements was 1.62 x 10^{-3} SI. Magnetic susceptibility measured on a sample the same size as a typical axe hammer was 0.99–1.02 x 10^{-3} SI. On lenses of local serpentinite it reached up to 10 times higher, from 30 to 54 x 10^{-3} SI. A measurement on one tool from Sammardenchia (perhaps deformed eclogite) was 0.53 to 0.71 x 10^{-3} SI. A tool from Trentino TN 1008/inv.2882 (transition jadeitite – eclogite) measured 0.48 to 0.53 x 10^{-3} SI. The lower ranges found on tools, compared to outcrops, probably relates to the weathering of the rock and their transport as cobbles in the river gravels.

Prehistoric Use: In the Early Neolithic settlement of Sammardenchia (north-eastern Italy) there were 105 eclogite artefacts in an assemblage of 292 pieces (36 % of the collection). Sixty-six tools of jadeitite make up another 23 % (Pessina & D'Amico 1999, 39). The Neolithic site is approximately 400 km from the closest known source in the Beigua Massif in north-western Italy.

III.1.8. Marbles

General Characteristics: Marble ("crystallised limestone") is a metamorphic rock formed by metamorphosis of carbonate sediments – limestones, and possibly of dolomite limestones to dolomites. According to composition they are variously called calcite marbles (90–100% $CaCO_3$), dolomite-calcite marbles (50–90% $CaCO_3$), calcite-dolomite marbles [50–90% $CaMg(CO_3)_2$] and dolomite marbles [90–100% $CaMg(CO_3)_2$]. Recrystallization of the carbonate occurred during metamorphosis. This can be seen in the increase in grain, and the concentration of the original clay or organic admixture into strips or streaks. The organic admixture has usually metamorphosed into a graphitic substance. Additional classifications are possible based on the stage of metamorphosis and the origin of the newly formed minerals when impure limestones are metamorphosed, including diopside, forsterite, grossular, tremolite, micas, epidote and quartz. Hejtman (1962) proposed a simple and practical division according to the rocks with which the marble occurs, such as phyllites, mica schists or paragneisses.

Background: Marble is a common raw material used to produce female statuettes, bracelets, decorations and even containers in the Balkans (e.g. necropolis in Varna) during the Neolithic and Eneolithic. Marble human idols with flat faces, standing up to 1 m in height, from the Cyclades in the Aegean, were sculpted in the second half of the 3rd millennium. These representations of woman, and some man, accompanied their owners to the grave, proving their importance. There are marble sources on the Paros and Naxos islands, as a result of which outstanding sculptural schools aroused on these islands in antiquity. The white marble from Paros was especially valued as the best of its day. Pliny the Elder mentions this marble in Naturalis Historia (XXXVII) where he lists some famous objects made from it. He calls it "lychnites lithos" or lamp-like stone, because it was quarried in mines using lamps. In prehistoric central Europe marble is rarely used for polished stone tools due to its softness. Despite this, maces and sledges were made from marble. Marble was commonly used for polished stone decorative items such as bracelets and pearl-like beads.

Location: Marble is common in the eastern part of Central Europe and it is not possible to list all sources. It is important to note that various types of non-metamorphic limestones were commonly labelled as marble in the trade. It is important to differentiate these from true marble. Marbles from the area of Sázava River, central Bohemia (especially the Bílý kámen Hill near the town of Sázava) were used in prehistory. There has been speculation about Moravia (Zblovice) and southern Bohemia as the source of some marble artefacts, but also marble from both the Krkonoše and Jizerské hory Mts. cannot be excluded given that metabasite was quarried locally. Quality striped marbles rise up along the Polish border in the Žulovská pahorkatina Hills. Significant bluish marble from the area of Nedvědice (10 km north-west of Tišnov) attracted attention. In the Austrian Waldviertel (a continuation of the Bohemian Massif) extensive marble bodies occur within the Drosendorf Unit in the north to south belt running from the Austrian-Czech border to the Danube. A shorter marble belt appears about 10 km east in the Moravicum Nappe. Quality marbles are found in the Strońie Group of the Orlice-Sněžník Crystalline Unit and in the Kaczawa Mts. in the Polish part of the Bohemian Massif. In the Western Carpathians more significant marble bodies exist only in Slovakia (the Spiš-Gemer Ore Mts. – Košická Belá and Kavečany north-west of Košice, surroundings of Železník and Tuhár north-west of Lučenec). No important marble bodies are found in Hungary.

Macroscopic Appearance: Marble comes in various colours, but bright white is prevalent. Grey marble with dusky to black graphitic laminas or rashes are common at Supíkovice, Dolní Lipová in the Zlaté Hory Hilly land at the Czech-Polish border and on the Králický Sněžník Mt. They can change into blue-grey to black due to the

growth of graphitic substances. Marble with the green patches (containing clusters of green to black-green serpentine) from the Vápenný Hill near Raspenava (south-east of Frýdlant, northern Bohemia) is also known. Marbles can be differentiated also by macroscopically visible minerals such as phlogopite (Studnice near Nové Město na Moravě, Milaveč near Moravské Budějovice), tremolite (Malovidy near Český Šternberk) and others (see Hejtman 1962, 299–311).

Stereomicroscopic Appearance and Thin Section: See the description of marble from the Bílý Kámen Hill near Sázava, below.

Prehistoric Use: Marble charms and beads have been ascertained accompanying Linear Pottery culture burials, and are often found along with *Spondylus gaederopus* shell decorations. The village of Vedrovice is a well-known Moravian site where two female graves were found with marble beads (506 pieces in grave 9/88, and 68 in gravel 8/88, the cadastral part called Za dvorem). Two discoid marble charms with 7 cm and 5 cm diameters were found in children's graves 84/80 and 78/79 in the cadastral part Široká u lesa (Podborský et al. 2002). Another 7 cm marble disc was recorded at Hodonice near Znojmo, again related to the Linear Pottery culture. Mrázek (1996, 40) characterised the raw material of the disc as clear calcite marble with a strong uneven yellow fluorescence in long-wave length ultraviolet light. The origin of the marble from the graves at Vedrovice and Hodonice is unclear. Mrázek (1996) thought the marble from the Suchá hora Hill near Zblovice (Varied Group of the Moldanubicum, 3 km north of Bítov, south-western Moravia) was the most probable source. He argued by the relatively short distance (36 km from Hodonice and about 50 km from Vedrovice, as the crow flies), and that the beads from Vedrovice have the same apparent fluorescence as the marble from Zblovice. Later fluorescence research conducted by the author (Přichystal 2002, 213) did not corroborate this hypothesis, opening the possibility that the source for the beads from Vedrovice and the smaller disc from the grave 78/79 may be the area of Bílý Kámen Hill near Sázava. The large discoid charms from Vedrovice grave 84/80 and from Hodonice are high quality white marbles, and their origin in the Bohemian Massif is questionable. In addition, the marble from the Suchá hora Hill near Zblovice has not a white colour but a bright grey to bluish bright grey one (5B 7/1) – Supplement/Photo 295.

White marble bracelets were popular in the Stroke-ornamented Pottery culture (see the chapter about marble from the Bílý kámen Hill near Sázava). Rare Moravian Painted Ware marble artefacts include a small marble plate from the Holý Hill near Brno-Maloměřice, the fragment of a sculpture (5 cm long leg) from Kramolín near Třebíč, and the rare find of 13 marble beads from a mass grave in Džbánice (Mrázek 1996, 42–43). The marble used in Džbánice represents a very high quality, white, fine-grained, translucent and easily polished stone.

The same author believes that the interest in marble revived during the Channelled Ware culture. The finds from this period include marble beads from various

Fig. 108. Statue of lion (length 1.12 m) from Moravská Nová Ves represents the oldest big stone sculpture in Moravia. It is carved from a Cenozoic limestone (the raw material was originally described as marble). Photo by the author.

sites in Moravia (21 cylindrical beads from Moravičany-Díleček, one bead from Uherský Brod-Kyčkov, 10 discoid pieces from Staré Zámky in Brno-Líšeň). They were made of high quality white fine-grained translucent marble. The beads still look fresh and have a shiny gloss. Medunová-Benešová (1964) assumes that the marble beads and charms related to this culture in Moravia were not likely made locally, and they demonstrate contacts with the Hungarian-Transylvanian area. Large numbers of marble beads are characteristic for the Eneolithic Bodrogkeresztúr culture, widespread in the area of Tisa River where burial finds from Bodrogkeresztúr and Pusztaistvánház in Hungary are renowned. The wealthiest grave from the latter site contained about 1000 such beads (Hillebrand 1929), which had been worn in multiple strings around the waist.

Waist beads made of the white marble are known also in Slovakia. Hovorka & Illášová (2002, 140) identified them as Neolithic and Eneolithic at Sila-Čab near Nitra, Nitriansky Hrádok, Šurany and Jelšovce. They believe that the globular hammer also found at Cífer-Pác had been polished from the similar marble. The other globular hammer from Svodín, attributed to the Lengyel Culture, was made from a showy white-grey marble with black graphitic laminas.

Marble use for the polished stone tools is very unique in the Bronze Age. Mrázek (1996, 76) describes a globular mace from the Late Bronze Age (Silesian phase of the Urnfield Culture) from Štramberk in the Nový Jičín district in northern Moravia. This was made of fine-grained white marble with many tiny calcite veins. Tiny centres of fissile aggregates with a pearl gloss had been created at their intersection. Gottwald (1924, 30) mentions a broken marble globe from Čechovsko near Prostějov.

The Roman Period was a glorious period for marble, even in the eastern part of Central Europe. Imported marble sculptures and other marble items appear in the Roman provinces (Pannonia, Noricum, Rhaetia, the western half of Hungary, and the Alpine regions of Austria

and Bavaria) south of the "limes romanum", but also in the barbarian areas north of the Danube. Some prime examples include the marble sculptures of the main Roman deity from the lapidary in the Hungarian Sopron (Scrabantia) or sculptures in the Lower Austrian Deutsch-Altenburg (Carnuntum in northern Noricum). The significant marble quarries existed in Carinthia, to supply marble to Virunum and Teurnia (Dworakowska 1983, 19). Part of a marble prism comes from a burial site near Šitbořice (2nd–3rd century AD), Mrázek (1996, 109) notes that a 20.9 mm bead made of the white fine-grained marble was found at an early Roman period site in Němčice nad Hanou (district of Prostějov).

Fig. 109. A view towards the Bílý kámen Hill above the town of Sázava (district of Kutná Hora) in the time of discovery of prehistoric marble quarries. Postcard, 1937.

III.1.8.1. Marble from the Bílý Kámen Hill near Sázava (central Bohemia)

Background: This area is likely the earliest known prehistoric non-flint stone mine in Europe. The discovery of prehistoric quarries on the Bílý Kámen Hill near Sázava (Fig. 109) highlights the significance of marble in central Bohemia from the Early Neolithic (Žebera 1939). A detailed mapping survey of traces after quarring on the Bílý Kámen Hill (Vencl 1971) shows the top flat part and western slope covered by numerous small quarries dating from the Neolithic to the end of the 19th century.

Location: The forested peak of Bílý Kámen (456 m) lies 1.5 km SSE of Sázava Castle (district of Kutná Hora). It runs 750 m along the north-east to south-west axis, bounded to the west by the road from Sázava to Bělokozly, and the Sázava River valley to the east. It was damaged by quarries opened in the early 20th century at its north-eastern and south-western extremes (Fig. 110).

Geological Setting: The Bílý Kámen marble deposit lies in the Šternberk-Čáslav Group on the border of the Moldanubicum and Kutná Hora-Svratka Region. It is known also as the Rataje Zone (after the town of Rataje nad Sázavou) in older publications. It divides the Kutná Hora Crystalline Unit from the Moldanubicum. The formation of the local mica paragneiss and mica schist is explained by the retrograde metamorphosis of the Moldanubian paragneiss. Some authors considered it the equivalent of the Varied Group of the Moldanubian Region, though it is currently usually classed as the southern part of the Kutná Hora Crystalline Unit. It was originally a volcanic-sedimentary rock complex with prevailing basic volcanic rocks (today's amphibolites). Its age has not been assessed palaeontologically; either the Upper Proterozoic or Lower Palaeozoic age is probable. Marble from Bílý Kámen runs along a northeast to southwest line and has a steep dip (60–80°) in mylonitized biotite gneisses. The 500 m long body has an average width of 100 m and has been damaged by several transverse faults, in the vicinity of which the rock has been crushed, limonitized and contains streaks of chlorite or sericite material. Dykes of pegmatite granite up to 2 m thick have been noted, which penetrate through the marble and have been tectonically crushed.

Macroscopic Appearance: The marble rises up in massive layers without visible parallel arrangement or foliation. It is medium to fine-grained, white at the first sight but in comparison to Alpine marble from Viruna in

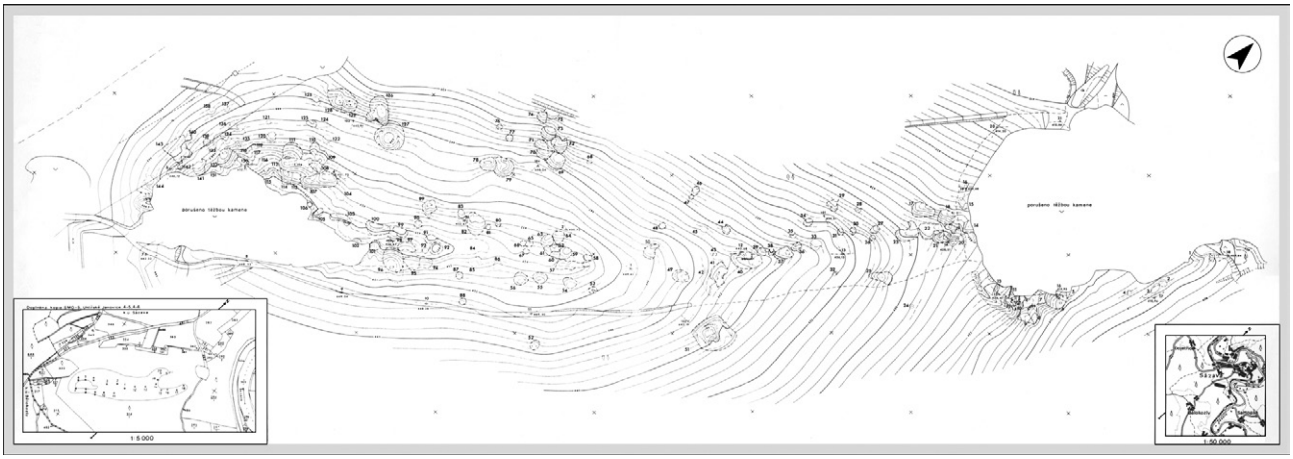

Fig. 110. Map of prehistoric and medieval mining pits for marble on the Bílý kámen Hill near Sázava. Length of the ridge is about 750 m and its both peripheral parts are damaged by recent quarries. After Vencl (1971).

Carinthia it tends towards a greyish or yellowish shade (Supplement/Photo 294).

Stereomicroscopic Appearance: Grains of the recrystallized calcite do not reach more than 1 mm. Tiny accumulations of finely scaled bright mica have occasionally been seen in some samples. The stone is not translucent, even at its edges.

Thin Section: Koutek (1936) conducted a petrographic analysis of the marble from Bílý Kámen in connection with the quarrying in the first half of the 20th century. It was noted to be a very pure crystallized calcite with rare occurrences of yellow-green minerals from the chlorite or serpentine group. Tiny scales of muscovite and garnet grain were occasionally identified. A significant presence of quartz or pyrite was not found.

Other Analyses: The chemical analyses published by Koutek (1936) show a very low presence of dolomite. In three analyses he found $MgCO_3$ (0.44–2.5 %), Fe_2O_3 (0.1–0.15 %) and the insoluble rest in HC1 (0.36–1.86 %). In one analysis it was extra ascertained SiO_2 (1.01 %) and Al_2O_3 (0.2 %).

Prehistoric Use: Based on finds of pottery, the marble mining was dated prevalently to the Late Stroke-ornamented Pottery period, similarly as was its processing in the southern vicinity of Kolín some 20–25 km from the prehistoric quarries. The marble bracelets in central Bohemia are thought usually to come from this source. A discrepancy exists in the characterization of the raw material from Bílý Kámen and petrographic analysis of the bracelets. Koutek (1936) labelled the raw material as a pure calcite marble, whereas the bracelets were likely dolomite marble and dolomite (Bukovanská & Březinová in Zápotocká 1984). Copious occurrence of these bracelets at the burial site at Rössen near Halle (eastern Germany) encouraged Zápotocká (1984) to consider the possibility of their use as barter for salt, which had been quarried in the vicinity of Halle since the Neolithic. Žebera (1944) asserts that the remains found in two wealthy graves on the outside of the square enclosure of a Funnel Beaker settlement near Makotřasy (17 km northwest of the Prague centre) were probably made from the Sázava marble.

III.1.9. Quartz-sillimanite rocks, fibrolites (western Moravia, southern Bohemia)

General Characteristics: Sillimanite-biotite paragneiss is formed during high-grade regional metamorphism from fine-grained clastic sediments rich in Al_2O_3. Apart from quartz it contains a variable quantity of plagioclase, orthoclase and biotite. Cordierite and garnet can be also present together with quartz-sillimanite lenticular aggregates as large as a few centimetres and known as fibrolite or bucholzite in older geological literature. A variety rich in quartz-sillimanite aggregates is known as fibrolitic gneiss.

Background: The author first encountered this unique raw material in the Czech region when studying polished stone tools from Hradisko near Křepice in western Moravia (Přichystal 1986). It is thought that this tool stone was also used in other parts of Europe where highly metamorphosed rocks of the Moldanubian Zone are found: Schwarzwald, Vosges, the Massif Central in France, southern part of the Armorican Massif on the Breton peninsula, and the Galicia Massif in Spain. Sillimanite axes were also identified in the La Viña area, near the Bay of Cádiz, south-western Spain (Domínguez-Bella et al. 2000) and in France.

Location: Sillimanite-biotite paragneisses as well as quartz-sillimanite to almost pure sillimanite lenses have been identified in many locations in western Moravia (e.g. Brtnice area SSE of Jihlava). They are also known from the Havlíčkův Brod or Rataje nad Sázavou areas. Quartz-sillimanite nodules several centimetres in size appear in South-Bohemian granulites near Srnín and Chvalšiny. They are found in the Kaplice mica schist Unit as well as cobbles in sediments of the Vltava and Malše Rivers near České Budějovice. Natural occurrences of quartz-sillimanite aggregates in the Czech Republic are fully reviewed by Vokáč & Houzar (2006).

Geological Setting: Sillimanite-biotite paragneiss is one of the most widespread rocks in the Moldanubicum, Bohemian Massif. Oval shaped whitish spots of sillimanite aggregates are normally distinguished on their foliation surfaces. Sometimes sillimanite with quartz form larger lens-shaped concentrations, usually around 5 cm long, with some exceptionally large examples between 15–20 cm. Quartz and sillimanite aggregates were also observed in some parts of the Gföhl orthogneiss and granulite. These aggregates are weathered out as "stones" from bedrock and their suitable shape for axes was noticed already in the Neolithic.

Macroscopic Appearance: Quartz-sillimanite lenses are always flattened, white-grey, and with silk lustre. Sillimanite forms fibrous aggregates mostly arranged parallel within the lenses. The aggregates are nearly monomineral in some cases, but generally they intergrowth with irregularly shaped grey quartz (Supplement/Photo 296, 297).

Thin Section: Sillimanite forms aggregates of tiny lath-like to needle-like colourless crystals that have extinction position parallel to their elongation. Cleavage cracks are distinguished in bigger crystals. The mineral is not pleochroic.

Prehistoric Use: The oldest object made of this raw material is a thin hoof-shaped wedge from the Linear Pottery cemetery at Široká u lesa near Vedrovice. Based on stereomicroscope study it is sillimanite-biotite paragneiss (Přichystal 2002a, 211) with a very low magnetic susceptibility of about 0.3 x 10^{-3} SI, partly due to the fact that the artefact covered only 20 % of the kappameter measuring head. Existing finds clearly show that quartz-sillimanite lenses were ground largely into small Eneolithic axes. The above-mentioned quartz-sillimanite axe found at Hradisko near Křepice is connected with the Early Eneolithic Retz-Křepice group. Weathered sillimanite-biotite paragneiss and a quartz-sillimanite lens were used for two flat axes found at the Eneolithic hillfort "Na hrádku" near Lhánice (western Moravia). Ceramic evidence suggests it is prevalently a Jevišovice culture settlement. A surface

find – chronologically unclassified sillimanite axe from Výčapy near Třebíč was described by Oliva & Houzar (1990). Vokáč & Houzar (2006) studied quartz-sillimanite polished stone tools in detail along with four other axes from Grešlové Mýto (Znojmo district). Currently we know seven artefacts originate from south-western Moravia. We can assume they also occur in southern Bohemia where first-class lenses of quartz-sillimanite aggregates are present in the Kaplice mica schist Unit of Moldanubicum or at some Eneolithic sites of Lower Austria. The abovementioned authors also found that unique polished stone artefacts of grey-white fibrous amphibole (tremolite) aggregates have a similar appearance.

III.1.10. Other metamorphic rock

Background: Other high-grade metabasites were used. In south-eastern Slovakia there are found blueschist and glaucofanite axes (Hovorka & Ilášová 2002) originating in the Meliata Group (Supplement/Photo 298). Prehistoric polished stone tools of granulite and granulitic gneiss are known from western Moravia (Vokáč 2008). Contact metamorphic plagioclase-pyroxene (diopside) hornfelses were used in Hungary for polished stone tools, less frequently they can be found also in Slovakia (Judik et al 2001, 123; Hovorka & Ilášová 2002, 112). Moving south-east the occurrence increases, and Hungarian authors assume their origin to be probably from the contact zone of special magmatic rocks association (banatites) in the Apuseni Mts. in Romania. Slovakian researchers found four flat trapezoid axes from this tool rock at the Lengyel site in Svodín, but sought its origin in the contact area of Central Slovakian volcanic rocks.

In the Bohemian Massif blueschists occur in the Rýchory and Železný Brod Crystalline Units or Góry Kaczawskie Mts. in Poland (Supplement/Photo 299). Considering the proximity of Jizerské hory Mts. metabasite mining area between Jistebsko and Velké Hamry in the Železný Brod Crystalline Unit, these blueschists might have been of interest to prehistoric peoples as well. Polished stone tools haven't been found to date. Glaucophane schists also occur in another part of the Bohemian Massif, in the Kraslice area (the Krušné hory Mts.).

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III.2. Igneous rocks

III.2.1. Diorite, porphyritic microdiorite (formerly diorite porphyry)

General Characteristics: Diorite is an igneous rock of intermediate composition (it is with the quartz content maximally up to 10%) and it has total prevalence of plagioclase feldspars above alkali feldspars. Plagioclases are acidic up to An_{50} (oligoclase, andesine). Amphibole and biotite as dark minerals are present, normally more so than pyroxene, and usually comprise 25–50% of the rock (Hejtman 1957, Streckeisen 1974). The stone appearance is generally dark and strongly grained. Porphyritic microdiorite (an older but still common name is diorite porphyry) is a dyke rock of porphyric appearance where phenocrysts form plagioclases and dark minerals (amphibole, biotite). The groundmass resembles diorite but it is more fine-grained.

Background: Already Matiegka (1894, 279) reported that diorite was used for polished stone tools in the Czech region. He listed it at the first place in his summary, though his diorite is likely to include more igneous plutonic rocks. Niederle (1894, 262) ranked it seventh. In Slovakia, Eisner (1933, 44) knew of only one “diorite wedge“ from Oravský Podzámok. Diorite polished stone tools had not been found in Hungary until recently. It is obvious that their sources must be sought in the Bohemian Massif crystalline units.

Location: Diorites crop out in many places on the Bohemian Massif, usually as a part of large granitoide bodies connected with the Cadomian and Variscan orogeneses. Biotite-amphibole or pyroxene-amphibole diorites are the most frequent. Diorites are found in southern Moravia in the Brno Batholith and Dyje Massif. In Silesia we know diorites from the Žulová Massif at Vojtovice. In eastern Bohemia small occurrences are found in the Železné hory Pluton in the surroundings of Nasavrky and the Chrudimka River valley. Diorite is also found in outcrops in western Bohemia (Mutěnín and Načetín Stocks, the Poběžovice and Kdyně Massifs). In the Central Bohemian Pluton it is possible to find prevalently only quartz diorites.

Small diorite occurrences of Variscan age have been described from Slovakian “core” mountains and the Miocene bodies in the Štiavnica Mts. represent the youngest diorites in the Central Western Carpathians.

Porphyritic microdiorites form numerous dykes in the Brno Batholith as well as in the south-western part of the Central Bohemian Pluton in the vicinity of Nepomuk (Hejtman 1957, 156–157). Diorites and porphyritic microdiorites in the Brno Batholith are the only known prehistoric sources, and are discussed below.

III.2.1.1. Massive amphibole diorite of the Brno Batholith (southern Moravia)

Background: Based on a literature review it is obvious that researchers of the 19th and 20th century identified polished stone tools from this interesting raw material in the Brno area. The rock was classified as syenite at the time. Červinka (1902, 106) noted "many broken syenite axe hammers, axes, waste bore-plugs were found at Vomice near Ivančice" (today's Omice). It is likely proof of the existence of a workshop where the raw materials from the Brno Batholith were processed. During stone tool research at the Moravian Painted Ware culture site in Brno-Bystrc (Přichystal 1981, 1988) the raw material used was identified as massive amphibole diorite from the Brno Batholith. It is necessary to underline the adjective confining because we know prevalently older Proterozoic schistose diorites in the Brno Batholith and those were not used for polished stone tools.

Location: Natural rock occurrences identical to the tool stone were observed by the author near the stop of water transport called Rokle at the Brno Dam reservoir, and north towards the spot heights Trnůvka and Knínický Sychrov (Fig. 111). Isolated diorite chips connected with preparation of semifinished artefacts were found at the Rokle outcrop. A part of the outcrop is now submerged in the reservoir at the Svratka River but could be a highly interesting site of prehistoric mining.

Geological Setting: The Brno Batholith is a Proterozoic igneous body created during Cadomian orogenesis. It forms an elongated triangle shaped body with apexes at the towns of Boskovice, Brno and Miroslav. Its tripartite structure, as seen on geological maps, includes a western granitoide part, a narrow central metabasite zone in the north-south direction, and an eastern granitoide part. Diorite rocks protrude as variously deformed Proterozoic metadiorites of schistose structure in the western part of the metabasite zone, or as younger Variscan (Carboniferous) undeformed NW – SE running diorite bodies in the western granitoide part (Fig. 112). These diorite bodies are of massive fabric, and were sites of prehistoric interest.

Macroscopic Appearance: It is usually medium-grained rock, dark grey-green when fresh. Amphiboles and

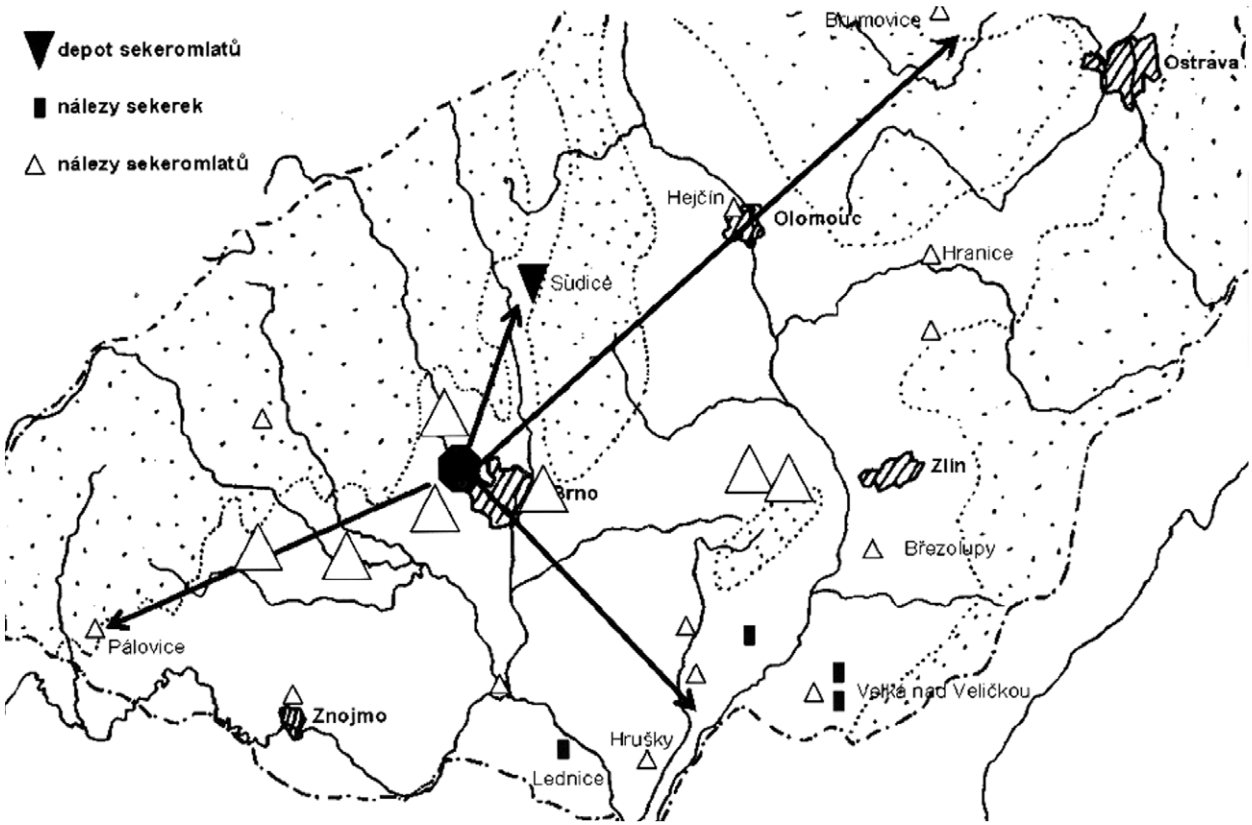

Fig. 111. Amphibole diorite of the Rokle type and its distribution in the Neolithic and Eneolithic in Moravia. After Vokáč, Kuča & Přichystal (2005). Black triangle – hoard of axe hammers; black rectangle – find of axe; blank triangle – find of axe hammer.

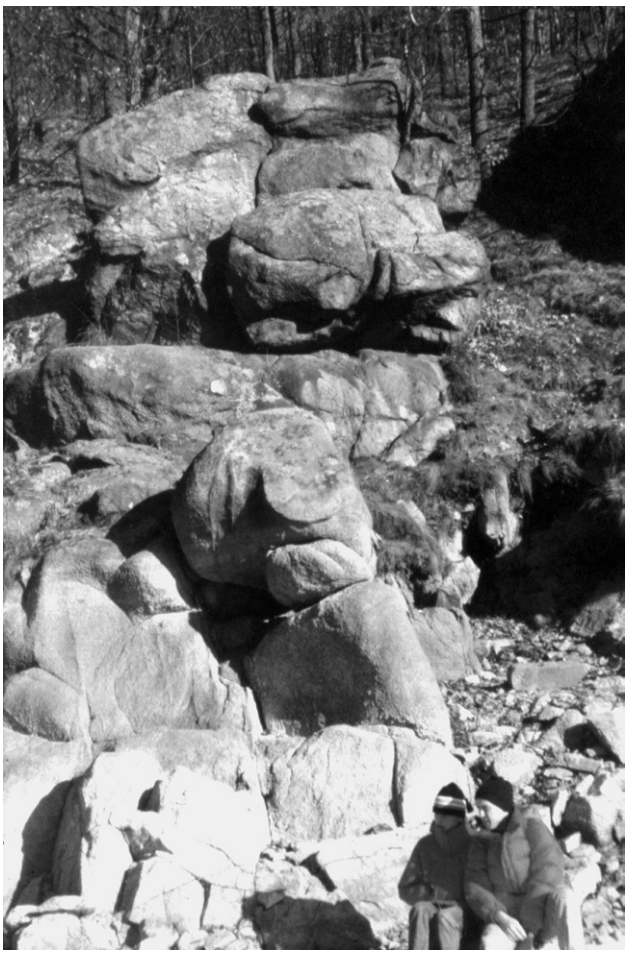

Fig. 112. A dyke of non-foliated diorite in the part called Rokle at the Brno Dam. Photo by the author.

feldspars can be usually seen with the naked eye. The feldspars are lath-shaped and spaces among them filled by amphiboles making the rock texture nearly ophitic (Supplement/Photo 300, 301, 302).

Thin Section: Plagioclases are intensively saussuritized. Besides prevalent amphiboles there is markedly less present chloritized biotite. Pyroxene was found in one sample but uralitizated and overgrown by pleochroic green-brown amphibole. Opaque minerals are represented by skeletal ilmenite with leukoxene rims; allotriomorphic quartz and carbonate were present sporadically. Apatite occurs in plagioclase rich parts (Supplement/Photo 303, 304).

Other Analyses: Magnetic susceptibility of half-finished axe hammers from the site Brno-Žebětín, including the Moravian Painted Ware settlement and a workshop close to the tool rock source, ranges from 2.4 to 7.15 x 10^{-3} SI. Similar sized artefacts from Brno-Kníničky on the opposite side above the Svratka River have values between 0.7 to 2.8 x 10^{-3} SI. It is probable that different dykes were mined in many other places.

Prehistoric Use: Several diorite-processing workshops are situated up to 5 km from the Rokle outcrops. From the notes of parish priest Eichler (1891, 8–9) from nearby Veverská Bitýška it is possible to interpret the nearest workshop lay some 2200 m up river above a meander (modern part of the valley called "Na Pile"). During construction of parkland for Veveří Castle (1875–1877) numerous drilled stone tools ("axe hammers"), axes, 11 waste bore-plugs, ceramics and polished stone tools were found. This is typical for the workshops in this area. Based on the find of an apparently red painted female sculpture, the workshop is identified as belonging to the Moravian Painted Ware culture. Another workshop with diorite fragments in an advanced state of processing (Přichystal 1988) was found during the construction of utility corridors in the Brno-Bystrc II housing development. From Brno-Kníničky cadastre we know a smaller Moravian Painted Ware village in the forest above Brno Dam, where diorite tools, fragments and processing waste are found (Kazdová & Přichystal 1996). It is about 3.5 km from the natural rock source. Another prehistoric settlement where the Neolithic farmers processed diorites was established in the cadastral part "U křivé borovice", in Brno-Žebětín, 3 km south of Rokle outcrops. Hundreds of diorite pieces, waste, fragments, half-finished products, and the occasional polished stone tools were acquired through surface survey. The site was examined in detail by Kuča, Kazdová & Přichystal (2005) and classified as a Moravian Painted Ware Ib settlement. Diorite was also used for drilled polished stone tools in Brno-Obřany, in the area of Líchy (Adámek 1944) about 10 km east of the natural source

Vokáč, Kuča & Přichystal (2005) attempted to document the prehistoric distribution of polished amphibole diorite tools in southern Moravia. Its large exploitation started with the Moravian Painted Ware culture. During the Ib period numerous settlements were established in the Brno area and the new stone source lead to the production of large numbers of drilled axe hammers. Amphibole diorite manufacturing culminated in the later stage II of Moravian Painted Ware culture, followed by a marked reduction. Sporadic diorite artefacts are found also in the Eneolithic cultures, for example at Brno-Stránská Skála Hill (Bell Beakers), Brno-Lískovec (the Jevišovice culture) and up to the Early Bronze Age (Ořechov near Brno). Macroscopically same diorite artefacts were discovered in the Olomouc area, central Moravia (Velký Kosíř Hill) and the Opava area, Czech Silesia (Brumovice Hill).

Hovorka & Illášová (2002, 84–85) found diorite axe hammers only in the surroundings of Senica, western Slovakia and have expected that the diorite raw material was transported from the eastern part of the Bohemian Massif. Recently, a diorite axe hammer has been found at Malé Raškovce, Michalovce district, eastern Slovakia, at a Baden culture settlement (cooperation with M. Kuča and M. Vizdal).

A local diorite source for polished stone tools found in Hungary is thought unlikely. The author thinks the diorite artefacts he saw in the Ebenhöch collection from the surroundings of Györ, northern Hungary, could have the Moravian provenance as well.

III.2.1.2. Porphyritic microdiorite (formerly diorite porphyry) from the Brno Batholith (southern Moravia)

Background: The author identified this raw material again at the beginning of 1980's when he studied settlements with the Moravian Painted Ware in Brno-Bystrc and Brno-Žebětín. The published designation diorite porphyry for a raw material of prehistoric artefact appeared for the first time in a report of Šebela & Přichystal (1983) with a view to an axe hammer connected with the older stage of Funnel Beaker culture from Brno-Líšeň.

Location: Dykes of porphyritic microdiorite crop out both in the territory of Brno city and in its surroundings; it has been recorded about 50 occurrences (Gregerová et al. 1986, 142). One of them was found for example to the east of a settlement with the Moravian Painted Ware in Brno-Žebětín.

Geological Setting: Porphyritic microdiorites form only thin dykes; their thickness usually varies from a few decimetres to several metres. One of the biggest dykes with a thickness of about 10 metres can be found at the road crossing Blansko – Šebrov – Olomučany. Their contacts with host rocks are sharp. They penetrate all three parts of the Brno Batholith but the concentration of occurrences in its Metabasite Zone and the vicinity is conspicuous. The prevalent direction of dykes is NNE – SSW, the second one is perpendicular to it. In spite of the distribution in the Cadomian Brno Batholith, there is no doubt about their substantially younger (Upper Carboniferous) age based on radiometric dating and almost non-deformed fabrics. Because the rock is more weathering-resistant comparing the host metabasites or granodiorites, it forms conspicuous rocky outcrops or blocks to smaller angular fragments.

Macroscopic Appearance: The prevalent variety has a confining porphyritic texture and on the fresh fracture the colour is dark greenish grey (5G 4/1) with hardly distinguishable phenocrysts. Patinated artefacts are greyish green to pale olive (10GY 5/2 to 10Y 6/2) with well visible phenocrysts of feldspar and hornblende up to 5 mm (Supplement/Photo 305).

Thin section: Phenocrysts are represented especially by 1–5 mm big lath-shaped crystals of plagioclase feldspar twinned according to the albite or albite-Karlsbad laws. In addition to twinning, zoning can be seen in some feldspar phenocrysts (Supplement/Photo 306, 307). Feldspar crystals are altered to zoisite, epidote, chlorite and sericite differently in individual dykes. The alteration is visible especially in the central parts of feldspars. Hornblende forms smaller phenocrysts that are partly chloritized or altered to fibrous amphibole of the actinolite-tremolite group. The groundmass has usually ophitic or pilotaxitic texture and it is composed from allotriomophic feldspar, quartz, amphibole, secondary minerals (chlorite, sericite, zoisite-epidote, carbonates), and opaque minerals. Modal composition of more than 30 porphyritic microdiorites from the Brno Batholith and optical characteristics of their feldspar are summarised by Gregerová et al. (1986, Tab. 24).

Fig. 113. Roughouts of battle axes made of porphyritic microdiorite. Moravian Painted Ware culture, Brno-Žebětín. Photo by the author.

Besides this prevalent variety there are some thin dykes built of almost non-porphyritic rock or at a few outcrops it was found porphyritic microdiorite with amygdaloidal structure. In the northern part of the Brno Batholith between Doubravice and Lhota Rapotina several dykes were affected by deformation (they have indicated a foliated structure).

Other Analyses: Magnetic susceptibility measured on roughouts made of porphyritic microdiorite from a Lengyel settlement in Brno-Žebětín (Fig. 113) varies between 0.36–0.55 x 10^{-3} SI; roughouts from Brno-Kníničky yielded gently lower values (0.28–0.32 x 10^{-3} SI). The rock form only thin dykes up to a few metres, so we can suppose each Lengyel settlement could use its own source. Generally the porphyritic microdiorites from the Brno Batholith have their magnetic susceptibility lower comparing massive amphibole diorites.

Prehistoric Use: Porphyritic microdiorities were worked basically in the same prehistoric periods as massive amphibole diorites, i. e. in particular by people with the Moravian Painted Ware since the phase Ib. The rocks were used especially for production of battle axes. Because of ball disintegration they were suitable also for riders (upper stones of saddle querns), for example in Brno-Žebětín or Rozdrojovice near Brno. Individual polished tools made of this raw material we know also from inventories of later Eneolithic cultures in southern and south-western Moravia.

III.2.2. Andesite and palaeoandesite

General Characteristics: Andesite is a volcanic rock with intermediate content of silica (52–64% SiO_2), fine-grained groundmass and phenocrysts of plagioclase and dark minerals. In chemical and mineralogical terms it corresponds to diorite. Plagioclases can be zonal and their average composition varies between oligoclase and andesine. The dark minerals are found in the following combinations: amphibole and biotite, amphibole and

pyroxene, pyroxene and olivine or sometimes separately pyroxene or biotite. Pyroxene occurs as monoclinic augite as well as rhombic hypersthene. Czech petrologist Hejtman (1957) divides andesites by the character of the prevalent dark mineral into biotite, amphibole, hypersthene and augite ones. Palaeaoandesite (i. e. usually partly altered andesite of Palaeozoic age) was called porphyrite in older literature. In contrast to Cenozoic andesite the palaeoandesites are usually brighter as a result of alteration.

Location: In the eastern part of central Europe extensive occurrences are found in Tertiary volcanic mountains of central Slovakia (Pohronský Inovec, Vtáčnik, Kremnické vrchy, Štiavnické vrchy, Poľana, Javorie), eastern Slovakia (Slanské vrchy, Zemplínské vrchy, Vihorlat Mts.) and northern Hungary (Zempléni-Tokaj hegyseg, Mátra, Cserhat, Börzsöny, Pilis Mts.). Lesser but important sources of andesite are found in the Carpathian Flysch Belt (south-eastern Moravia near Uherský Brod) and in the Polish part of the Pieniny Klippen Belt in the area of Krościenko and Szczawnica (Supplement/Photo 310).

The best-known sources of palaeoandesite are in the Upper Cambrian to Ordovician Křivoklát-Rokycany and Strašice Belts in central Bohemia and the Krkonoše Piedmont Basin in northern Bohemia.

Macroscopic Appearance: Tertiary andesite is a porphyritic rock with phenocrysts of plagioclase and dark minerals, especially amphibole, biotite or pyroxene, and occasionally the relics of olivine. The colour of fresh cut andesite is black-grey or bright purplish grey with black phenocrysts apparent in patinated artefacts (Supplement/Photo 308). Moravian andesites to trachyandesites from the vicinity of Uherský Brod are grey-green with significant 1–2 cm big black-green amphibole phenocrysts (Supplement/Photo 309). Propylitized andesite from the best-known outcrop on Bučník Hill near Komňa is bright grey and the dark minerals are usually decomposed. In addition to it, the rock usually contains carbonates and pyrite. Palaeoandesites from the Křivoklát-Rokycany Belt rise on its north-western side and are bright grey-green. The dark minerals (probably biotite and amphibole) have been completely chloritized and the groundmass usually has a trachytic texture. Types without apparent phenocrysts occur there as well.

Thin Section: Trachyandesite from the Bučník Hill near Komňa has been studied as an example (Supplement/Photo 311). The porphyric rock contains phenocrysts of plagioclase, amphibole and biotite. Tiny feldspar prismatic crystals are recognizable in the fine-grained groundmass, which sometimes flows around the phenocrysts and creates a trachytic texture. Plagioclases (andesine to acid labradorite) are showing multiple twinning and the phenocrysts often create radial accumulations. A zonal texture with a more calcic core is common. The amphibole has also a zonal texture with a darker core and twinning is quite usual according to /100/. It is pleochroic, green-brown and reaches extinction angle at $\alpha\gamma/c = 21°$. A mixture of chlorite and opaque mineral appears on the edges of its phenocrysts. Biotitization happens after cleavage fractures. Biotite is less common than amphibole. Its hypidiomorphic thin sheets have red-brown–ochre pleochroism. Both dark minerals sometimes enclose apatite. Apatite, sericite, chlorite, pyrite and pyrrhotite have been found in the rock groundmass.

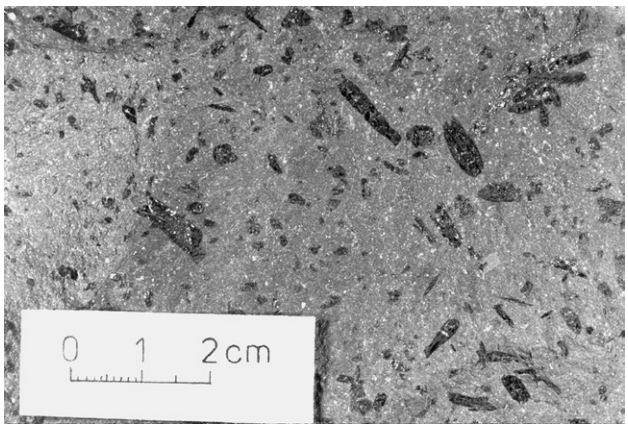

Fig. 114. Andesite from Luhačovice, SE Moravia. Miocene andesitic rocks from the Magura Group of the Carpathian Flysch Belt are usually markedly porphyritic with dark phenocrysts of hornblende. They served as raw materials for polished tools in the surroundings of their natural outcrops. Photo by L. Plchová.

Other analyses: Magnetic susceptibility of biotite-amphibole trachyandesite from the Bučník Hill is around 0.7×10^{-3} SI. Coarsely porfyritic andesite not affected by propylitization, from Bánov or Nový Hrozenkov, ranges from 10 to 13×10^{-3} SI. For comparison: dark andesite from Rybník near Levice (central Slovakia) has a magnetic susceptibility around 4.3 to 4.5×10^{-3} SI. High magnetic susceptibility has been measured on andesite from the Vžar Mt. in the Polish Pieniny Mts., at around 22.4×10^{-3} SI.

Prehistoric Use: Andesites were used in areas where they are naturally abundant as in central and eastern Slovakia, and northern Hungary. Hovorka & Illášová (2002, 90) found andesite was used for the polished stone tools in dozens thin sections in Slovakia. Hungarian researchers rarely ascertained andesite in the Miháldy's assemblage, which contains collections from the Bakony Forest and vicinity (Szakmány et al. 2001, 111)

Tiny bodies of the trachyandesite to trachybasalt are known from the Magura Group of the Carpathian Flysch Belt, east of Uherský Brod (SE Moravia), particularly in the area that lies in the midst of Bojkovice, Bánov and Starý Hrozenkov. They are rarely found further west (Fig. 114). These exceptional igneous rocks occur in an extensive area built of sandstones, siltstones, claystones and conglomerates. The author found tiny hatchets, probably Eneolithic, and round crushers made from andesites, in the assemblage of amateur collector L. Ježek from Dolní Němčí near Hluk. The artefacts come from an area between Dolní Němčí and Slavkov, several kilometres southwest of the natural andesite outcrops. Andesite artefacts are likely to be found on the Bánov hillfort, which is situated on the top of an andesite breccia body.

As is the palaeoandesites (porphyrites) concerned, Brus (1987) found palaeoandesite tools during his studies of polished stone industry from the area of Bílina, NW Bohemia. He has supposed the Křivoklát-Rokycany Belt as their primary source.

III.2.3. Melaphyre (Permo-Carboniferous basaltic palaeoandesite)

General Characteristics: The term melaphyre is commonly used for Permo-Carboniferous (Upper Palaeozoic) volcanic rocks in Central Europe. Its chemical composition usually corresponds to basaltic andesite. It consists of plagioclase, pyroxene (augite, pigeonite, hypersthene) and up to 10% olivine. In today's petrographic classification of volcanic rocks (Streckeisen 1980) the term melaphyre has been replaced by basaltic andesite. Because it is easy to identify it macroscopically, the term melaphyre is still used in geological practise.

Background: Eisner (1933, 44) was probably the first to recognize melaphyre as a raw-material used in polished stone industries, when he noted "a thick melaphyre axe from Dreveník near Spišské Vlachy (Slovakia) with both sides sharpened into a cutting edge" and classed it as Eneolithic. A natural source of melaphyre is found at Kvetnica near Poprad.

Location and Geological Setting: There are well-known Permo-Carboniferous occurrences in the Krkonoše Piedmont Basin in the vicinity of Turnov (Kozákov, Frýdštejn). They are well-known thanks to finds of semiprecious varieties of silica as early as the reign of Charles IV and Rudolph II. Other melaphyre bodies rise up around Jilemnice, Stará Paka and Semily. They occur also in the Intra-Sudetic Basin north-east of Broumov and as a belt in Poland, between the town of Kamienna Góra and Waligóra Mountain (936 m). Polish collectors have also found Permian melaphyres with agates in the Góry Kaczawskie Mts. (Nowy Kościoł, Wleń, Lubiechowa).

Permo-Carboniferous melaphyres of similar appearance have been described also in the Central Western Carpathians in Slovakia. They are a part of the "melaphyre" Ipoltica Group of the Choč Nappe (Hronicum) and they rise up in various core mountain ranges. The best-known locations include the Petrklin Hill (587 m.) near Sološnica in the Malé Karpaty Mts., and Kvetnica in the Kozí chrbty Range, south of Poprad. Suitable cobbles are also found in Váh River gravels (Supplement/Photo 322). Individual melaphyre cobbles around 9 cm long, probably originating in the Austrian Alps, have been found in Lower Badenian gravels near Mušov in southern Moravia (Přichystal 2010).

Macroscopic Appearance: Melaphyre has an appearance that is easy to recognise macroscopically or using a stereomicroscope. There are either highly porous types with aphanitic groundmass or compact porphyritic types with large feldspar phenocrysts. Porous (amygdaloidal) melaphyre has hollows that are usually filled by the varieties of silica, especially chalcedony, jasper and agate. Amethyst or crystallized quartz can be present as well. Carbonates and chlorites appear in the amygdale fillings as well. Appearance of the rocks is than spotted grey-brown to purplish brown with whitish, green, red or differently coloured oval patches of up to several centimetres (Supplement/Photo 323).

Other Analyses: Magnetic susceptibility of melaphyres from the vicinity of Turnov in northern Bohemia varies substantially. A sample from the Kozákov Hill was only 0.5–0.8 x 10^{-3} SI, whereas melaphyre from Frýdštejn was 10 times higher, from 8.5–9.5 x 10^{-3} SI. Similar measurements to the Kozákov melaphyre were obtained on melaphyres from Kvetnica near Poprad. Six centimetre big porphyritic melaphyre pebbles from gravel in the Váh River near Pruské measured around 1.1 x 10^{-3} SI. Only slightly higher magnetic susceptibility was found for a melaphyre pebble from Mušov, southern Moravia (1.42 x 10^{-3} SI).

Prehistoric Use: Four polished stone tools made from this raw material are known from the area of Slovakia. Hovorka & Illášová (2002, 88) found melaphyre in two axe hammers at the Hontiany museum in Levice and one axe hammer from the SNM Ethnographic Museum in Martin. Soják (2000, 225) mentions a fragment of a hatchet from Stráne pod Tatrami in the district of Kežmarok.

This tool rock has not been reliably identified so far in Moravia, but its use in Krkonoše Piedmont Basin in Bohemia is likely.

III.2.4. Gabbro

General Characteristics: The term gabbro is an old Florentine stone-cutting term derived from the name of the town of Gabbro in Tuscany, central Italy. German geologist Leopold von Buch introduced it into the professional literature in 1810. It is a plutonic igneous rock with the chemical composition approximately corresponding to basalt. It consists of basic plagioclases (labradorite or bytownite) and pyroxenes. Hornblende and olivine are common minerals; biotite can also be present.

Location: In regard to prehistoric use for polished stone tools, the most significant source appears to be the body of the coarse-grained metagabbro on the eastern and southern slopes of Ślęża Mt. in Lower Silesia. Sachanbiński (1979, 209–210) mentions other high quality decorative gabbros coming from the vicinity of the Sowie Góry Mts. in Polish Silesia, particularly at the localities of Wolibórz, Nowy Dzikowiec, Braszowice, Nowa Ruda and Słupiec.

It is not been possible to enumerate and characterise all the small gabbro occurrences in the Czech Republic. Examples in the Moldanubian Region include Pecerady and Chocerady near Benešov within the Central Bohemian Pluton, Mařiž near Slavonice (SW Moravia), and other smaller occurrences in Lower Austria on the eastern margin of the Moldanubian Pluton, Korolupy south-west of Moravské Budějovice in the Vratěnín Group of the Moravicum. In the Bohemicum they rise up within the Ransko, Kdyně and Poběžovice Massifs, within the Polička and Letovice Crystalline Units and in the Orlické Mts. (Špičák Hill near Deštné). Small individual

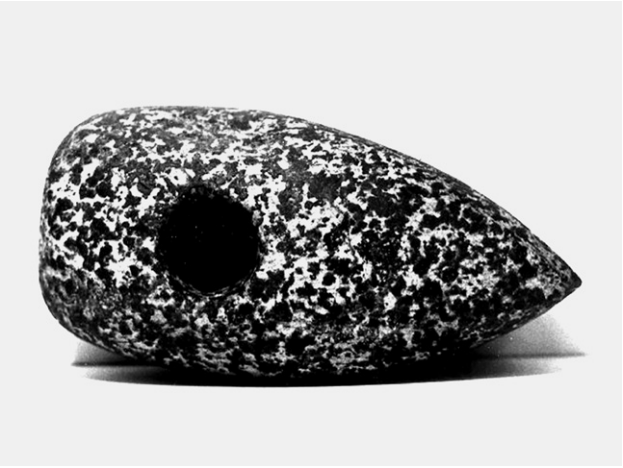

Fig. 115. A battle-axe made of hornblende gabbro, length 10.3 cm. Corded Ware culture. Rymice near Holešov, central Moravia. Foto by the author.

bodies have been identified in the Brno Batholith in Brno-Kohoutovice, Podskalský mill near Ostopovice, etc.

The prehistoric use of gabbro from Szarvaskő in the Bükk Mts. has been published in Hungary. Only one occurrence of the olivine gabbro is known in Slovakia, on the southern slope of the Nízké Tatry Mts. north of Heľpa (Ivan et al. 1996).

Macroscopic appearance:

1. Coarse-grained metagabbro from Ślęża (Lower Silesia, Poland)

It is a dusky green to black-green patchy rock with a massive and coarse-grained structure, in which the diallage crystals can reach up to 3 cm. The patchy variety was especially used for polished tools. Pyroxene and plagioclase are found, with some black ilmenite and yellowish pyrrhotite. Magnetic susceptibility measured on the metagabbro boulders above the car-park at the Tąpadla Pass between Ślęża and Radunia reached no more than 0.25–0.35 x 10^{-3} SI.

2. Olivine hornblende-pyroxene gabbros within the Moldanubian Pluton (western Moravia, northern Austria)

They are known from Mařiž near Slavonice, Rosental near Kautzen, Reinprechts and Wultschau westward from Weitra (Supplement/Photo 313). These small bodies of homogenous rock with a massive texture and brownish black-grey colour are coarse-grained and their texture is almost ophitic. Lath-shaped plagioclases (labradorite – bytownite) are surrounded with pyroxene, magnesium-rich biotite, fibrous uralite and small relics of olivine (Gnojek & Přichystal 1997, 236). Magnetic susceptibility ranges from 0.55 to 2.7 x 10^{-3} SI (Reinprechts).

Prehistoric Use: Gabbro artefacts are very rare in the Early Neolithic. A hoe found in the grave 2/85 at Vedrovice ("Za dvorem") was made of patchy coarse-grained olivine gabbro (Supplement/Photo 314, 315) with magnetic susceptibility of 3.6–3.7 x 10^{-3} SI (Přichystal 2002, 212). Frequent gabbro axe hammers have been ascertained in raw material stone basis of the Corded Ware culture in Moravia – 17 items, it represented 4% of the studied large collection (Přichystal & Šebela 1992). Grains of uralitized pyroxene and white-grey plagioclase are about 0.5 cm big. The authors assume a source for the tool rock in the area of Ślęża (Fig. 115). As is gabbro occurrences in the Czech Republic concerned, probably the Ransko Massif could serve as a suitable rock source. Local gabbros were easily accessible from central Bohemia via the Doubrava Furrow and some of them have a high quality and attractive appearance, such as the dark troctolite with whitish patches, having a high magnetic susceptibility of 43.9 x 10^{-3} SI.

In Slovakia there is only one mention of olivine gabbro used for a large drilled axe hammer kept in the museum at Senica (Hovorka & Illášová 2002, 82). Unfortunately there is no detailed chronological classification. The authors assume it originated from the eastern part of the Bohemian Massif and believe that Slovak gabbros were not amongst frequently used tool stone for the polished stone industry. Surprisingly, not much gabbro was used even in Polish Silesia (Choleva 2004, 22). He found only two pieces (0.8% of the collection), which he classified to the Funnel Beaker culture. In Lesser Poland A. Přichystal identified an axe hammer from a Corded Ware culture grave in the village of Smroków NNE of Cracow as made of gabbro (Wlodarczak 2006, 380). In Hungary researchers usually have described these rocks as microgabbros and include them in one group with diorites and dolerites (Szakmány & Starnini 2002, Oravecz & Józsa 2004), which has made difficult to identify their real presence.

III.2.5. Basaltic rocks (including basanite, nephelinite, tephrite)

General Characteristics: These are the most common basic volcanic rocks (i. e. containing not more than 53 wt.% of SiO_2) and are created by strongly calcic plagioclases, clinopyroxenes and very often by olivine. The opaque minerals found include magnetite or ilmenite. The rocks can also contain amphibole, biotite or orthorhombic pyroxene hypersthene. From the standpoint of praxis it is necessary to include in the term basaltic rocks besides typical basalts also macroscopically unidentifiable olivine basanites, olivine nephelinites and tephrites (rocks having in addition different content of foids, especially nepheline or leucite). In central Europe only the Cenozoic (Tertiary and Quaternary) rocks were formerly labelled in this manner.

Background: Basaltic rocks were identified very early as raw materials for prehistoric stone tools. In Bohemia basalt appears on the list of tool stone by Matiegka (1894, 279), in Slovakia for example Eisner (1933, 46) notes finding a basaltic axe hammer in the Topľá River at Skrabské (eastern Slovakia).

Location: In light of the Central European custom to only label Cenozoic rocks as basalts, there are mentioned in Bohemia as natural basaltic sources those in the České Středohoří Mts. and quantity of small localities in northern, central and western Bohemia. It has been necessary

to take into account also occurrences of other basaltic rocks with a substantial content of foids (tephrites, basanites and nephelinites). As is the small basaltic localities concerned, the hill with the Castle of Košumberk, situated near the village of Luže (south-west of Vysoké Mýto) is the easternmost occurrence of olivine nephelinite.

In northern Moravia and in Czech Silesia occurrences of Pliocene-Pleistocene basalts are especially around Bruntál (Fig. 116). Miocene basalts are found around Opava. Tiny bodies have been ascertained also at other localities in the Nízký Jeseník Highland. The westernmost occurrence lies at Zálesí near Javorník (Rychleby Mts.). Basaltic rocks are also found in Polish Silesia (Lądek Zdroj, Nowa Cerekwia south-east from Głubczyce, Dębowiec, Góra Św. Anny and Ligota Tułowicka in the area of Opole). Other outcrops are known from the south-western tip of Poland between the towns of Lubań and Zgorzelec (e. g. Kamienna Góra in Lubań) or between the towns of Złotoryja and Jawor south of Legnica. In addition large pieces of quality olivine basalts appear as erratic materials in the sandpit Opole-Groszowice. In the Carpathian Flysch Belt in Moravia a significant source of dolerite basalt is at Starý Hrozenkov east of Uherský Brod (Supplement/Photo 321). Other occurrences of the basaltic rocks are found in central and southern Slovakia (Kalvária in Banská Štiavnica, Brehy near Nová Baňa, Lučenec, Fiľakovo).

In Hungary numerous sources of Cenozoic basalts are found along the border with Slovakia (Salgótarjan – Lučenec), other occurrences are concentrated north of the Balaton Lake (Balaton Highland) and Lower Cretaceous basalts crop out in the eastern Mecsek Mountains. Small but archaeologically significant outcrops of Tertiary basalts are found in Austrian Burgenland (Oberpullendorf, Pauliberg).

Macroscopic and Stereomicroscopic Appearance: They are grey-black massive rocks with an aphanitic groundmass, in which greenish yellow phenocrysts of olivine or black pyroxene are seen. They can sometimes be porous. Neolithic and Eneolithic basalt artefacts are always strongly patinated with bright grey surfaces, on which brown phenocrysts of olivine or pyroxene can be seen. An important characteristic is their high magnetic susceptibility, which ranges from 20 to 35 x 10^{-3} SI within the basalts of the central part of Nízký Jeseník Highland, to slightly lower values around Opava (8–20 x 10^{-3} SI). Isolated outcrop of dolerite basalt in the Magura Group (Carpathian Flysch Belt) at Starý Hrozenkov near Uherský Brod reaches up to 6.8 x 10^{-3} SI.

Prehistoric Use: A rare basalt shoe-last celt was found at the Moravian Painted Ware site Těšetice-Kyjovice in Moravia (L 6314, Vokáč 2008), see Supplement/Photo 316. In Silesia and Moravia basalt was an important rock used by the Corded Ware Culture, where it comprises 51 pieces (or 12 %) of a 416 pieces collection of axe hammers (Přichystal & Šebela 1992, 34). Basalts in Hungary were favoured tool stones. Biró & Szakmány (2000, 29) found they were the next most common tool stones, after the group of greenschists and amphibolites. Within a study of 659 Neolithic polished stone tools, 124 pieces (19 %) were

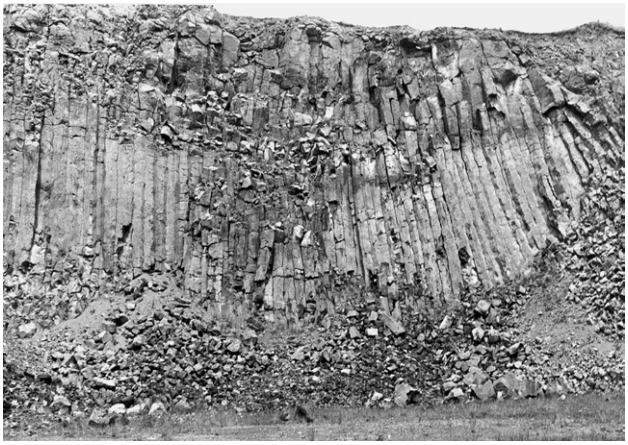

Fig. 116. Lava flow with columnar jointing of the Venus volcano, south of Bruntál. Alkaline basalts of Tertiary – Pleistocene age from northern Moravia and Silesia yielded suitable raw material especially for battle axes. Photo by the author.

basalts. In Slovakia, Cenozoic basalts occur only sporadically in the collections of Middle Neolithic and Early Bronze Age (Illášová 2001). In Poland basalt was a favourite raw material especially in Greater Poland, where it forms 15 % of an extensive Neolithic assemblage (Prinke & Skoczylas 1980), or in Kujawy (9–12 %). Surprisingly, lower figures were found in Upper Silesia (Foltyn et al. 2000).

III.2.6. Diabase, metadiabase, metadolerite (palaeobasalt, doleritic palaeobasalt)

General Characteristics: In Central Europe, Palaeozoic (or usually also Proterozoic) basalts changed by secondary alterations, that are mostly medium to coarse-grained but sometimes porous with aphanitic groundmass, are traditionally classified as diabases. Current petrographic terminology (Streckeisen 1980) does not recommend to take a rock age into account for classification, and to use the term dolerite or diabase only for coarse-grained basalt. But it is necessary to differentiate between these palaeobasalts in tool stone stereomicroscopic or naked eye study. Their appearance and provenance are completely different from Tertiary or Quaternary basalts.

Location: The most important diabase (palaeodolerite) occurrences in Moravia are within Devonian volcanic rocks of the Konice-Mladeč Belt in the Zábřeh Highland, the Šternberk-Horní Benešov Belt in the Nízký Jeseník Highland, and the Jindřichov (Czech Silesia) – Pokrzywna (Polish Silesia) Belt in the Zlaté Hory Highland. Visible metamorphic foliation is mostly developed in metadiabases of the Vrbno Group in the Hrubý Jeseník Mts. Proterozoic, Ordovician, Silurian and Devonian diabases have been identified in the Barrandian area in Bohemia. In Slovakia they occur in the Devonian-Lower Carboniferous Rakovec Group in the Gemericum. As for the Polish part

of the Bohemian Massif, probably the most interesting diabase is from the village of Słupiec near Nowa Ruda that is used as a decorative stone (Sachanbińsky 1979, 209).

Prehistoric Use: Diabases and metadiabases were found among polished stone tools of the Corded Ware culture in Moravia and Czech Silesia on several occasions (Přichystal 1999, 218). Hovorka & Illášová (2002, 83) identified two metadolerite axes (S-23, S-30) deposited in the museum of Senica, western Slovakia. The authors belive they originate from sources in the Bohemian Massif or as cobbles from gravels of the Morava and Danube Rivers.

III.2.7. Spilite and spilite volcaniclastic

General Characteristics: Extrusive Proterozoic or Palaeozoic basalts with preserved volcanite structure and texture but usually having mineral composition similar to metamorphic rocks in the greenschist facies (albite, K-feldspar, chlorite, actinolite, carbonate, titanite, leucoxene, rarely with relicts of pyroxene or more basic plagioclase) have been classified as spilites in Central Europe. The IUGS subcommittee permits using the term spilite in the above written definition (Streckeisen 1980). Spilites are accompanied by volcaniclastics (tuffs, tuffites, hyaloclastites) at all Central-European occurrences.

Background: In the Late Eneolithic the important Řivnáč culture dominated central Bohemia, with several dozen hilltop and hillfort sites. A large number of polished stone axes were made primarily of one raw material identified as spilite by Žebera (1955). In spite of Proterozoic spilite outcrops in central Bohemia, Žebera didn't think they were suitable due to tectonic damage. He looked for the origin of the tool stone of Řivnáč culture artefacts in the German Harz Mts. where younger Devonian spilites are found. However the short distance from spilite's natural occurrences in the Barrandian area and Řivnáč sites is eye-catching enough to think he was mistaken. Vencl (1975, 67) considered this possibility upon information on thin sections examination of lithic artefacts from the hilltop site of Prague-Zámka by researchers from the Landesmuseum Halle. They also concluded the material has been local from central Bohemia. Later, Fridrich & Kovářík (1980) thought that they found the prehistoric spilite mine at Vrané nad Vltavou south of Prague.

Location: Spilites crop out in the Barrandian area in five remarkable north-east to south-west belts. The central 140 km long stripe between Domažlice and Kralupy is the longest, the next one spreads between Slatina and Pavlíkov and the farthest north-west belt is between Stříbro and Plasy. South-east of the central belt spilites are found between Klatovy, Dobříš and Rokycany. The easternmost zone is the Jílové Belt within the Central Bohemian Pluton.

Apart from the Barrandian area, Devonian spilites occur in the Moravo-Silesian Klippen Belt that runs through the middle of the Drahany and Nízký Jeseník Highlands. Suitable spilite sources for the polished stone industry are thought to exist in north-east of Konice in the Zábřeh Highland, or between Šternberk and Moravský Beroun in the Nízký Jeseník Highland (Supplement/Photo 328, 329). Other important spilite occurrences are situated in the northern part of the Volovské Mts. (Spiš-Gemer Ore Mts.) in Slovakia.

Geological Setting: Spilite is a special type of basalt with the structure and texture of volcanites, but a mineral composition corresponding to weak metamorphic rock of greenschist facies. It is explained by a special metamorphic process that changed it after extrusion at the sea bottom. In the Barrandian the spilites are a part of the Upper Proterozoic Kralupy-Zbraslav Group and their pillow lavas reflect their submarine origin. Apart from the lavas, different types of volcaniclastic sediments (tuffs, tuffites) are plentiful. Spilites in the Drahany, Zábřeh and Nízký Jeseník Highlands represent typical basinal development of the Devonian (but also partly of the Lower Carboniferous, locality Ecce Homo near Šternberk) in the Moravo-Silesian Region. Geologically, Slovakian spilites fall into the Rakovec Group of the Gemericum, which is considered to be of the Devonian age as well. In all cases we are dealing with submarine volcanism where different volcaniclastics, such as, tuffs, tuffites, and hyaloclastites are found, together with pillow lavas.

Macroscopic Appearance: The rock from Vrané nad Vltavou (sample by M. Zápotocký) is aphanitic, dark yellowish green (10GY 3/2) on a fresh surface and with an almost conchoidal fracture (Supplement/Photo 326). But it has also a considerable jointing. A distinguishable strapping with several millimetre thick dark green and grey-green alternating strips is visible on weathered parts. Magnetic susceptibility is very low at 0.06–0.1 x 10^{-3} SI.

Thin section: Thin sections of the raw material from three Eneolithic sites in the Kladno and Slaný areas (Tuchoměřice-Kněživka, Makotřasy, Kvíc) were identified by K. Domečka (in Turek & Daněček 1997, 134–135). He ascertained the rock from all the sites as a weakly metamorphosed crystal tuff. The rock texture is micronematoblastic with preserved crystaloclastic relics. It consists of plagioclase, monoclinic amphibole, epidote, chlorite, opaque mineral, clinopyroxene, and amygdaloidal spilite fragments. Crystaloclasts of 0.05–0.5 mm in size are largely angular plagioclase. The groundmass is formed by an aggregate of monoclinic amphibole needle crystals and epidote group minerals, together with chlorite and plagioclase. K. Domečka compared the tool stone with the rock from Vrané nad Vltavou and pointed to the lack of a relict crystaloclastic structure and laminas rich in plagioclase crystaloclasts in the rock from Vrané that is characteristic for the tool stone of the artefacts.

Šreinová, Šťastný & Šrein (2002) conducted petrographic and geochemical analyses to compare the rock from presumed prehistoric open-pit mine at Vrané nad Vltavou and artefacts from the Řivnáč culture site Klobouček (Praha 5–Hlubočepy). They came to the conclusion that the rocks are completely different. They defined the rock from Vrané as tuffaceous siltstone while the raw material of Řivnáč axes as spilite tuffite. That's why they eliminated prehistoric mining of the spilite tuffite at Vrané nad Vltavou.

A. Přichystal reviewed both a thin section from Vrané nad Vltavou (Supplement/Photo 326, 327) and, thanks to J. Zavřel from Prague, also from a polished stone tool fragment from Hostivice-Palouk (Supplement/Photo 324, 325). Neither lithic artefact from Hostivice resembles the supposed source at Vrané nad Vltavou.

Prehistoric Use: Spilite volcaniclastics of the Barrandian Proterozoic reached of maximal importance in the period of Řivnáč culture. After the find of a processing site for polished stone axes at the Klobouček settlement (Prague-Hlubočepy), researchers began looking for the tool stone source mine. Fridrich & Kovářík (1980) thought that they found the mine at Vrané nad Vltavou, in a sharp cut of the left bank of the Vltava River where they described overburden dumps from prehistoric mining and the remains of blind shafts. According to these authors, the archaeological research of the shafts detected a number of mining tools like wedges, heads, and hammers as well as burned rocks. They classified the mine as Eneolithic. According to V. Šrein (oral report) the shafts are holes formed by repairs made to the Vrané Dam in the 1930's. The source of the Proterozoic volcaniclastics has not yet been reliably documented (see research results of comparative thin section studies above).

Numerous spilite tools are found already in the Early Funnel Beaker sites (Turek & Daněček 1997, 134). In their opinion they represent more than a half of the polished stone tools at some Řivnáč hilltop sites. The use of Proterozoic volcaniclastics ended during the Corded Ware culture. Processing of the Moravian Devonian spilite for polished stone tool has not been reliably documented. Spurný (1964) thought (based on J. Kukla's expert opinion), that they could be the source for a depot of four half-finished shoe-last adzes from Bezměrov, Kroměříž district. This depot is connected with the Linear Pottery culture.

III.2.8. Teschenite and picrite

General Characteristics: Teschenite is usually a dyke rock classified to the group of basaltic rocks with analcime. It was first identified in the Podbeskydská Hilly land, north-west area of the Moravo-Silesian Beskydy Mts., in 1861. The name is derived from the Silesian town of Těšín. Its dark minerals include pyroxene, amphibole and biotite. Plagioclase, alkalic feldspars and analcime represent the light minerals. Five years later the find of picrite from the same area was introduced in the contemporary literature. The term comes from the Greek "pikros" (bitter) in reference to the high content of magnesium. The rock is ultramafic, ultrabasic and rich in olivine phenocrysts. Augite, amphibole and biotite may be present. Both rocks together with basalts and other unusual rock types (monchiquite, fourchite, ouachitite) form the teschenite association.

Location: Rocks of the teschenite association are typically found in the Podbeskydská Hilly land in a belt between Hranice in Moravia, Těšín, and Bielsko-Biała in Poland. The Polish part between Skoczów and Bielsko-Biała has markedly less magmatic rocks than the Czech part. The other region with picrite and teschenite occurrences is in the Barrandian in central Bohemia. Teschenites are found between Karlštejn and Hlásná Třebáň, and picritic rocks in two strips. The northern strip includes outcrops between Sedlec and Loděnice, south of Křižánky and north of Slavíky. The south one is found between Hlásná Třebáň and Rovina, south of Mořinky and Řeporyje (Fiala 1970).

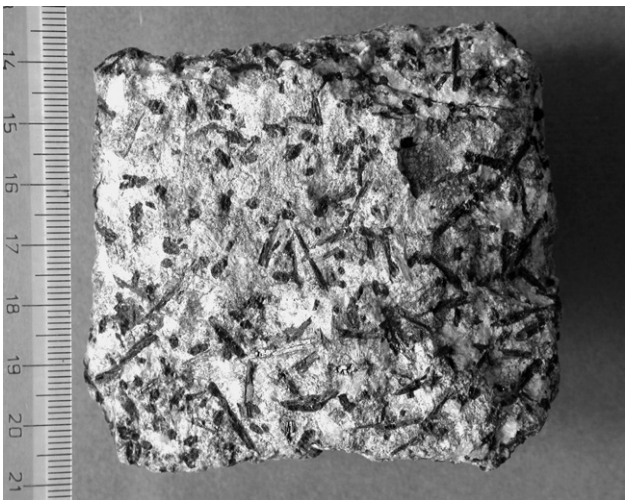

Fig. 117. Teschenite from Nový Jičín, northern Moravia, is a conspicuous porphyritic rocks. Photo by the author.

Geological Setting: Rocks of the teschenite association in the Podbeskydská Hilly land are Lower Cretaceous and protrudes from the Silesian Unit of the Carpathian Flysch Belt. Outcrops are found only in the Těšín-Hradiště Formation of the Baška development. So they are not in the Moravskoslezské Beskydy Mts., as it is sometimes wrongly assumed, because the Beskydy Mountains have been formed by the Godula development of the Silesian Unit. In the Prague Basin of the Barrandian, Fiala (1970) described occurrences of teschenitic basalts with analcime and picritic diabases to diabase picrites as a part of local Silurian volcanism.

Macroscopic Appearance: Teschenites from the area around Čertův mlýn near Nový Jičín (the Podbeskydská Hilly land) are striking, with sharp porfyritic appearance where dark needle-like pyroxenes and amphiboles reach to 5 cm in length with little isometric feldspars between them (Fig. 117; Supplement/Photo 330). The rock disintegrates easily into sandy detritus from which dark column-like pyroxenes or amphiboles may be collected. These striking minerals were used in prehistory as a temper for pottery production in the period of Púchov culture (Přichystal 2005).

Picrites are dark to green-black rocks with aphanitic groundmass and numerous small faces caused by light reflection on small phenocrysts of fissile dark minerals (micas, pyroxenes, amphiboles) so they can resemble lamprophyres.

Thin section: Hovorka et al. (2002) described a teschenite tool thin section from the Cífer-Pác site. It is

a medium-grained grey-brown rock with massive structure built of nearly unaltered multiple twinned albite plagioclases. Dark minerals are represented by purplish markedly pleochroic clinopyroxene, which is usually overgrown with intensively brown pleochroic kaersutite amphibol. Thin columnar apatite and opaque minerals are present as accessories.

A. Přichystal documented a teschenite artefact from Vávrovice near Opava in Silesia. According to the thin section and microprobe study the axe hammer rock is comprised of ternary feldspars, often in a fan-shaped arrangement. Hypidiomorphic to idiomorphic pyroxenes of diopside composition and amphiboles (kaersutites) are present, with the occasional analcime and needle-like apatite. The last one forms little inclusions in feldspars.

Prehistoric Use: Hovorka & Illášová (2002, 83, 88) provide us with both the only one picrite and teschenite finds from western Slovakia. They suppose the tool rocks come from Danube gravels as cobbles having original sources in the Podbeskydská Hilly land. According to the authors, they were transported to the Danube through the Bečva and Morava Rivers. But this is highly improbable.

An older archaeological contribution (Janovský & Skutil 1938) describes a 12.5 cm long teschenite battle axe found at Zahnašovice, 2 km south of Holešov related to the Corded Ware culture. This site is about 35 km from the nearest teschenite-picrite occurrences. The above mentioned teschenite artefact from Vávrovice near Opava, from P. Stabrava's archaeological research, is half of a battleaxe (i. n. 2218). Its magnetic susceptibility is 6.4 x 10^{-3} SI. The location is about 40–50 km from natural teschenite sources in the Podbeskydská Hilly land. Surprisingly the processing of polished teschenite tools has not been found close to the natural outcrops (Čípová 2006), despite a rich tradition of polished stone stone tool manufacturing in the area.

III.2.9. Phonolite

General Characteristics: The term phonolite ("sound stone" from the Greek "phone") refers to the property that when struck with a hammer, the stone chimes like a bell. It is a fine-grained porfyritic igneous rock with a marked abundance of nepheline. It also contains alkali feldspars (sanidin, anorthoclase), sodium pyroxene (usually aegirine) or amphibole, relics of titanite, apatite and zircone. Sanidin and nepheline form phenocrysts, and aegirine dark radiated aggregates. The rock has greenish or brownish-grey colour, with a mostly greasy lustre.

Prehistoric Use: Phonolites are often used for poli-shed stone tool production in southern and central Hungary. Hungarian authors identify their different types (e.g. Szamárhegy or Kövestetö types of phonolite; Biró et al. 2003). The source area is the Mecsek Mts. with the Early Cretaceous alkaline volcanites. Local phonolites were most likely used for polished tools in the České středohoří Mts. in north-western Bohemia.

III.2.10. Granites, granodiorites, quartz diorites, rhyolites, dacites

General Characteristics: This is a group of plutonic and extrusive igneous acid rocks with quartz. Plutonic magmatites (granite, granodiorite, quartz diorite) differing in K-feldspar and plagioclase content are classified as granitoides and macroscopic identification of individual types is sometimes difficult. The rock grain usually ranges within medium-grained to coarse-grained 0.33–10 mm. Dark minerals in granites are represented mostly by micas (biotite, muscovite) or tourmaline; biotite and amphibole occur mostly in granodiorites and quartz diorites. The rocks may be epigranular or porphyritic. Rhyolites and dacites are porphyritic superficial lavas with a fine-grained to aphanitic groundmass (low than 0.33 mm). Phenocrysts are formed by quartz or orthoclase and biotite. In dacite they are represented by plagioclase, amphibole, and more rarely pyroxene. If dacites do not contain quartz phenocrysts, they cannot be easily distinguished from andesites in most cases.

Prehistoric Use: Acid plutonites and volcanic rocks were used rarely for polished stone tools in Central Europe. In spite of outcrops of rhyolites and dacites in SE Slovakia and north-eastern Hungary, they are not often identified as tool raw material. They remain largely hidden with "unspecified igneous stone" (Biró & Szakmány 2000, 29) but it is clear that they did not represent important tool rocks. Oravecz & Józsa (2004) macroscopically identified only 3 rhyolite artefacts within a collection of 225 artefacts from the Hungarian National Museum.

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III.3. Sedimentary rocks

III.3.1. Lower Carboniferous (Culm) siltstone, silty shale and greywacke

General Characteristics: On the fresh surface the Lower Carboniferous clastic rocks are dark grey to grey-black and differ in the size of fragments from which they are formed. Greywacke is immature sandstone, it means that in addition to quartz it contains rock and feldspar fragments. Greywacke grain size in the Czech professional literature is noted as between 2–0.063 mm (see Hejtman 1981); upper and lower limits may differ slightly at different classifications. Siltstones have more than 50 % of grains between 0.004–0.063 mm and often occur together with clay shales or form transitional rocks (silty shales, clay siltstones).

Background: The first reference to this tool stone appears in the writings of the great amateur archaeologist A. Gottwald who operated in the Prostějov area. He described a 5.6 kg hammer with groove from Aloisov (today's Alojzov) on the east slope of the Drahany Highland as "a hammer from local Culm sandstone" (Gottwald 1916). Fourteen years later he described another large grooved hammer axe from Čechovice on the south-west border of Prostějov with more precise determination of the raw material: local Culm greywacke. According to current knowledge the Culm (Lower Carboniferous) sediments represented one of the most important raw materials for polished stone tools during the Eneolithic

Fig. 118. Hlinsko near Lipník nad Bečvou. A view towards the Moravian Gateway from the place of prehistoric quarrying of Culm siltstones near the hillfort of Badenian Culture. Photo by the author.

in Moravia and Silesia. This was proven with the discovery of a large workshop at Holasovice near Opava (Janák & Přichystal 2007) for the processing of Lower Carboniferous siltstones.

Location: Lower Carboniferous rocks build the prevalent part of the Drahany Highland, the southern part of Zábřeh Highland, the Nízký Jeseník Highland, the eastern part of Zlaté Hory Highland and the smaller block of Maleník Hill on the south-east side of the Moravian Gateway (Fig. 118). Small but important occurrences form underlying rocks in the city of Olomouc.

Geological Setting: The Moravo-Silesian Lower Carboniferous includes all clastic rocks: conglomerates, greywackes, siltstones and silty shales. The Moravice Formation of Nízký Jeseník Highland formed of greywackes on the one hand and alternation of greywackes, siltstones and shales on the other reaches to the southern surroundings of Holasovice where we know the most important workshop for axe hammers made of Lower Carboniferous siltstones.

Macroscopic Appearance: The dominant raw material from Holasovice and other locations in the Opava area is dark grey to grey-black (N3–N2, Munsell colour chart) in fresh wet cut. It is usually a homogeneous rock with massive structure but alternation of layers with slightly different colour was rarely found on artefacts (Supplement/Photos 332, 333). The raw material is aphanitic (without distinguishable mineral components). Weathered Lower Carboniferous sediments are grey-brown, green-brown (especially cobbles and pebbles from river gravels), sometimes yellowish brown or reddish.

Stereomicroscopic Appearance: A very fine-grained aleurite texture formed of whitish minerals in the dark clay matrix is visible within clay siltstone to silty shale (Holasovice, Opava-Palhanec) in water immersion (Supplement/Photo 334). Culm greywacke is easily distinguishable thanks to its arenaceous texture, dark colour and abundant stone fragments including striking black-grey shales.

Thin Section: The author studied thin sections of Silesian (Silesian museum in Opava, Strahovice, and Opava-Palhanec) and Moravian (Štramberk, Šišma) polished stone tools as well. Sharp or slightly curved quartz grains with undulatory extinction dominate in the raw material, but also sharply angular quartz grains with homogeneous extinction occur that may be indicative of volcanic quartz. Fragments of plagioclases with polysynthetic twinning or K-feldspars with no twinning are also common, lamellae of muscovite and baueritized biotite with brown pleochroism relics appear very often. Quartz and feldspars fragments are about 0.02 mm size, micas range to 0.05 mm (Strahovice). Heavy minerals are represented only by zonal green tourmaline and titanite. Further opaque schliers of probably organic matter or limonite infiltrations are present. Clay content often reaches to 50% so the rocks are classified between clay siltstones to silty shales (Supplement/Photo 335).

Fig. 119. Eneolithic battle axe made of Culm graywacke. Eastern slope of the Velký Kosíř Hill, district of Prostějov. Photo by the author.

Maštera (1972) described the raw materials of two polished stone tools from the Baden culture hillfort at Hlinsko near Hranice and a reference sample from the nearby Podhůra quarry. He identified the rocks as fine-grained greywackes in two cases (a tool and a reference sample); the other tool as a clay siltstone. Greywackes have a fine arenaceous texture with chlorite-sericite and silty matrix. The average grain size of clasts ranges from 0.12 to 0.18 mm and include fragments of rocks, quartz and feldspars, with some micas (biotite and muscovite). Garnet, zircon, tourmaline and leucoxene are present as accessories. Abundant fragments of polycrystalline quartz, Culm silty shale, phyllite, granitoides close quartz diorite to granodiorite, gneiss, and porphyritic volcanic rocks are characteristic for both greywackes.

Other Analyses: Magnetic susceptibility of fresh siltstones from the highest level of the Podhůra quarry close to supposed prehistoric mining ranges from 0.16–0.26 x 10^{-3} SI. Culm siltstones hammer axes from Holasovice and other locations in Czech and Polish Silesia have very low values, from 0.04 to 0.09 x 10^{-3} SI. They rarely exceeded 0.1 x 10^{-3} SI and reached higher values very exceptionally.

Prehistoric Use: The remains of the Eneolithic processing of this tool stone have been found across Moravia (Přichystal 2000). Remains are often found in the Prostějov and Olomouc area (Corded Ware culture), Vyškov (Jordanów culture), Hranice or Lipník area. Finds from Czech and Polish Silesia show that it was the primary tool stone of the Funnel Beaker culture in that area (Janák & Přichystal 2007). Prehistoric mining took place near Holasovice, at Opava in Silesia, during the Funnel Beaker culture period. Pavelčík (1990) referred to Culm greywacke and siltstone mining by people of the Incised Pottery Culture at Hlinsko near Lipník. Other specific sites of exploitation may be expected in the area of Velký Kosíř Hill (442 m, 14 km west of Olomouc) where the author obtained several polished greywacke tools (Fig. 119; Supplement/Photo 336).

III.3.2. Sandstones

General Characteristics: Sandstones are bright greenish, yellowish or brownish; in addition the colour is depending on the degree of weathering. They are often calcareous and it is possible to identify the presence of green mineral glauconite in marine sandstones using the stereomicroscope. These clastic rocks are classified as psammites or arenites (the grain size 2–0.063 mm). The main constituent is quartz (substantially less feldspar, mica and rock particles) with a mud (silty) matrix or mineral cement (silica, carbonate or ferrous minerals). Quality sandstones are usually of Cretaceous age, from the Cretaceous platform development on the Bohemian Massif or Silesian Unit of the Carpathian Flysch Belt, or the Tertiary in other units of the Carpathian Flysch Zone.

Prehistoric Use: Currently we have identified only sporadic use of sandstones (quartz arenites) for polished stone tools, which, due to aspects of the rocks character were used largely as whetstones. In a study of Corded Ware axe hammers in Moravia and Czech Silesia they included 24 artefacts, which together with siltstone and claystone comprised 6% of the whole assemblage. Přichystal & Šebela (1992) assume they were largely extracted from the Carpathian Flysch Belt (Fig. 120; Supplement/Photo 337). It is probable that some sandstone from the Bohemian Cretaceous Basin could appear in the tool stone basis used by the Bohemian Eneolithic cultures.

In Polish Silesia (Choleva 2004, 22) sandstones were the sixth most frequent tool stones found in an assemblage of 70 artefacts, including querns, axes and axe hammers. Sandstone is a relatively significant tool stone used for the polished stone tools in Hungary, comprising 19 pieces of a 186 piece assemblage (Biró & Szakmány 2000, 29). Oravec & Józsa (2004, 109) found a higher ratio (39 of 255) in the assemblage in the Hungarian National Museum, but again the collection included probably grinding stones (querns).

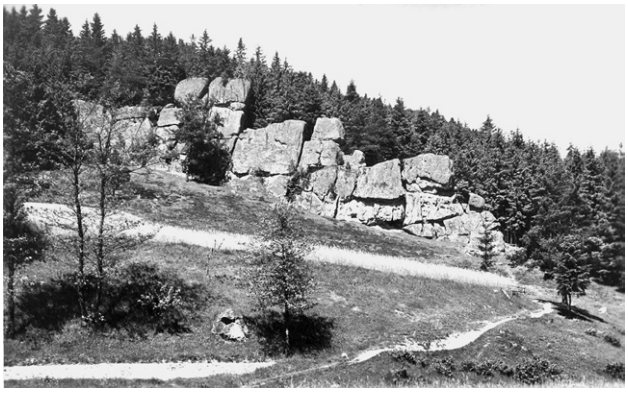

Fig. 120. Devel's Wall at Lidečko, SE Moravia, is formed of high-quality sandstone cropping out in the Carpathian Flysch Belt. Postcard, 1941.

III.3.3. Palaeogene claystone (eastern Slovakia)

General Characteristics: Claystone is a compacted, non-fissile and fine-grained sedimentary rock, largely composed of clay-sized minerals under 0.004 mm.

Location: Production of axes from this low-quality soft tool rock occurred in a relatively extensive area of eastern Slovakia, bounded by Sabinov, Humenné and Michalovce.

Geological Setting: Banská, Hovorka & Šiška (1998) identified the Central Carpathian Palaeogene formations as the source of this claystone. It rises up at the base of the Huty Formation (Eocene and Lower Oligocene) and in the Middle Oligocene Zuberec Formation.

Macroscopic Appearance: The claystone is bright green-grey to dirty brown. The surface of calcareous claystone artefacts have a microporous structure as a consequence of the weathering of the calcium carbonate. It is possible to observe changes in colour on the cross-section related to the intensive patination of the surface. The boundary zone, which is up to 1 cm thick, is significantly paler than the central part. In addition it has a more or less visible concentric structure, parallel with the unpatinated centre.

Thin section: Microscopic examination found that the rock consists of clay minerals, silty quartz fraction and carbonates (Banská, Hovorka & Šiška 1998). Within the centre of the artefacts a higher content of carbonate is preserved with the refractive index corresponds with calcite. Its content varies between 25–36%. Tiny idiomorphic dolomite crystals (0.X mm) are found. These simple singular crystals are also preserved in the border zones of artefacts, and are intensively pigmented by iron compounds. Such colouration is seen also in accumulations of microscopically fine-grained (silty) quartz particles. Carbonates have been replaced by a combination of opal and chalcedony.

The authors identified the clay minerals as kaolinite or illite on the basis of the refractive index (1.550–1.590). Glauconite, pyrite, some tiny chlorites and organic matter were also found as accessories. Carbonates and shales rarely appeared in the fragments. Uneven red-brown patches are ferric oxides and hydroxides. The only microfossils are relics of foraminiferans (*Globigerina sp.*).

Prehistoric Use: Claystone hatchets were produced in the Neolithic and Eneolithic in several places in eastern Slovakia. Banská, Hovorka & Šiška (1998) identified them at Šarišské Michalany (10 km north-west of Prešov). According to the authors the raw material – calcareous claystone – has the source in the Central Carpathian Palaeogene Basin and crops out in the surroundings of Šarišské Michalany as well. There is a fair amount of semifinished products and waste at the site, and it is one of only a few prehistoric polished stone tool processing centres found in Slovakia. These tools were produced by the Bükk culture in the latter phase of the broader Linear Pottery culture in Central Europe. A Corded Ware axe manufacturing centre was identified at Brestov-Dielna, 3 km north-west of Humenné (Strakošová 2001)

Fig. 121. Hallstatt fortified settlement at the Malý Chlum Hill near the village of Krhov in the Boskovice Furrow had a special tunnel entry quarried in local Cretaceous opoka (silty spongolitic marlstone). The mined rock was used for construction of the rampart. Excavation of A. Štrof in 1984. Photo by the author.

and about 55 km east of Šarišské Michalany. Square partly smoothened axes were produced and over 1,700 production fragments have been found at the site. The authoress supposes that the claystone source is situated on the outcrop at Vyšné Ladičkovce about 8 km to the north. The third place site of Palaeogene claystone axe production has been found at Moravany, 10 km west of Michalovce (Nowak et al. 2006) and 25 km south of Brestov. This was primarily a workshop at which the tool stone was chipped and polished. Some axes are very small (3.3 x 1.8 cm). The site is identified as early eastern Linear Pottery culture (Körös culture).

Similar qualities as the Carpathian Palaeogene claystone has a special rock from the Bohemian Cretaceous Basin called opoka (silty calcareous claystone with numerous sponge spicules). The opokas are easily processed and could also be used for polished stone artefacts. Numerous prehistoric settlements were located in the vicinity of their outcrops in western Moravia (Fig. 121).

III.3.4. Limestones (carbonate rocks)

General Characteristics: Limestones are rocks formed by precipitation from solution, sometimes with a substantial presence of organism relics (organogenic origin), or sometimes directly (chemogenic origin). They are composed especially of calcite, partly can be present dolomite or aragonite and usually they were deposited as marine sediments. Detailed macroscopic classification is usually based on the presence of fossils, such as corals, brachiopods, orthoceratites, algae, nummulites and others. Microscopic classification in thin sections is based on textures and calcite grain-size analysis (Folk's classification, Dunham's classification). Special types of limestones include Quaternary freshwater travertines, calcareous tufa and cave sinters.

Background: Limestones are soft rocks unsuited to making polished stone tools, but are nevertheless found within the polished stone artefacts of special purpose (maces). They had been easily processed into mainly decorative items such as beads, charms (in the Central European Neolithic), or also female sculptures (in the Balkan and Greek Neolithic).

Location: In the eastern part of Central Europe a wide range of limestones from Proterozoic slightly metamorphosed limestones to Quaternary travertine and tufa exist. Palaeozoic and Mesozoic limestones seems to be potentially suitable for polished stone artefacts. These rocks can been found across an extensive area. They are sufficiently consolidated and nonporous. Palaeozoic limestones are especially of Devonian age, from the Bohemian and Moravian Karst, with a wide range of other smaller outcrops (e. g. Čelechovice, Konice-Mladeč and Hranice Devonian in Moravia). Góry Świętokrzyskie (Holy Cross Mts.) in Poland are a significant source for Silurian, Devonian and Triassic limestones. Triassic or "Muschelkalk" limestones are abundant in southern Poland in the vicinity of Opole. Extensive occurrences of other types of Triassic carbonate rocks such as the Gutenstein or Wetterstein limestones, are spread across the Central and Inner Western Carpathians, in Slovakia and northern Hungary. Jurassic limestones rise up primary in the Pieniny Klippen Belt and in the Carpathian Flysch Belt, as the tectonic fragments or olistolites (Pavlovské vrchy Highland, Štramberk).

Macroscopic Appearance: Colour can be very variable from white through to grey, yellowish and reddish up to black. Limestones usually contain macro- or microfossils after which they are named, e. g. Silurian cephalopod limestone from the Barrandian, Jurassic crinoidal limestone from the Stránská skála Hill in Brno, Tertiary bryozoan or algal (previously lithotamnium) limestone in the Carpathian Foredeep. A simple test to identify composition is the use of 3 % HCl dropped onto the rock. $CaCO_3$ decomposes and CO_2 is released with a characteristic fizz. It is possible to use vinegar instead of HCl. Calcite is the dominant mineral of limestones and reaches grade 3 on the Mohs' scale. This mineral is soft and it is possible to scratch it with a steel blade. Limestones are not often pure and contain a clastic admixture of quartz, feldspar and other lithic fragments.

Prehistoric Use: An Upper Palaeolithic Gravettian sculpture, the Willendorf Venus, is probably the oldest example of the use of this rock. It comes from a well-known site in Wachau, Lower Austria, along the Danube valley between Ybbs and Krems. In 1908 an 11cm sculpture known as "Venus I" was found on the borderline of layers 8 and 9, and is dated between 25,800 and 24,000 BP. It is carved in an oolitic limestone. Based on the contemporary information (Binsteiner et al. 2008, Přichystal 2008) the raw material probably comes from the Stránská skála Hill in Brno (Supplement/Photo 340, 341).

Neolithic and Eneolithic polished limestone tools are rare in eastern Central Europe. A. Přichystal found a part of stone macehead made of probably Jurassic limestone on the eastern slope of Velký Kosíř Hill (Fig. 136); the artefact had to be transported for a long distance. Another

axe hammer from Wodzisław Śl. (20 km south-east of Racibórz, Upper Silesia) had been ground from yellowish Triassic algal (diploporous) limestone (author's determination for A. Podgórski from Wrocław), and is classified as belonging to the Corded Ware culture. It is a rare find, because Choleva (2004) does not list limestone at all in his summary of Neolithic tool rocks in Silesia. A similar situation exists in Slovakia, where natural sources of limestones are widespread (in the Triassic, Jurassic, Lower Cretaceous, Palaeogene, Sarmatian, Quaternary), but their use for polished stone tools or weapons is unknown. But there have been described cylindrical limestone beads decorated by engraved lines (Točík, ed. 1970, 126), similar to beads found in Bicske and Zengővárkonyi in Hungary.

A small number of limestone artefacts are known in Hungary because only 7 of 225 Neolithic and Eneolithic polished stone items in the Hungarian National Museum have been made of limestone (Oravecz & Józsa 2004, 110). Their infrequent use for the polished stone tools or weapons is certainly connected with the fact that the rocks are soft. Berounská (1987) assessed Eneolithic stone maces (very likely symbolic artefacts), which are something of an exception in Central Europe. The lithic raw material was identified in 47 artefacts, with slightly more limestone artefacts (9) than serpentinites (7 pieces). It is evident that the characteristics required for practical use were not taken into account. Conversely it must have been important that the rock was easily worked.

III.3.5. Bituminous siderite claystone (Kounov sapropelite, "švartna" in Czech)

General Characteristics: "Švartna" is the local Czech name for this strongly bituminous siderite black claystone with copious coprolites and fish scales. The name is derived from the German "Schwarte", meaning roasted bacon skin. Based on the sedimentary rocks classification, it belongs to kaustobiolites, subgroup sapropelites. Strictly speaking it is a type of coal with an inorganic clastic admixture, formed by the anaerobic decomposition of plants and animal organisms at the bottom of water reservoirs.

Background: Žebera (1980) notes that J. Žofka, a grammar school professor in Kladno, found the first Kounov sapropelite jewellery manufacturing site at the Late Hallstatt settlement near Velká Dobrá (district of Kladno) in September 1932. Local farmers initially noticed the waste from jewellery production in the area of the prehistoric manufacturing sites, calling them "little fallen stars". Mining clerk J. Bauman initially mentioned this raw material in the local press, and noted the production of Kounov sapropelite around Nové Strašecí. In the early 20th century the prehistoric bracelets were identified as lignitic, with the term "švartna" or Kounov sapropelite coming into use later. A modern comprehensive evaluation of the Kounov sapropelite and macroscopically similar rocks was conducted by Venclová (2001) with petrographer B. Žáková and palynologist P. Valterová.

Location: Outcrops stretch from Přílepy and Kněževes eastward across Kounov, Kroučová, Kalivody, Libovice, Slaný, Velvary, Kralupy and Mšeno. The most accessible sourcers of the Kounov sapropelite are in the area of Přerubenice, Bdín, Srbeč, Hřešice and on the slopes of the valley around the Srbeč stream.

Geological Setting: The greatest occurrences of the Kounov sapropelite are in the western part of the Kladno-Rakovník Basin. This Upper Carboniferous rock forms a 10–20 cm thick layer in the roof of the upper Kounov black coal seams in the vicinity of Rakovník and Slaný. Stratigraphically it is a part of the Slaný Formation of the limnic Upper Carboniferous in the central Bohemian area.

Macroscopic Appearance: It is brown-black to grey-black compact rock without recognisable grains, but with well-developed bedding planes along those it disintegrates into thin to sheet-like flat fragments. A film of ferrous oxides or hydroxides and other secondary minerals (gypsum, calcite) is common on the bedding planes of weathered pieces. Unpolished stone has a dull lustre. Faunal relics include fish scales and coprolites.

Thin Section: According to Žáková (2001, 229) pelobitumenous matter is prevalent, with tiny lenticular or flaky inclusions visible under fluorescence. They are 4–10 μm and have a yellow to yellow-brown fluorescence. B. Žáková classifies them as liptodetrinites and they probably represent the remainders of tiny cellular algal vegetation. Aside from this type, the colonies (bodies) of the other alginite type *Botryococcus* (green algas characteristic for limnic or limnic-brackish environment) have been found as well. She even found a third type of alginite in some samples. Inorganic material includes clay minerals, microcrystallic pyrite (usually limonitized), clastic calcite, siderite, quartz, mica mineral and sometimes a radioactive mineral with a white edge, which has not yet been identified.

Prehistoric Use: The Kounov sapropelite is a well-known raw material used for the production of black bracelets in the Hallstatt and especially La Tène periods. It is probable that a "magic power" was ascribed to the black colour of the sapropelite, which appears with polishing. The oldest bracelets come from a Late Hallstatt period juvenile skeleton burial found in a grave at Bylany, near Český Brod, and another skeleton burial near Železnice in the Slaný area (Žebera 1980, 237). Two "švartna" bracelets have been described in a Hallstatt sacrificial site of approximately the same age in the Býčí skála Cave in the Moravian Karst. Venclová (2001) summarised the processing of Kounov sapropelite by Celts in the La Tène period in detail. Her work also includes a list of "švartna" or similar rock artefacts in Central Europe. K. Žebera assumed that Celts mined this raw material, as the sapropelite is always strongly weathered on outcrops. He has mentioned that the probably Celtic gallery was discovered by modern mining near Hřešice in the Slaný area (Žebera 1986, 15). More detailed information on such important find is not available, and that is why Venclová (2001, 67) notes that La Tène mines have not yet been proved.

III.3.6. Březina shale (southern Moravia)

General Characteristics: Moravian geologist J. Dvořák introduced the term Březina shale into the Czech professional literature, naming the rock after a local village near Brno. These dusty to sandy shales are grey-green, olive-brown or red-brown after weathering (Supplement/Photo 339). They form about 30 m thick layers under the Culm sediments of the Drahany Highland. Their bedrock usually contains limestones of the Líšeň Formation. Based on well-preserved trilobites and brachiopods, they are classified as Lower Carboniferous, corresponding to the Lower Visean stage.

Background: This rock is not suitable for polished stone tools because it is too soft and disintegrates often in small fragments, on the other hand it was ascertained its using for this purpose during a rescue excavation in the quarry of the cement factory at Mokrá near Brno (Šebela, Škrdla & Hložek 2002; Kuča 2007).

Location: The Březina shale is known mainly from outcrops along the southern boundary of the Moravian Karst. It has been identified also outside the Moravian Karst in central Moravia (Čelechovice na Hané, Hranice).

Other Analyses: Magnetic susceptibility is very low and ranges from 0.13–0.14 x 10^{-3} SI. Gamaspectrometric measurement on the outcrop at Mokrá obtained values of 1.8–2 % K, 2.9–4.2 ppm U and 10.2–11.8 ppm Th.

Prehistoric Use: Archaeological research at the village of Mokrá has provided information about processing of the shale during the period of Moravian Ware culture, phase Ic. Aside from finding rocks commonly used for polished stone tools in the Brno area (Želešice type metabasite and Rokle type amphibole diorite), researchers found a rare miniature axe hammer and axes made of local Březina shale. A fair amount of the raw material and waste was found in a few archaeological features. The practical purposes of the occasional polished stone tools production have not been reliably explained because of very low quality of the Březina shale.

III.3.7. Iron ores

Background: Iron ores are a unique raw material suitable for the production of the polished stone tools. In the eastern part of Central Europe several polished artefacts made of this unusual material have been found in the area of the Moravian Gateway (around Nový Jičín in northern Moravia) and only individual finds from two other places. The iron ores used are of sedimentary or volcanic-sedimentary origin and underwent a weak regional metamorphosis in some cases.

Prehistoric Use: The oldest item classed in this group is not the classic Neolithic or Eneolithic polished stone axe, but a famous Palaeolithic sculpture called the Petřkovice or Landek Venus. This 46 mm high female torso was carved and smoothed from a piece of red-brown iron ore (hematite) and was found near one of the Gravettian fire places on the Landek Hill, Ostrava-Petřkovice. The raw material of the sculpture is a massive and compact dusky

Fig. 122. Axes made of iron ores (hematite and limonitized hematite) from the surroundings of Nový Jičín in the Moravian Gateway. The bigger axe with groove (lenght 14.6 cm) comes from the village of Libhošť, the lesser one was found at Sirkové Lázně (recently a part of Nový Jičín). Photo by V. Janák.

brown (5R 2/2) stone without visible grain or inclusions and with very low magnetic susceptibility (0.07 x 10^{-3} SI). The description of raw material is complicated by the thin film of preserving varnish with sporadic mineral impurities. C^{14} dating of artefacts from the location delivered dates between 20,790 ± 270 BP and 23,370 ± 160 BP. This site is classified as the Gravettian younger Willendorf-Kostenkian phase (Svoboda et al. 2002, 183).

Fragments of similar raw material were found near the sculpture during archaeological research. They have been used for the preparation of polished sections and their observation in reflected light, or for the preparation of thin sections and for the x-ray structural analysis (Cílek & Jarošová 2000). Study of polished facets of the ore fragments from the site conducted with the help of the energy dispersive analyser (EDAX) found Fe_2O_3 in the range of 65.5 to 67.5 %. Based on the x-ray investigation, hematite is prevalent (55–60 % of the sample material) and goethite [FeO(OH)] is found up to 10 %. The occurrence of quartz had been proven by several methods and falls between 25–26.4 %. Quartz creates partly significantly angular grains of several micrometers, and slightly larger gently crystalline aggregates are found up to 10–15 µm. Newly formed SiO_2 appears to slightly impregnate the whole stone. Other minerals include the decomposed remains of muscovite and unspecified clay minerals. Natural occurrences of only brown to yellow limonite films or concretions formed on the local Upper Carboniferous clastic sediments are known at the locality. For this reason Cílek & Jarošová (2000) have supposed the source of the raw material in older Devonian rocks of the Hrubý Jeseník Mts. around Rýmařov or in the Nízký Jeseník Highland around Horní Benešov, or the iron ores redeposited on the fluvial terraces of the Opava River.

Apart from the Landek Venus, other interesting Gravettian items include a ground hematite disc with

35 mm in diameter, found in the famous male grave Brno II in Francouzská Street, in 1891. The assemblage and C^{14} date the artefact to the Willendorf-Kostenkian phase (Svoboda et al. 2002, 203), the same period as the Landek Venus. According to Mrázek (1996, 27) a gingery brown to reddish hematite was used as the raw material for the disc (limonite had been mentioned in the older papers).

A remarkable concentration of five Eneolithic to Old Bronze Age axes having usual shapes but made of iron ores (Fig. 122) were found in the northern part of the Moravian Gateway around Nový Jičín (Janák, Přichystal & Grepl 2004). A notched axe weighting 1.5 kg, 146 mm long and made of a massive piece of hematite was found at the Libhošťská Hůrka Hill near Libhošť (6 km north-east of Nový Jičín) in 1913. The raw material of the axe is dark brown (5YR 2/2) but the streak is red. Its magnetic susceptibility is low (0.80–0.88 x 10^{-3} SI). Based on its shape, it can be classed as an Early Bronze Age axe. The other item is a 220 g heavy, 89 mm long axe with a round butt, oval cross-section and symmetric edge. It was found at Sirkové Lázně, now a part of Nový Jičín, before 1920. The axe is probably of the Eneolithic or Early Bronze Age. It has been made of massive limonite or limonitized hematite. The surface and streak has brown to brown-red colour. Magnetic susceptibility is slightly higher, at 1.33 to 1.4 x 10^{-3} SI. According to a manuscript report (for more details see Janák, Přichystal & Grepl 2004, 184), the third item was a part of probably iron ore axe hammer, found in the area of Dolejší Kunčice north-west of Nový Jičín in 1891. The artefact came from a private collection. Unfortunately its current location is unknown. The collector J. Diviš recently found a fourth polished stone tool near the village of Sedlnice 8 km north-west of Nový Jičín (Diviš 2005). He described it as an axe of common Eneolithic shape 8 x 5 x 2.8 cm. It has been perfectly polished with a metallic appearance. It is very similar to the artefact from Sirkové Lázně and the collector has supposed to be also made of hematite. Finally, Grepl (1998) found a fifth hematite tool at the Kotouč Hill near Štramberk, a well-known prehistoric site near Nový Jičín (8 km south-eastward).

The concentration of polished stone tools made of this unusual raw material around Nový Jičín is very significant and probably caused by the proximity of a suitable iron ore source. Quality hematite ore is found in the nearby area of the Nízký Jeseník Highland, where originated as a result of Devonian undersea volcanism. The iron ores rise up in a narrow geological unit called the Šternberk-Horní Benešov Belt in the middle part of the Culm sediments. This local Lahn-Dill type of iron ores (prevalently hematite) was used as a dye already in the Palaeolithic. Finds of Palaeolithic chipped artefacts from the vicinity of iron ore natural occurrences around Šternberk and Moravský Beroun on the one hand and pieces of the same type of hematite at Palaeolithic stations in Moravia and southern Poland (Přichystal 2002, 75) on the other hand prove that. Mining and processing of these iron ores during the Early Iron Age have been evidenced by accumulations of furnaces that have been found near Štarnov in the area of Šternberk.

The Odra River has its spring only 12 km far from the iron ore deposits near Moravský Beroun, than it flows from the Nízký Jeseník Highland to the south-east and just at Nový Jičín it turns at a right angle to the north-east. Following its stream and valley it was possible to reach the area with sources of iron ores in the prehistoric times.

Numerous Neolithic and Eneolithic sites in Moravia yielded usually only partly ground pieces of hematite. The purpose of hematite using is not always clear. Generally it is supposed it was powdered for a body dye or colouring substance for surface of ceramic products, for example in the period of Moravian Painted Ware. In some cases the hematite pieces have signs of grinding, so they could serve as a special type of very fine-grained whetstone, in addition they left red colour on the tool surface. As examples of Neolithic localities with red colour relics in small depressions on the stone shoe-last adzes surface the author can mention the settlement with Linear Pottery at Vedrovice (south Moravia) or Vésztö in Hungary, the biggest Neolithic tell in the Pannonian Basin (Kárpát-medence). Pavelčík (1986) has introduced similar partly ground nine hematite pieces and one limonite fragment from a hillfort of the Chanelled Ware culture at Hlinsko near Lipník nad Bečvou in the Moravian Gateway. One piece has even the shape of very small axe (length 39 mm) with a pointed back and an elongated facet instead of the edge. We know also a unique hematite bead from a Bošáca culture hillsite at Bánov (Uherský Brod area, SE Moravia).

III.3.8. Other sedimentary rocks

The professional literature has described also using of siltstone and claystone of different sources as those from the Moravo-Silesian Lower Carboniferous (Culm) and Central Carpathian Palaeogene. It is possible to mention such rocks from the Flysch Belt of the Western Carpathians. Polished stone tools from Proterozoic siltstone may be found in central Bohemia, occasional using of Upper Carboniferous-Permian fine-grained clastic rocks can be supposed in areas with the same age bedrock. Rocks of relatively good quality, especially in Slovakia, include Low Triassic quartzites (quartz sandstone with siliceous cement) forming usually the lowermost part of cover units in the majority of the Tatricum core mountains. Their large flat cobbles from river gravels were even more suitable for manufacturing polished stone tools. The author found an adapted quartzite cobble with ground groove, used as a prehistoric mining tool, on a refuse rock pit tip of the cupper ore mine at Špania Dolina-Piesky, central Slovakia (Supplement/Photo 338). A few other quartzite tools (a polished cobble and a ring brace from Nitriansky Hrádok, a chisel from the Slovak National Museum in Martin) are mentioned by Hovorka & Illášová (2002, 99). A Neolithic quartzite statue in the Senica museum was described by Pichlerová (1961). In Moravia, quartzite was used for making a mallet with groove (3.3 kg weight) found at Otaslavice in the Prostějov area (Gottwald 1916).

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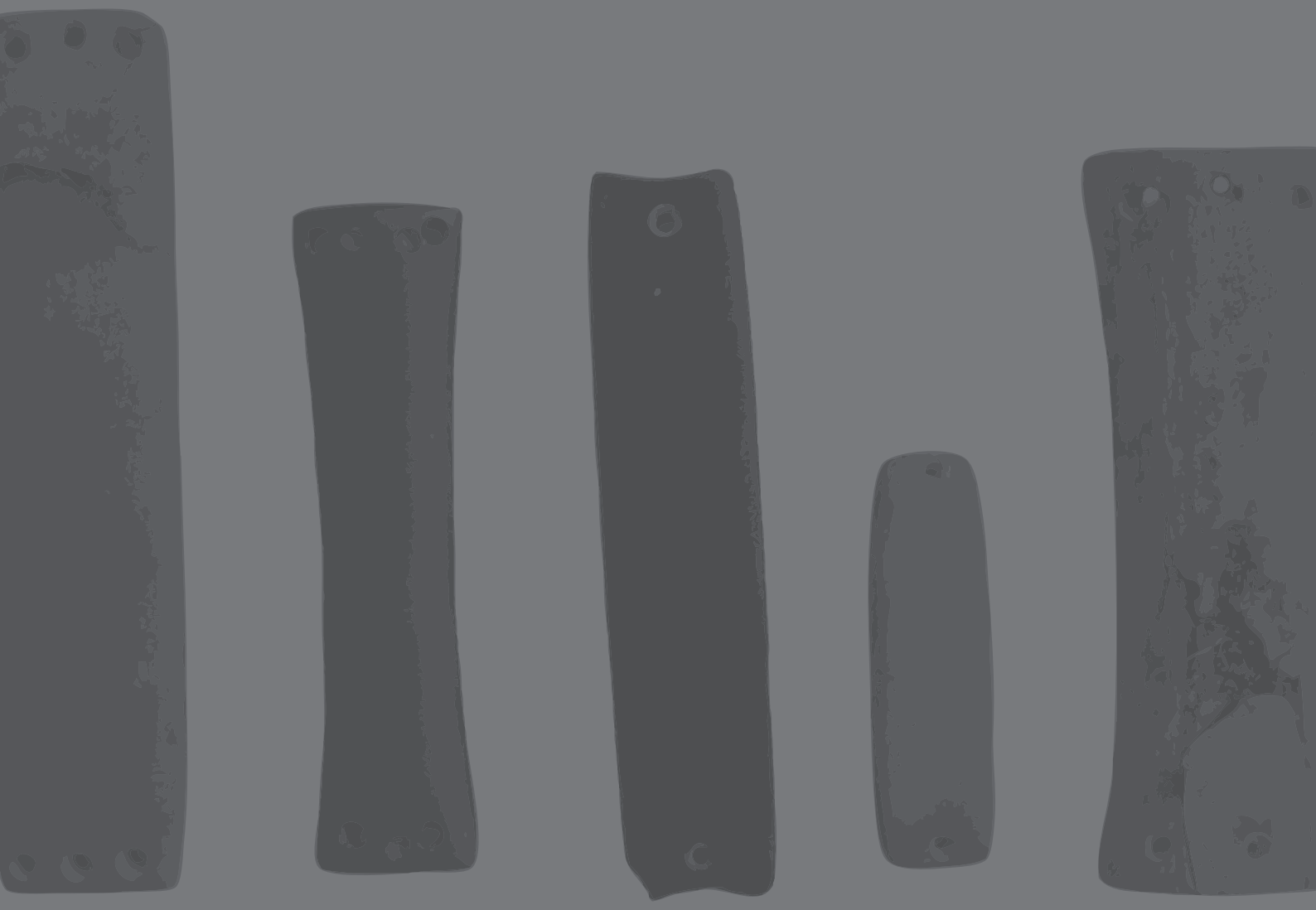
IV.
RAW MATERIALS OF WRISTGUARDS



Stone wristguards served to protect the inside of the archer's wrist usually of the left hand against the recoil of the bow string. They were used by people having the bow as a principal hunting weapon and their position on the left wrist is shown for example on Neolithic rock paintings of bowmen in Tassili (Lhote 1962, Figs. 22, 43, 44), a rocky area in the central Sahara Desert north-east of Ahaggar, Algeria.

In Central Europe wristguards are usual artefacts of the Late Eneolithic Bell Beaker and Proto-Únětice cultures and the Nitra group from the Early Bronze Age. The author studied raw materials of eight wristguards from a burial ground of the Nitra group at Holešov, central Moravia (Přichystal 1985). Dominant rocks are fine-grained sandstones to siltstones of yellow brown colour, with content of muscovite, sometimes calcareous. One wristguard is made of dark slate and for two next was used very light grey silicified radiolarian claystone (Supplement/Photo 342). A source area for the prevalent fine-grained clastic rocks is supposed in the Carpathian Flysch Belt east and south-east of Holešov. The radiolarian claystones come most probably from the Pieniny Klippen Belt of the Western Carpathians (the vicinity of Vršatské Podhradie in the Bílé Karpaty Mts.) where they occur together with radiolarites used for chipped tools. Similar raw materials (fine-grained micaceous sandstone and non-calcareous siltstone with sponge spicules) were used for two wristguards from Březolupy and Kunovice (district of Uherské Hradiště) connected with the Bell Beaker culture (Vaškových 2007).

As is other Bell Beaker wristguards found in Moravia concerned, it has been published raw material composition of a wristguard from a grave at Jezeřany-Maršovice: non-calcareous greenish yellow grey Tertiary claystone, partly disintegrated (Přichystal 1981). Used rocks for wristguards were studied as well when P. Dvořák prepared a catalogue of the Bell Beaker culture finds in Moravia. Přichystal (1992) ascertained non-calcareous micaceous silty claystone and non-calcareous micaceous sandstone in Brno-Holásky, greyish black Lower Carboniferous (Culm) shale at Ivančice, brown red Devonian silty shale in Brno-Líšeň etc.

A large collection of wristguards from a Bell Beaker culture burial ground at Hoštice-Heroltice near Vyškov (central Moravia) was studied recently by Přichystal & Všianský (2012). All eleven wristgards have been prepared from fine-grained or aphanitic sedimentary rocks prevalently of Tertiary age: 5 fine-grained feldspathic sandstones, 2 marlstones to sandy limestones, 1 silicified claystone and 1 tuffaceous shale. The last two artefacts (wristguard and small bored flat pebble serving probably as a wristguard) were made from dark to black Culm shales.

A study of twelve wristguards of the Bell Beaker culture from north-western Bohemia showed the fine-grained sedimentary rocks (silty claystones) of the Tertiary or Carboniferous age are dominant also there. Cretaceous sandstones were used as well (Přichystal 2000, 133).

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V.
RAW MATERIALS OF WHETSTONES

Whetstones (hones) are small stone artefacts served to finish grinding and polishing of axes in the Neolithic and Eneolithic, in younger periods of prehistory they were needed to sharpen knives and other edged metal tools. This function outlasted up to the first half of the 20th century when the natural rocks have been replaced by artificial whetstones made of silicon carbide (SiC). Bored rectangular whetstones could be used as pendants but their size and form varied widely. Two part whetstones with a central groove are believed to serve for manufacture of arrow shafts. Whetstones usually have on their surface characteristic curved polished planes or furrows. Comprehensive data on prehistoric or early medieval whetstones are represented in the Czech archaeological literature by publications of Kaván (1961) and Vencl (1964).

Recent analogies from New Guinea and finds from Central European prehistory show the grinding of stone tools has been done first on big boulders (polissoirs) often with distinctive worn grooves. They are found very often near settlements where the grinding was accompanied by watering or suitable rock boulders could be situated just in small water streams. The traces after using (grooves) have usually shape of the V letter in the cross section. Various hollows and grooves as evidence after sharping of swords or other metal tools can be found on many medieval sandstone buildings. Wankel (1884) mentioned them on churches walls of central Moravia; Lustig (1942) described them from Prague churches. Vencl (1995, 24) documented medieval traces after sharping of halberds on the gate of the Bridge tower (entry to the Charles Bridge from the Little Quarter in Prague) or after unidentified metal edges on the Saint Giles church walls in Prague. Very distinctive grooves after sharping are on the outer back wall of the St. Vitus' Cathedral at the Prague Castle (Fig. 123) or the author found them also on the gate of the Cimburk Castle in the Chřiby Highland (Moravia).

Very interesting traces after grinding were found at a few natural sandstone localities of the Bohemian Cretaceous Basin. Vencl (1995) described a boulder of fine-grained sandstone under overhanging rock in the cadastral area of Brtníky (district of Děčín) covered by tens grooves of various directions after grinding of rounded objects. Finds of potsherds in the boulder vicinity permit to explain the grinding grooves as even from the Eneolithic. Next outcrops with grinding traces have been ascertained near the confluence of the Suchá Bělá and Kamenice Rivers or above the confluence of the Olešnice and Kamenice.

Janšák (1955) informed about three big boulders with traces after grinding (polissoirs) in the Neolithic stronghold at Pečenice (central Slovakia). According to him the polissoirs would be of volcaniclastic rock – fine-grained trachyte tuff (comparing recent geological map it is more probably rhyolite or andesite tuff). Š. Janšák believed the stronghold at Pečenice was a centre of polished stone tools production because there are their numerous finds in the surroundings.

Fig. 123. Notches connected with grinding of medieval metall veapons on Cretaceous sandstone ashlars in the back part of the St. Vitus` Cathedral in the Prague Castle are analogical to tracks after grinding of prehistoric stone implements. Photo by the author.

Abrasive raw materials, usually fine-grained clastic rocks with high contents of quartz (quartz sandstones, orthoquartzites, arkosic sandstones, and siltstones) were used to manufacture whetstones. Quartz sandstones of the Bohemian Cretaceous Basin, Cretaceous – Tertiary sandstones of the Carpathian Flysch Belt, arkosic sandstones of the limnic Permian and Upper Carboniferous or fine-grained rocks of the Moravo-Silesian Culm (siltstones, silty shales) represented such abrasives in the eastern part of Central Europe.

More than 900 whetstones made of very fine-grained sandstones or calcareous medium-grained sandstones of Cretaceous (Cenomanian) age have been found at the Neolithic site (especially Linear Pottery culture) of Bylany near Kutná Hora. Their raw materials were acquired in the area of Bohemian Cretaceous Basin. V. Hoffman and A. Hoffmanová (in Pavlů & Rulf et al. 1991) have supposed the surroundings of Kutná Hora or the vicinity of Hořice (about 50 km to the NNE). Generally there are various sandstones in the Bohemian Cretaceous Basin considered as suitable raw materials for whetstones even in the 20th century (Králův Dvůr, Nehvizdy, Hořice sandstones and others). Rybařík (1993) characterized in detail the sandstone from the vicinity of Králův Dvůr nad Labem. An isolated occurrence of high quality Cretaceous quartz sandstones with small limonite concretions has been occasionally quarried at Maletín west of Mohelnice (NW Moravia). This rock appeared among raw materials of whetstones at a well-known site with the Linear Pottery culture in Mohelnice and it was distributed in prehistory towards central Moravia, for example it was probably ascertained at the site of Kostelec na Hané, a settlement from the Late Roman Period (determination by the author in Vachůtová 2006; Supplement/Photo 345).

Brownish arkosic sandstones of Permian age were also very popular because they appeared at the both

Neolithic sites of Bylany and Mohelnice. Ulrychová, Fediuk & Pauliš (2005) found numerous whetstones made of Permian arkosic and limonite sandstones in the area of Jičín in northern Bohemia. These rocks were also used as whetstones at Neolithic settlements in the surroundings of Boskovice Furrow in Moravia because the Furrow is filled with the Permian and Upper Carboniferous arkoses and arkosic sandstones (Supplement/Photo344). As examples it is possible to introduce Brno-Žebětín and Rozdrojovice near Brno (culture with Moravian Painted Ware) or Vedrovice (Linear Pottery culture) SE of Moravský Krumlov. Culm siltstones and silty shales were used for whetstones in central and northern Moravia (for example in the area of Velký Kosíř Hill near Prostějov; Supplement/Photo 343).

Outstanding sources of rocks for whetstones occur also in the Flysch Belt of the Western Carpathians (Supplement/Photo 347). An adapted pebble of flysch sandstone served originally as a whetstone (Přichystal 2000) but later was used probably for grinding of big bones for a cremated burial of the Lusatian urnfield culture found at Třebčín, district of Olomouc (Supplement/Photo 360). Whetstones for sharping of scythes in the 20th century were manufactured from a flysch sandstone quarried at Liptál near Vsetín (SE Moravia). Hovorka & Illášová (2002, 93) ascertained arkosic sandstone probably of the Palaeogene age as a raw material of whetstones in Slovakia. Some thermally metamorphosed fine-grained rocks could be used as polissoirs as well (Supplement/Photo 346).

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VI.
RAW MATERIALS OF CRUSHERS, SADDLE QUERNS, ROTARY QUERNS AND MILLSTONES

Raw materials for milling equipment have always been an object of the due attention in the past. This is also documented by a number of accounts from the Middle Ages that corroborate the privileged position of millstones because the quality of an important foodstuff (bread) was dependent on them. For example in his *Miscellanea historica regni Bohemiae* from 1679 (publ. 1986, 105), B. Balbín states: „We produce millstones at home, both the upper and lower ones. There is no region in Bohemia that would have to procure millstone from another part as it is our quarries, in which the most suitable is cut loose". Similarly J. A. Komenský in his work *Physicae* from 1633 divided stones into common and precious (gemstones), and, apart from opoka, pumice, quartz, whetstone, touchstone, marble, and magnetite he also mentions millstone among eight types of common stones (Suk 1992). Even with marking off medieval properties the sources of millstones were especially listed alongside gold, iron, and other metal mines. Prasek (1903, 21) mentions a deed by Margrave Vladislav Jindřich I, who, upon defining the property of the Hradisko Monastery in Olomouc, stated that „whatever of gold, iron, millstones, and other metals will be found within the estate of the given monastery, the proceeds of these will be kept by the monastery".

In Central Europe saddle querns (also grain rubbers, hand mills, crushers, and grinding stones) only appeared in a systematic manner with the coming of the earliest farmers with Linear Pottery. A saddle quern is a two-part equipment primarily used for crushing of grain; it consisted of a stationary lower stone bottom in the shape of an oval, slightly concave saddle with a polished upper surface (a crusher), and a smaller, globular stone (a rider). This was either rotated by hand or used as a pestle. The term grain grinder is often used for this oldest type of hand mill although the equipment might not always be used for the preparation of flour. Their usage for triturating of dyestuffs has been described; they could have been used for crushing of various fruits, bones, possibly also minerals or ceramic potsherds as a temper for newly made pottery. Occasional finds of stones with surfaces after grinding have been recorded as early as in the Palaeolithic.

VI.1. The Neolithic to Hallstatt Period

In the Czech Republic the raw materials of saddle querns or grain rubbers of the Linear Pottery culture are quite well known, as large collections of these have been examined at the three best known sites – at Bylany near Kutná hora, central Bohemia; Mohelnice, northern Moravia, and Vedrovice, southern Moravia. The weight of common Neolithic to Hallstatt lower stones usually varies around 3 to 8 kg.

The Neolithic settlement at Bylany has yielded a vast collection of 597 pieces of saddle querns; according to Pavlů & Rulf et al. (1991, Tab. 60) the absolute majority of these (over 70 %) have belonged with the Linear Pottery culture, the smaller part (fewer than 5 per cent) to the Stroke-ornamented Pottery, and the rest was designated as Neolithic (it could have been related to both of the above). The raw material evaluation of the entire complex of the so-called other stone industry (querns, whetstones, stones with no further classification) was carried out by Hoffman & Hoffmanová (1991), who have ascertained a wide spectrum of igneous rocks, sediments, and metamorphic rocks. Unfortunately their paper does not provide a clear differentiation of the raw material composition of querns (millstones in their paper) from whetstones and non-classifiable artefacts. Tourmaline-muscovite granite (39 pieces) was used for querns; this rock probably originates from Přibyslavice (at a 16 km distance from Bylany), and would represent the only rock for querns transported from a greater distance. The other types of rocks ascertained were capable of acquiring within the Kutná Hora Crystalline Unit, i.e. roughly in the wider surroundings of Bylany. From the group of igneous rocks these are granite pegmatites (43 pieces) and aplites (38 pieces) occurring as dykes in the gneisses of the above mentioned geological unit. Among the raw materials of querns it is also possible to class a prevailing part of the determined metamorphic rocks: micaschist to micaschist gneiss (50 pieces), biotite gneiss, migmatite, red orthogneiss, and pencil gneiss of the Doubravčany type (105 pieces in total); then erlan (44 pieces), metaconglomerate, quartzite and metaquartzite (123 pieces), granulite (55 pieces), and scarns (48 pieces). Quartz conglomerates of Cretaceous age (51 pieces) probably also belong to the raw materials of querns. All the above metamorphic rocks were capable of acquiring within the Kutná Hora Crystalline Unit; the same applies to the Cretaceous quartz conglomerates, which form a basis of the sedimentary filling of the Bohemian Cretaceous Basin in the vicinity of Kutná Hora.

Likewise over 400 stone artefacts from the settlement of the culture with Linear Pottery in Mohelnice, northern Moravia, were studied from the point of view of the raw materials used (Přichystal, in press). Querns were mainly made of Culm greywackes, which protrude in the immediate vicinity of the settlement on the other bank of the Morava River. The greenish grey rocks with magnetic susceptibility of 0.07–0.27 x 10^{-3} SI form layers of an ideal thickness from 5 to 10 cm. Another group of used rocks is represented by mylonitized and slightly metamorphosed Devonian quartz conglomerates and sandstones, with which the author assumes an origin from the southern part of the Vrbno Group (5–13 km to NNE). Polymict conglomerates of Culm age were in use as well; their sources are located at an approx. 8 km distance from Mohelnice, towards W and SW. Wholly analogous were the outcomes of a research of a settlement object with Linear Pottery and Lengyel cultures in Postřelmov, about 16 km N of Mohelnice (Kašpárek 2005), where all artefacts considered to be saddle querns or crushers were made either of coarse-grained Culm greywackes or slightly metamorphosed quartz sandstones to conglomerates of the Vrbno Group.

In the South-Moravian archaeological locality of Vedrovice stone saddle querns were also discovered at

the „Široká u lesa“ burial ground of the Linear Pottery culture (LBK Ib to the beginning of IIa), whilst from the „Za dvorem“ necropolis these are unknown (Podborský et al. 2002). A total of 6 such artefacts come from three male graves (4 pieces), one female, and one child's grave. According to an assessment by Přichystal (2002), five of them were manufactured from the same type of rock – light grey aplitic granite, sporadically slightly porphyritic with phenocrysts of feldspar and lamellae of muscovite. The rock has an insignificant magnetic susceptibility ranging from 0.01 to 0.05 x 10^{-3} SI. The sources of this raw material are dykes of aplitic granites that form morphologically expressive ridges or groups of boulders in the elevated plain of Krumlovský les Highland to the north of Vedrovice. The sixth artefact is of biotitic orthogneiss (its 0.07–0.11 x 10^{-3} SI magnetic susceptibility is higher), acquired most probably as an imperfectly rolled flat piece from the gravels of the Jihlava River. This item made of a different raw material comes from the grave 69/78, in which alone there were two saddle querns. On the working surface of one quern from grave 36/76 traces of a red dyestuff were ascertained using the stereomicroscope; the same was recorded on one amphibolite cobble. Obviously the saddle querns placed into the graves were a part of a certain burial ritual (they were repeatedly found near the heads of the dead), and they were either used especially for the preparation of the red dyestuff that is also present in the graves, or this definitely was their last purpose.

Apart from the above sites processed in detail there are individual data on saddle querns from the graves of people with Linear Pottery where the placing of saddle querns into the graves was a part of a similar burial ritual as in Vedrovice, and they were most often used for the preparation of the red dyestuff, with which the dead bodies were scattered or spread. In Slovakia such a find was published from Bratislava-Mlynská dolina where a little child's corpse was covered by an entire saddle quern with traces of usage, and with the working surface turned upwards (Farkaš 2000). The saddle quern was made of a coarse-grained granodiorite that most probably originates from the nearby outcrops below the Bratislava Castle. Several saddle querns were also unearthed at the necropolis in Kleinhadersdorf near Poysdorf, Lower Austria (Neugebauer-Maresch 1992, 10) and one comes from a grave at the settlement in Asparn a.d. Zaya – Schletz. The last one has been exhibited in the Asparn museum and based on macroscopic evaluation of the author, its upper part is made of purple arkosic sandstone coming probably from an outcrop of basal Devonian clastic rocks at Tasovice near Znojmo (about 38 km to the NW); a Tertiary sandstone was used for the lower part of the quern.

Beeger (1980) published an outline of raw materials used for querns and whetstones from the Neolithic to the Middle Ages in Saxony. He has mentioned examples of the Linear Pottery culture (Kmehlen, district of Grossenhain, or Nickern near Dresden), of the Globular Amphora culture (Paltzsche near Dörschnitz, district of Meissen) and of the Bronze and Hallstatt ages. Lower Triassic sedimentary rocks and the Dobritz “quartz porphyry” were used in the NE surroundings of Dresden; arkosic sandstone, conglomerate and volcanic rocks (“quartz porphyry and porphyrite”, according to the recent terminology rhyolite and andesite) of Permian age from the Döhlener Becken were manufactured in the vicinity of Dresden.

VI.2. La Tène period

The data on the raw materials of querns connected with other primeval cultures are merely sporadic, and only the rocks used for rotary querns in the La Tène period have been processed in detail. The transition from saddle querns to rotary querns is recorded in Greater Poland, where in the Hallstatt period milling was practised on big, flat or slightly concave lower stones by a hand-operated rubbing stones in the shape of bread, by which a rotation movement was carried out. Such milling equipment is known from Biskupin – a famous Polish locality of the Hallstatt age (Błaszczyk 1977, 15). They have become a prototype of rotary querns that only started to be widely used in the La Tène period. These comprised a thick lower stone with a socket for the spindle and a hemispherical upper stone, which was rotated by means of a wooden handle at the side. Grain was poured through the middle hole and it fell out crushed at the sides. Improved stone rotary querns were still in use at remote places in the hilly regions of Central Europe (e.g. in the Moravskoslezské Beskydy Mts.) at the beginning of the 20th century.

With regard to their diameter, the weight of rotary querns could have reached up to 15 to 20 kg, with the Celtic two-part querns even 40 kg. It may be assumed that every basic unit (a family, a house) of the then society possessed such a milling equipment of their own. For instance at the Celtic oppidum in Hrazany (central Bohemia) rotary querns of approx. 40 cm diameters were found nearly in all the houses (Jansová 1965, 61). At another oppidum from the La Tène period – Staré Hradisko in the Drahany Highland (Böhm 1941, 435) has even interpreted the remnants of a hut near the gate as a flour mill. He has ensued from the lower stones of querns found directly in the hut with other, damaged ones in its vicinity.

Querns from Staré Hradisko amounting to 143 units were characterized in the work by Čižmář & Leichmann (2002) also from the point of view of raw materials. An absolutely prevailing rock material (64 pieces, 45 %) was tephritic phonolite from the Kunětická hora Hill; arkose, most probably from the Boskovice Furrow (30 pieces, 21 %), orthoquartzite (20 pieces, 14 %), algal limestones and sandy limestone (15 pieces, 10 %), olivine basalt (6 pieces, 4 %), greywacke to greywacke conglomerate (4 pieces, 3 %), “quartz porphyry” (2 pieces, 1,5 %) and sandstone (2 pieces, 1,5 %) were represented as well. A surprisingly marked relationship to the products from the Kunětická hora Hill in a distance of over 100 km from Staré Hradisko indicates the economic importance of production centres and their vast distribution network.

The data on raw materials for querns from the La-Tène period in Bohemia were summarised by Waldhauser (1981). The studied collection included 96 verified querns and next 65 likely items. Their raw materials were determined prevalently by M. Mág. In the northern part of Bohemia three basic raw materials dominate (together 81 %): "quartz porphyry" of the Žernoseky type, tephritic phonolite of the Kunětická hora type, and Permian arkose (perhaps from Přílepy near Rakovník). He also mentioned phonolite of the Mariánská skála (near Ústí nad Labem) type, sandstone, orthoquartzite, limestone, granodiorite, syenite, gneiss, and granite, and as distant imports rotary querns manufactured from basalt of the Mayen in Rhineland type (found at Třebušice, Starý Kolín; a distance from the source is about 430 to 550 km) and from Slovak rhyolites.

VI.3. Early Middle Ages

Large collections of rotary querns from almost all important early medieval localities in former Czechoslovakia have been studied from the raw material point of view, so our knowledge of this time period is

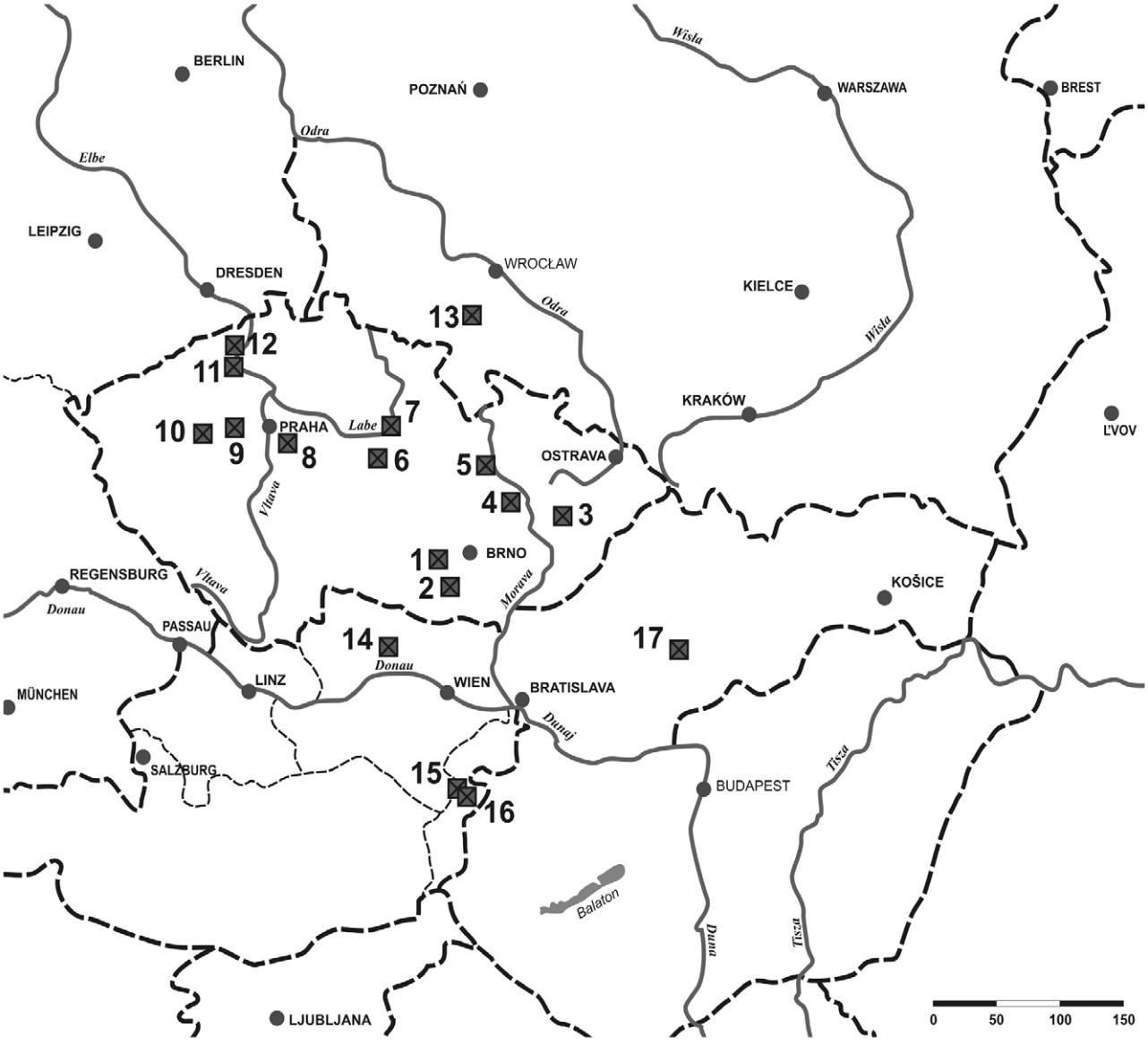

Fig. 124. Some important sources of raw materials for rotary querns and millstones. 1 – mica schist at Čučice; 2 – aplitic granite at Vedrovice; 3, 4, 5 – Culm greywackes at Hlinsko near Lipník, Velký Kosíř near Prostějov and Mohelnice; 6 – orthoquartzite at Lipoltice; 7 – tephrite phonolite from the Kunětická hora Hill near Pardubice; 8 – granite at Říčany near Prague; 9, 10 – Carboniferous arkosic sandstones at Kamenné Žehrovice near Kladno and Přílepy near Rakovník; 11 – rhyolitic ignimbrite at Žernoseky; 12 – trachyte from Mariánská skála Hill at Ústí nad Labem; 13 – granite at the Ślęza Mt. near Sobótka; 14 – mica schist at Altenhof near Gars am Kamp; 15 – basalt at the Pauliberg Hill in Burgenland; 16 – basalt at Oberpullendorf in Burgenland; 17 – rhyolite at Vyhne near Banská Štiavnica.

relatively good. As is Moravia concerned, it is possible to mention early medieval strongholds at Mikulčice near Hodonín, Staré Město near Uherské Hradiště (T. Kruťa in Hrubý 1965, 243; Zacherle 1977), Břeclav-Pohansko (Škvrnová 1975, Gilíková 1997), Staré Zámky in Brno-Líšeň (Škvrnová 1979) and Pavlov-Horní pole (Přichystal 2004). Chotěbuz-Podobora represents a locality from Czech Silesia (Přichystal 1995, Gilíková 1997), Pobedim north of Piešťany from Slovakia (Bialeková & Husák 1987) and Opolánky east of Poděbrady from Bohemia (Princová-Justová 2004). Tourmaline-biotite-muscovite or garnet-biotite-muscovite mica schists are the prevalent rocks at all localities excluding Staré Město near Uherské Hradiště and Pobedim near Piešťany. The second place is usually occupied by rhyolites from Slovakia but they are dominant in Staré Město and Pobedim. It is rather surprising in Staré Město because this locality has a different rotary querns composition comparing other two important strongholds (Mikulčice, Pohansko) in southern Moravia. Additional raw materials are usually dependent on geological composition of the surroundings of individual strongholds. The prevalence of two principal rocks (mica schist, rhyolite) on the large territory from Lower Austria to Upper Silesia is evidence of established workshops and well organized distribution nets. In Saxony, Beeger (1980) has informed about an important mining place of "quartz porphyry" and production centre from the 8th to 13th century with preserved traces after broken out semi-finished querns at Sornzig and Festenberg near Baderitz.

Another production area of early medieval rotary querns is situated in Lower Silesia in southern Poland (Jaworski 2008). Besides a well-known production centre of granite rotary querns on the slopes of Ślęża Mt. K. Jaworski has also described a workshop of mica schist querns at Kamieniec Ząbkowicki and another manufacturing place of gneiss cataclasites at Gilów near Niemcza. Granites near Strzelin represented also a high-quality source. He also summarized data about the production of granodiorite querns at Kittlitz near Löbau and on the Schmoritzberg Mt. near Binnewitz in Upper Lusatia (eastern Germany).

As follows from the previous text and other published data, the spectrum of rocks used for milling equipment in the primeval era is very large. Out of igneous rocks various types of granitoids (aplitic granites, granodiorites, syenites) and effusive volcanic rocks like basalts, phonolites, andesites, rhyolites, preferably those with a slab-like disintegration were modified. Favourite rocks were clastic sediments from the group of psammites (sandstones, greywackes, arkoses, and orthoquartzites) and psephites (fine-grained conglomerates), with which an important role was played by their ability to form layers. Querns made of sandy limestones are known as well. Especially in the Early Middle Ages metamorphic rocks (mica schist, paragneiss) became very popular as they were easily chiselled out from rocks alongside their schistose structure.

The lines below present detailed characteristics of only some selected sources deemed most important by the author. As is igneous rocks concerned, it is Říčany granite from the eastern surroundings of Prague, granite of the Ślęża Mt. in southern Poland, rhyolite ignimbrite from Žernoseky near Lovosice, trachybasalt of Kunětická hora near Pardubice, and rhyolites of central Slovakia. Raw materials from the group of sedimentary rocks are represented by Culm greywackes to conglomerates of the Moravo-Silesian Region and Ordovician Lipoltice orthoquartzites from the Železné hory Mts. Metamorphic rocks (mica schists, gneissses) of the Moravicum (Vranov-Olešnice Group, Moravian Mica Schist Zone) were used as characteristic raw materials in the Early Middle Ages.

VI.4. Biotite granite of the Říčany type and granitoids of the Central Bohemian Pluton

Location: The small town of Říčany is located less than 20 km SE of Prague, and the Říčany granite massif stretches between this village and Kostelec nad Černými lesy. It has an irregular rhomboid shape 12 km long; its width varies between 11 and 6 km. Roughly in the middle of the massif there is a village bearing a discriminating name Žernovka ("quern-stone village") with the best-known quarries in its surroundings. The National Nature Reserve Voděradské bučiny comprising granite boulder tongues and seas of rock stretches for the most part on the Říčany granite.

Geological Setting: The Říčany granite forms the NE end of the Central Bohemian Pluton representing its youngest part. Therefore it is tectonically least disturbed and thus most suitable for breaking out bigger pieces. It features two developments – porphyritic and epigranular. The porphyritic type crops out at the margins of the

Fig. 125. Medieval roughouts of millstones for ore grinding, made of the Říčany granite. The valley of Zvánovice Brook. After Kudrnáč (1982).

massif among Jevany, Černé Voděrady, Tehov, and Březí, whilst the epigranular type is found in its central part, in the wider surroundings of Žernovka (Kašpar 1936). The entire Central Bohemian Pluton covering 3200 km^2 form an exceptionally varied body as it is built by a number of other types of granitoids (mainly granodiorites and tonalites), some of which were also used for manufacturing of primeval milling equipment. By its composition the Říčany granite clearly differs from the other rocks of the Central Bohemian Pluton although it is roughly of the same, Variscan age.

Macroscopic Appearance: Bluish or pinkish grey rock, medium- to coarse-grained. Porphyric biotite granite contains K-feldspar phenocrysts up to 2 to 3 cm long and their quantity may exceed 50 % of volume in places. In the epigranular granite there is a presence of darker enclosures rich in biotite having the composition that corresponds with syenite or granodiorite.

Petrographic Description: Apart from K-feldspar, plagioclase, quartz, and biotite also tourmaline and muscovite were ascertained in small quantities. On the basis of a planimetric analysis by V. Steinocher the ratio of plagioclase to orthoclase in the Říčany granite appeared to be around 1:1; thus the rock would be classified on the boundary between granite and granodiorite as adamellite (for more detail see discussion in Hejtman 1957, 29). According to chemical analysis by A. Orlov in 1933 the predominance of K_2O over Na_2O in the epigranular Říčany granite from Žernovka is almost double, absolutely the highest of all analyzed biotite granites in a synoptic table by Hejtman (1957, 33), therefore it is unambiguously a granite.

Prehistoric Use: The granitoids of the Central Bohemian Pluton played an important role on the vast and archaeologically well-explored territory of central and southern Bohemia. They were used also in Prague, as the city underlying rocks comprise sediments of Palaeozoic and Mesozoic ages the prevailing majority of which was unsuitable for the manufacture of grain grinders or querns. For this reason already Štorch (1921, 65) has noticed during his descriptions of saddle querns from Neolithic pits in Prague that they were usually made of granite, and only then he has mentioned those of mica schist and sandstone. The sporadic accounts on saddle querns of the Řivnáč culture also mention granites as raw materials. Petrographic research could prove what types of granitoids these really are but the origin from the Central Bohemian Pluton is highly probable. We have to suppose using of the Říčany granite, Požáry and Sedlčany granodiorites because they are located closest to Prague. A pit connected with the Stroked Pottery culture was discovered in Prague-Liboc and it contained five saddle querns (J. Turek in Lutovský & Smejtek et al. 2005, 171, 230). Unfortunately, the stone raw material has not been mentioned. Recently new data on raw materials of querns in Prague appeared in a few expert opinions of J. Zavřel.

The quality of the Říčany granite is proven also by its usage in the past centuries. A workshop from the 13th to 16th centuries producing milling stones for ore (Fig. 125) is known not far from Černé Voděrady, in the Zvánovický Brook valley (Kudrnáč 1982). Archaeological research discovered 45 semi-finished millstones with a diameter between 80–125 cm, a height 35–65 cm and a weight 460–2100 kg. Taking into consideration they were crushed for gravel before 1949, their number had to be at least fifty. One semi-finished millstone was found even in the rock above the brook.

The Říčany granite from the Kamenka wood (Kamenná leč) near Louňovice, 2 km S of Žernovka, has been used among others for the J. Fügner monument at the Olšany Cemetery in Prague, or as a foundation stone for the National Theatre in Prague (Rybařík 1993).

VI.5. Biotite granite from the Ślęża Mt. (Lower Silesia, southern Poland)

Location: The Ślęża Mountain (718 m) stands out as a prominent, isolated massif from the flatland of Lower Silesia, approximately 30 km S of Wrocław. Its peak is superior to the surroundings by more than 500 m; so that when the weather is fine it is visible not only from a great part of Lower Silesia but also from the Czech borderline mountains. Because of its exceptional position in the primeval ages it is called the Olympos of Central Europe.

Geological Setting: From the geological point of view Ślęża constitutes the NE edge of the Bohemian Massif. Its prominent morphology is due to Pleistocene continental ice sheet that had roughly 300 m thickness; it has eroded and levelled the surrounding landscape, and only Ślęża has protruded from the ice tongue as a 200 m high

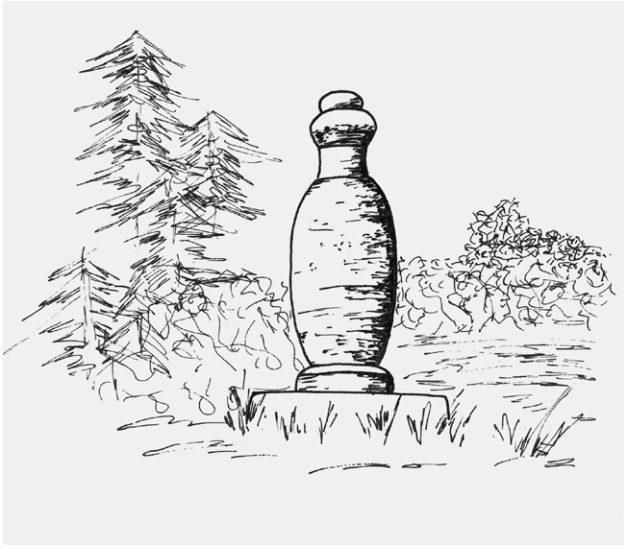

Fig. 126. Mount Ślęża, Polish Silesia. A granite scupture called Monck (probably of the Hallstatt age) has a higher magnetic susceptibility (up to 0.33 x 10^{-3} SI) comparing the other stone sculptures. Drawing by V. Obrová.

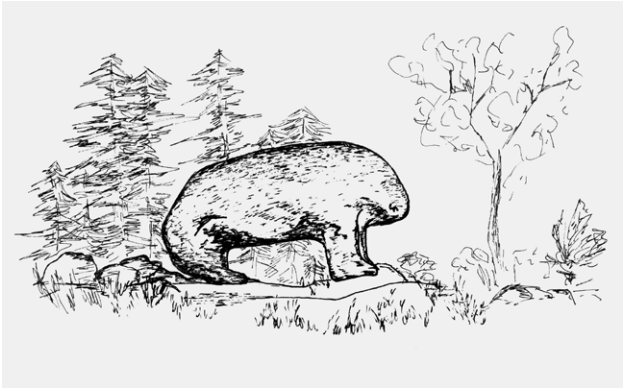

Fig. 127. Mount Ślęża, Polish Silesia. The sculpture of bear near the mountain top was probably carved by the Celts. Length 1.47 m. Magnetic susceptibility of the granite is only 0.00–0.01 x 10^{-3} SI. Drawing by V. Obrová.

nunatak. At that time the peak was exposed to an intense frost weathering, thus it is covered by vast sea of boulders. The NW slope of the mountain and its peak are formed by biotite granite of Variscan (Upper Carboniferous) age that is a part of extensive Strzegom-Sobótka Pluton. In the southern and eastern part coarse-grained amphibole metagabbro protrudes; the slopes towards Sobótka are built of amphibolites.

Petrographic Description: The Ślęża type granites are light, medium-grained, two-mica or biotite rocks that have most recently been petrographically studied in detail by Wójcik (2000). These rocks were used as Neolithic saddle querns. A somewhat different type, fine-grained aplitic granite is the raw material of the majority of renowned prehistoric stone sculptures (Figs. 126 and 127; Supplement/Photo 363). This granite consists of quartz, almost pure albite, microcline, muscovite, and garnets (almandine – spessartine). Biotite, titanite, chlorite, epidote, klinozoisite, and magnetite are present in an accessory manner. Such fine-grained aplitic granites are only known in a narrow zone at the contact with gabbros. The stone for sculptures was not quarried but acquired from loose granite blocks, which have resulted from frost weathering in the Ice Age. From the region of Lower Silesia A. Wójcik has also evaluated 80 rotary querns or their parts, out of which 34 were manufactured from biotite granite and 26 from fine-grained or aplitic granite; with all of them she assumes they originate from the Ślęża Mt. The rest of the rotary querns were made of erratic boulders or the Strzelin granite.

Prehistoric Use: The oldest artefacts are Neolithic saddle querns (we are aware of roughly 20 pieces). Almost twenty prehistoric stone sculptures are placed on the Ślęża summit, its slopes and the surroundings (Figs. 126 and 127). The age of the stone sculptures, the sizes of which range from 1.5 to 2.4 m, has been discussed for a long period of time, and most recently summarized by Domański (2002, 92). According to the current state of cognition it seems probable that some of them are undoubtedly related with the Lusatian culture, or with the emergence in the Hallstatt Age. A more recent origin cannot be excluded with statues of bears (Fig. 127) that had analogies existing on the Pyrenean Peninsula in the La-Tène Period; actually on the basis of amber imports contacts between the two territories are being considered. Statues of lions apparently originate from a sculptural workshop of the XIIth to XIIIth centuries AD that must have existed on the northern slope of Ślęża (Korta 1988, 188). It were probably the Celts who started to extract and work granite for rotary querns although neither on Ślęża nor in its surroundings proofs of this notion have been found so far. However, archaeological excavations have confirmed extraction of granite and production of rotary querns by the people of the Przeworsk culture during the Roman Period, and also later on during the Migration Period. Stone quarries and workshops for their manufacture including numerous semi-finished products or fragments of querns dated roughly from the beginning of the Christian era to the IVth century AD have been described by Domański (2002, sites 25 and 26). Granite rotary querns from this period have been discovered e.g. as far as in Wrocław.

VI.6. Rhyolitic ignimbrite from Žernoseky (Oparno Valley, northern Bohemia)

General Characteristics: Rhyolitic ignimbrite represents a pyroclastic rock of an acidic composition. It was deposited from a pumiceous pyroclastic flow (glowing avalanche), where high temperatures have caused sintering of the individual parts. Generally the rock is characterized by an occurrence of the so-called fiamme, crest-like drawn plastic glasses originating at the time of creeping of the pyroclastic flow. Authors of older papers believed the rock formed a lava flow or subvolcanite body and classified it as quartz porphyry. According to the IUGS Subcommission on the Systematics of Igneous Rocks (Streckeisen 1980) special names for palaeovolcanites are not recommended, so based on the thin section study in this case it is necessary to use the term rhyolitic ignimbrite.

Location: Rock outcrops including mining pits with semi-finished rotary querns occur in the cadastral areas of Oparno (a part of Velemín municipality) and Malé Žernoseky, north of Lovosice. The valley named after Oparno stretches alongside the Milešovský Brook, a left-side tributary of the Labe River. Rhyolitic ignimbrites crop out in the southern part of Oparno Valley, whilst its northern slopes and the following 4 km long canyon-shaped valley of the Labe called Porta Bohemica are cut in metamorphic rocks.

Geological Setting: A remarkable valley bears a relation to an isolated emergence of a crystalline complex with a not entirely clear situation from the regional geology point of view. It is usually divided into two parts: the

Fig. 128. K. Žebera with roughouts of rhyolitic ignimbrite millstones at Velké Žernoseky. Photo by J. Bárta, 1963. Internet archives of the Czech Geological Survey in Prague, ID 9455.

western part with gneisses, migmatites, and mica schists is compared to the crystalline complex of the Krušné hory Mts. (Saxothuringicum), whilst the eastern part built of mica schists and phyllites with layers of metabasites is most probably considered to be Upper Proterozoic rocks of the Bohemicum. The crystalline complex is overlaid by a sheet of rhyolitic ignimbrites of Upper Carboniferous age that is up to several tens of metres thick. Thin layers of conglomerates form both the overlying and underlying rocks of the rhyolithic ignimbrites.

Petrographic Description: The rock is well exposed in the Kubo company quarry, where it features a marked columnar disintegration (Supplement/Photo 366, 367). The colour of its matrix is light auburn (10YR 5/4) with conspicuous 2–3 millimetre crystals of dark quartz and yellowish feldspars. Tinier crystals of biotite are essentially fewer, large elongated rips of small glassy rhyolite bombs of up to several cm are also present. The rock has no preferential rectification to be noticed. Due to later alterations a part of the rocks is of white-grey colour and the small glassy bombs in them are entirely kaolinized.

Prehistoric Use: It may be assumed that the rock was used for the manufacture of saddle querns as early as during the Neolithic and Eneolithic. According to Waldhauser (1980, 67–68) rhyolitic ignimbrite („quartz porphyry“) of the Žernoseky type ranked among the three most important raw materials for the Celtic rotary querns in the northern half of Bohemia. The production centre between Malé Žernoseky and Oparno has supplied not only the Krušné hory Piedmont Basins area but also the Celtic oppida Závist near Zbraslav, Hrazany, and Strakonice. Rotary querns made of the rock also appear in eastern Bohemia. Semi-finished products were exported as well (Fig. 128). The maximal distance of a transported quern is about 117 km.

VI.7. Trachybasalt (tephritic phonolite) from the Kunětická hora Hill near Pardubice, eastern Bohemia

General Characteristics: It is an effusive volcanic rock forming transition between trachyte and basalt. Apart from calcium-rich plagioclase it also contains alkaline feldspars, and in the case of low SiO_2 content also representatives of feldspathoids, especially nepheline. Substantial occurrence of nepheline is necessary to classify a rock as phonolite. Pyroxene is present as a dark mineral and amphibole appears in smaller quantities. By augmentation of feldspathoids the rock is called basanite in case it contains olivine, and if olivine is absent, it is designated as tephrite. It is obvious from the above that the exact classification of such rock tends to be complicated as proven by exactly the example of Kunětická hora.

Background: As a conspicuous morphological elevation close to Pardubice it has become the focus of attention of petrographers already in the 19th century when F. Zippe, E. Bořický, J. Jahn, K. Hinterlechner and others were concerned with it (an overview by Pacák 1946). The name of the rock has undergone changes from basalt through phonolite, trachyte, dolerite, trachybasalt, tephrite, nepheline tephrite and tephritic phonolite (see Hejtman 1957, 260). In the most recent geological map 1 : 50 000, sheet 13–24 Hradec Králové (O. Shrbený in Straka et al. 1986) the volcanic rock of Kunětická hora has been classified as coarse-grained natrolite-sodalite trachybasalt with nepheline.

Location: Kunětická hora Hill (307 m) is a distinctive East-Bohemian dominant 6 km north of Pardubice. Due to its 82 m exaggeration over the surrounding flat landscape the hill is visible from afar, which is moreover augmented by a medieval fortified castle on its summit. Southern part of Kunětická hora has been damaged by stone quarrying in the 19th and the beginning of the 20th centuries.

Geological Setting: Kočandrle (1973) has occupied himself with the geology of the locality in detail. The bedrock of the subvolcanic body comprises calcareous claystones of the Březno Formation of Lower Coniacian (Upper Cretaceous) age. The southern part of the summit is built by the volcanic rock, whilst on the northern part its overlying rock is preserved – thermally metamorphosed calcareous claystones to porcellanites with only scarcely perceptible original bedding but intensely broken up by several systems of fissures. J. Kočandrle has designated the magmatic body as hypoabyssal laccolith elongated in the WNW – ESE direction, with numerous xenoliths of Cretaceous sediments. Therefore it was not a typical volcano as magma has apparently set in the depth of several hundred meters underneath the surface. The age of the volcanic rock is estimated at 18 to 25 million years (Upper Tertiary).

Petrographic Description: Brownish grey fine-grained volcanic rock, epigranular, in places with small isometric cavities that are filled with white or rose mineral (Supplement/Photo 371). Pacák (1946, 253) has described

as a characteristic sign of the rock its endogenne contact alteration, it means corrosion of light and dark minerals, occurrence of zeolites and replacing of minerals by calcite. As a consequence of the contact alteration is also variability in the rock composition, that is why so many different opinions on the rock classification. The volcanic rock is composed of K-feldspar, plagioclase feldspar, nepheline, sodalite, natrolite and egirinaugite with apatite, magnetite and pyrite as accessories.

Other Analyses: Magnetic susceptibility can reach relatively high but rather fluctuating data that range usually from 13 to 17 x 10^{-3} SI but sometimes they come up to 28 to 32 x 10^{-3} SI.

Prehistoric Use: The rock was probably used for the manufacture of saddle querns as early as the Neolithic and Eneolithic, although in the most recent overview on the prehistory of East Bohemia (Vokolek 1993, 15) only conglomerate is mentioned as an often used rock. A workshop from the La-Tène Period, which produced rotary querns on the southern foothill of Kunětická hora, was brought forward by Diviš-Čistecký (1893) at the end of the 19th century. According to Waldhauser (1980, 68), the advantageous position of Kunětická hora has enabled supplies of rotary querns to the entire eastern Bohemia, and partly also to central Bohemia. In his opinion they appear as a prevailing material in the surrounding landscape on the area of about 450 km^2. The high representation as far as the Celtic oppidum of Staré Hradisko near Plumlov (central Moravia) is relevant.

Fig. 129. Mount Sitno (1009 m), central Slovakia. A fortified site of the Bronze Age was situated at this highest top of the Štiavnické vrchy Mts. Subjacent andesites represented suitable rocks for lower part of millstones. Postcard, about 1950.

VI.8. Rhyolites from Central Slovakian Miocene volcanoes

General Characteristics: Rhyolite is an acid extrusive igneous rock corresponding with its chemical composition to granite. It has usually a very fine-grained to glassy groundmass with phenocrysts of quartz, alkali feldspars (sanidine in particular), biotite, rarely amphibole or pyroxene.

Location: Rhyolites crop out especially in the northern part of Štiavnica Mts. among Hliník nad Hronom, Žiar nad Hronom and Vyhne, it means in the immediate eastern vicinity of the Hron valley. Other rhyolite bodies occur west of the Hron valley as well, for example at Nová Baňa (from the geomorphological point of view it is already the northern slope of Pohronský Inovec Mts.) and Žarnovica in the valley between the Pohronský Inovec and Vtáčnik Mts. An extensive outcrop of rhyolite we know also from the southern margin of the Kremnica Mts. in the surroundings of Bartošova Lehotka. According to the geological map, a small rhyolite body lies in the central part of volcanic Javorie Mts.

A large rhyolite block-field north of the Vyhne valley under the Kamenný Hill (495 m) in the Štiavnica Mts. seems to be the most promising area for production of prehistoric rotary querns and medieval millstones. Stone blocks cover an area of about 5 ha and up to 1937 they were worked for millstones. Since 1937 the area is protected as a state nature preserve under the name Sea of rock at Vyhne with an area of 133 000 m^2.

Geological Setting: The Štiavnica Mts. represent relic of a colossal stratovolcano, one of the biggest in the Western Carpathians in the Upper Tertiary. The mountains are especially built of various types of andesite and its pyroclastic rocks, acid rhyolites are present less. Rhyolites in the vicinity of Hliník nad Hronom extruded in the last fifth period of the Štiavnica stratovolcano development (Konečný & Lexa 2001, 194). They are a part of the Jastrabá Formation (Upper Sarmatian). The Sea of rock at Vyhne originated as a consequence of rockslide that was caused probably by an earthquake. The locality has evident gravitational sorting with an accumulation of smaller stone boulders in the upper part and with bigger ones in the lower part.

Petrographic Description: The dominant rock at Vyhne is reddish to mauve porphyritic rhyolite with phenocrysts of quartz, sanidine, biotite and altered feldspar plagioclase (Supplement/Photo 368–370). In the lower part of Sea of rock the boulders have a brecciated structure with veinlets of red jasper and white quartz. Rhyolite lavas from Hliník nad Hronom show another picture having rose shade and porous structure. The pores up to 1 cm are arranged and elongated in the direction of lava flowing. The groundmass is very fine-grained with only small phenocrysts of volcanic quartz and biotite. Such porous rhyolites are often present as raw materials of rotary querns at early medieval strongholds in southern Moravia.

Prehistoric and Medieval Use: Based on the thin section study, rhyolite outcrops between Hliník nad Hronom and Vyhne were very probably sources for early medieval rotary querns. Bialeková & Husák (1987) have mentioned quarrying of rock for rotary querns in the 9th to 11th century especially at Nová Baňa and Žarnovica (16 km SW and 12 km W of Banská Štiavnica). Petrographic analyses of early medieval rotary querns in Slovakia (for example from Pobedim) indicate using of central Slovakian

rhyolite quarries already in the 9th century and a well-organized distribution network. The authors drew our attention to many unclear questions such are the social position of producers, ownership of quarries and way of finished querns distribution. Maliniak (2005) studied in detail relics of human activity at another potential locality close to the southern margin of Štiavnica Mts. Its name is Žarnosek and lies in the cadastral area of Kráľovce-Krnišov (12 km SSE of Banská Štiavnica). He interpreted a document from 1246 when the area under interest was named Baňa ("Mining place") as evidence about mining of raw material for production of rotary querns. Two lesser quarries with traces of old access roads to them have been identified during a surface prospection. There are no reports in written sources on modern age mining of stone at Žarnosek. Because of lacking any archaeological investigation, it was not possible to determine more precisely timing of the quarries.

VI.9. Andesites from Central Slovakian Miocene volcanoes

General Characteristics: Andesites and their natural occurrences in eastern Central Europe have been described already in the chapter on raw materials of polished stone artefacts.

Prehistoric Use: Carpathian andesites used for rotary querns at the Slavonic stronghold Pobedim near Piešťany, western Slovakia, were described by Bialeková & Husák (1987, 245). They form the second rock group (36 pieces, it is 28%) following rhyolites and the authors described three main varieties: pyroxene, pyroxene-amphibole and amphibole-biotite andesites. The rock colours are prevalently grey to brownish grey and excluding one piece they have compact structures without evident pores or cavities. The authors have supposed they come from the closest central Slovakian volcanic mountains, it means from the Pohronský Inovec Mts. and western to southwestern parts of the Štiavnica Mts. Generally it is the same area where the prevalent rhyolites were acquired.

VI.10. Orthoquartzites and conglomerates from Lipoltice (eastern Bohemia)

General characteristics: The definition of orthoquartzites can be found in the scope of raw materials used for chipped tools (chapter II.5.1.). Conglomerates are characterized in the following chapter concentrated on the Culm rocks.

Background: The mentioned rocks have principal outcrops on the 500 m long crest above the village of Lipoltice designated as Lipoltická skála (Lipoltice Rock, 297 m). Resistant orthoquartzites emerge in the form of knobs above the surrounding Cretaceous sediments; for this reason they must have attracted the primeval man also by their morphology. However a part of these interesting natural sights in the surroundings of Horní Raškovice was affected by quarrying later on as until the half of the 18th century because the Lipoltice orthoquartzites and conglomerates have belonged among the most popular raw materials for the production of millstones in eastern Bohemia.

Location: They emerge at the NE side of the Železné hory Highland, in the partial geomorphological unit called the Chvaletice Hilly land. The rocks form a narrow band about 20 km long that begins on Hůra near Slatiňany and continues to the north-west through Horní Raškovice near Heřmanův Městec, Lipoltice, Brloh, Jankovice, as far as Škudly SW of Přelouč. Orthoquartzite outcrops are up to 15 m high.

Geological Setting: Orthoquartzites, quartz conglomerates, greywackes and siltstones are parts of the Lipoltice Formation of Ordovician age. From the point of view of regional geology this is the Přelouč syncline of the Chrudim Palaeozoic. Fossil fauna comprising brachiopods and the *Bavarilla hofensis* trilobite was ascertained in Brloh near Lipoltice. On the basis of this find the rocks may be more precisely classified into the earliest Ordovician stage, the Tremadocian, and they correspond with the Třenice Formation in the Barrandian.

Petrographic Description: Coarse-grained orthoquartzites are light (whitish, yellowish) coloured. Among quartzite benches it is possible to find weaker layers of quartz-sericite shales. Monomict quartz conglomerates form a conspicuous layer in the middle of the formation. The dominating material of perfectly rolled small pebbles is white quartz; small pebbles of black phthanites also appear in places (V. Havlíček in Beneš et al. 1963).

Prehistoric Use: The rocks are used probably at Neolithic sites in the regions of Chrudim and Přelouč. For example Vokolek (1993, 15) mentions exactly conglomerate as the raw material often used for saddle querns in eastern Bohemia, unfortunately he does not provide any further assessment.

VI.11. Lower Carboniferous (Culm) greywackes and conglomerates

General characteristics: Consolidated clastic sediments of Lower Carboniferous (Culm) age, i.e. roughly 360 to 325 million years ago. Greywackes (litharenites) belong to the size category of psammites or sandstones with 2 mm as the upper limit of grain diameter, but there are not uniform opinions about the lower limit (usually 0.063 mm). Greywackes differ from sandstones or arkoses of the same granularity by the substantial presence of rock fragments. Conglomerates consist of fragments over 2 mm and rank into the group of psephites. Clasts forming conglomerates are originally pebbles to cobbles in various degrees of rounding.

Background: In central and northern Moravia, i.e. close to outcrops of Lower Carboniferous rocks in the

Drahany and Nízký Jeseník Highlands, the Culm conglomerates belonged to the most favoured raw materials for making of saddle querns. Quartz pebbles of fluvial origin or partly rounded local orthoquartzites ("sun boulders") were used as the upper stones (riders). A great quantity of querns has been recorded on the eastern slopes of the Drahany Highland south of Prostějov by I. L. Červinka and A. Gottwald as early as towards the end of the 19th century. Apparently for this reason Červinka (1902, 118) has mentioned sandstones as the second raw material for this equipment (he meant Culm sandstones, nowadays Culm greywackes).

Location: There are extensive occurrences of Lower Carboniferous (Culm) rocks in Moravia: the Drahany Highland, southern part of Zábřeh Highland, Nízký Jeseník Highland, Maleník Horst, and outcrops in the area of the city of Olomouc. Lower Carboniferous greywackes also emerge in places on the east edge of the Boskovice Furrow: NE of the Veveří Castle near Brno, and close to the southern termination of the Boskovice Furrow at Hostěradice west of Miroslav.

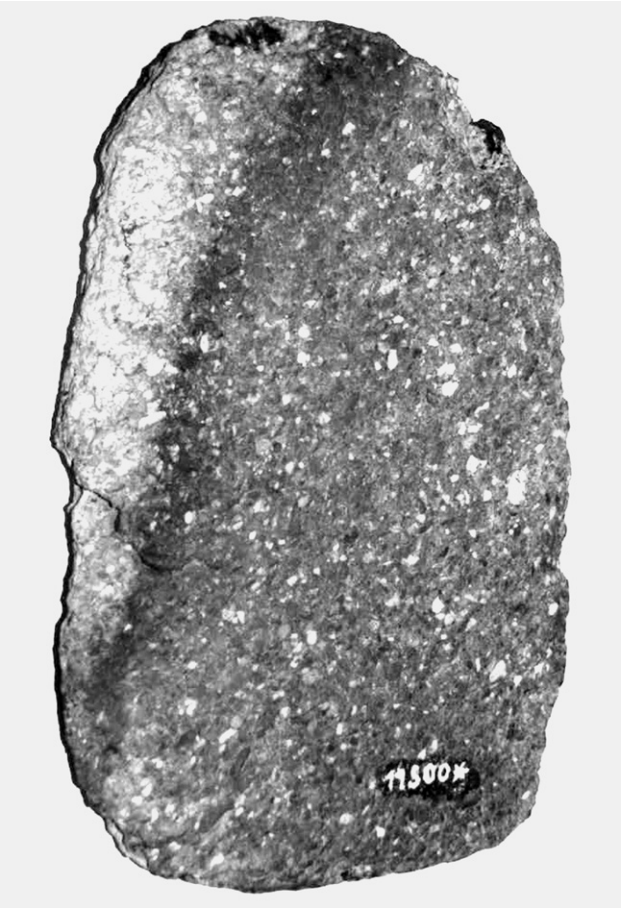

Fig. 130. „Stone altar" from an important sacrifice place in the Býčí skála Cave (Moravian Karst) was put together from three lower saddle querns. For the biggest one (length 53 cm) there was used a Culmian conglomerate (see picture). The artefact is deposited in the Natural History Museum (Naturhistorisches Museum) in Vienna. Photo by the author.

Macroscopic Appearance: The raw materials used for saddle querns can be characterized as coarse-grained greywackes or fine-grained conglomerates. In a fresh state these rocks are dark grey, with weathering they acquire a greenish-grey, brownish-grey to yellowish-grey colour. We are aware of examples of even reddish to red-brown colouring of greywackes and conglomerates from the Drahany Highland (e.g. from a well-known Celtic oppidum Staré Hradisko WSW of Ptení). This is most probably related with an intense weathering in the warm climate during Tertiary. Conglomerates are distinctly spotted due to light cobbles in the dark rock matrix. These rocks usually feature a confining structure without distinctive bedding, they are not calcareous and thus they do not turn porous even after weathering. Both greywackes and conglomerates are characterized by the presence of only partly rounded black Lower Carboniferous shales (Supplement/Photo 356–359).

Other Analyses: Magnetic susceptibility of Lower Carboniferous greywackes is usually low. Greywacke saddle querns from the area of Velký Kosíř Hill in central Moravia show values around 0.15–0.21 x 10^{-3} SI. Conglomerate querns have a wide dispersion of measurements because of various pebble presence but fine-grained varieties show the same data as greywackes.

Prehistoric Use: Generally the presence of Lower Carboniferous greywackes may be stated at settlements from the Neolithic through to Early Middle Ages. A prominent occurrence of saddle querns from this raw material has already been mentioned at the Neolithic settlements of Mohelnice and Postřelmov in northern Moravia. Saddle stones made of Lower Carboniferous greywackes are typical for the Badenian hillfort at Hlinsko near Lipník nad Bečvou. The author found a few saddle querns made of greywacke to conglomerate in the area of a Funnel Beaker culture workshop on the limestone Stránská skála Hill in Brno. They were transported at a distance of about 4 km from the Říčka valley.

Neolithic and Eneolithic querns from greywackes and fine-grained conglomerates are abundantly found at many sites of the Prostějov region: Prostějov-Čechovice, Dětkovice, Otaslavice-Obrova noha. Beautiful greywacke saddle querns were acquired by the author on the eastern slopes of Velký Kosíř Hill at the Vinohrádky locality (Slatinice municipality cadastre), where a settlement of the Silesian culture of the Urnfield Period prevails. Lower Carboniferous conglomerates from the Velký Kosíř Hill have been used for two rotary querns found at a settlement of the late Roman Period in Kostelec na Hané (determination by the author for a paper of D. Vachůtová).

From the famous Býčí skála Cave in the Moravian Karst, which has recently been interpreted as a sacrificial and cultic site from the late Hallstatt Period (e.g. Přichystal 1996), J. Wankel has described a stone structure comprising three stones that he termed an altar. A modern research of these stones deposited in the Naturhistorisches Museum in Vienna has shown that these were three querns made of three different rocks from various regions of origin. The biggest of them (Inv.

No. 11 500) is 53 cm long, its width varies from 33 and 30 cm and the thickness is 7.7 to 4.5 cm (the dimensions differ from those stated by J. Wankel and adopted by further authors later on). The weight is 21.8 kg and it is made of a dark Lower Carboniferous conglomerate with a distinctive indication of foliation planes, and apart from pebbles of quartz it also contains partly rounded fragments of grey Devonian limestone and black Lower Carboniferous shales. The conglomerate apparently originates from the area SE of Jedovnice, at least about 8 km far of the Býčí skála Cave (Fig. 130).

In central Moravia the utilization of greywackes for rotary querns in the La-Tène Period may be corroborated at some oppida situated in the Drahany Highland (e.g. Staré Hradisko near Okluky, Ježkovice-Černov). Surprisingly though, the number of rotary querns made of greywacke to greywacke conglomerates at Staré Hradisko is very small, only 4 pieces out of 143 (Čižmář & Leichmann 2002, 270). However on the surface of Drahany Highland dozens of anthropogenic excavations are known at various places, e.g. in the surroundings of village Ruprechtov, some of which might have served for the extraction of greywackes for this purpose (Černý & Štelcl 1975, 172).

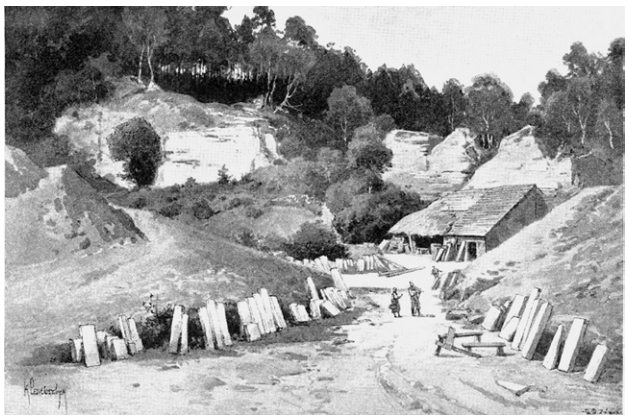

Fig. 131. Kamenné Žehrovice – a quarry for Upper Carboniferous arcosic sandstone. Drawing by K. Liebscher, 1903. Archives of the author.

VI.12. Arkoses and arkosic sandstones of the limnic Permian and Upper Carboniferous

General Characteristics: Arkoses and arkosic sandstones are classified as arenaceous clastic rocks containing quartz and 25 % or more of feldspar (arkose) and with more feldspar than rock fragments (arkosic sandstone or lithic arkose). Because feldspars are mostly derived from weathered granites and have very often rose or reddish colour, in addition many clasts are coated with a thin film of red iron oxides or hydroxides, arkoses and arkosic sandstones have usually reddish colour as well.

Location: Extensive occurrences of limnic Permian and Upper Carboniferous clastic sediments are especially in central Bohemia: the Radnice, Plzeň, Manětín, Rakovník and Kladno Basins. Other potential sources of such rocks are represented by remains of the Blanice Furrow with the largest area at Český Brod and two lesser relics at Vlašim and Chýnov; the southernmost one lies at České Budějovice. In northern Bohemia arkoses and arkosic sandstones crop out in the Krkonoše Piedmont Basin and Itra-Sudetic Basin. There are also two small remains in the Krušné hory Mts. (Brandov and Mikulov) and a denudation relic near Kraskov in the Železné hory Highland (eastern Bohemia). In Moravia it is possible to find Permian and Upper Carboniferous limnic arkoses and arkosic sandstones only in the Boskovice Furrow.

These rocks were popular also for production of millstones in the last centuries. Sources with outstanding properties for such purposes were exploitated for example at Kamenné Žehrovice (Fig. 131) and Doksy in the Kladno Basin or at Přílepy in the Rakovník Basin. Arkosic sandstones from Nučice SE of Kostelec nad Černými Lesy (a relic of the Blanice Furrow at Český Brod) were also in demand. Permian rocks including conglomerates from the Boskovice Furrow (probably from the surroundings of Ivančice) were used for millstones in western Moravia (e.g. in the extinct medieval village of Mstěnice near Hrotovice).

Geological Setting: A geological overview of limnic Permian and Upper Carboniferous occurrences in the Bohemian Massif is to be found in the chapter I.4.1.7. of this book. Probably the most important raw material source in Bohemia – arkose and arkosic sandstone from Kamenné Žehrovice – is a part of the Nýřany beds of the Kladno Formation (Upper Carboniferous, Westphalian C).

Petrographic Description: Generally the rocks are compact durable materials with reddish brown colour when they are fresh; if they are weathered the colour changes to rose or yellowish brown. Macroscopically one can distinguish fragments of red feldspars, in fine-grained conglomerates even small pebbles of granitic rocks. Arkoses and arkosic sandstones from Kamenné Žehrovice are very variable (whittish grey, yellowish grey, rusty or reddish); in addition the rocks used for building purposes turn dark or black after weathering in the city environment. According to petrographic literature the source at Kamenné Žehrovice contains arkosic sandstones, arkoses and fine-grained conglomerates. Similar changes in granularity and colour can be seen at Přílepy, another important site. Rocks are composed of fragments and small pebbles of white and grey quartz, black phthanite, and siliceous slates, usually rose grains of feldspar, abundant muscovite, fragments of shales and weathered granites (Vachtl 1935). Cement is represented by kaolinite minerals with micas admixture, or by silica. If it contains iron oxides, the rocks have yellowish, brown yellow or rusty colour. More coarse-grained rocks with small pebbles in places were used for millstones.

Prehistoric and Medieval Use: Upper Carboniferous and Permian arkosic sandstones to arkoses because of their durability belonged to very popular rocks both in the prehistoric times and in the Middle Ages. As is central

Bohemian sources concerned, the Upper Carboniferous arkosic sandstones to arkoses from Kamenné Žehrovice were used for Neolithic saddle querns at many places (Rybařík 1988). The same author has also mentioned raw material of a stone man head from the Celtic oppidum at Závist south of Prague: fine-grained arkosic sandstone. Since the Middle Ages up to roughly 1965 the rocks from Kamenné Žehrovice had been used both building stones and for various stone products (thresholds, windowsills, boundary stones, feeding troughs, millstones). Popularity of the rocks from Kamenné Žehrovice proves also B. Wachsmann' engraving of local quarry that appeared in the Commemorative Document "By the people, for the people!" issued in May 1880 for the benefit of the National Theatre in Prague.

We can suppose the source at Přílepy served also for prehistoric saddle and rotary querns because rocks from the both sources (Kamenné Žehrovice and Přílepy) had been worked for millstones since the Middle Ages up to the first half of the 20th century and they have even their special Czech names. Vachtl (1935) has mentioned that "Přílepy stone" was for millstones more popular than "Žehrovice stone".

As is arkoses and arkosic sandstones from the Boskovice Furrow concerned, the author found numerous saddle querns made of these rocks at a settlement of the Linear Pottery culture in Vedrovice. It is possible to follow their occurrences at many other Neolithic sites in the Boskoviec Furrow and its surroundings (e. g. at a settlement of the Moravian Painted Ware culture above the Brno Dam reservoir in Brno-Kníničky).

VI.13. Mica schists

General characteristics: Mica schist is a coarse-grained medium grade regional metamorphic rock of pelitic composition with a marked schistosity. Contrary to two-mica gneiss it contains practically no feldspars, thus it comprises quartz and both micas (especially muscovite, fewer biotite). To distinguish individual mica schists from various natural resources it is necessary to investigate chemical composition of accessory minerals, which may be represented by garnet rich in aluminium (almandine), tourmaline, staurolite, and kyanite.

Background: As a spectacular, silver glossy rock, mica schist has not escaped the attention of researchers already towards the end of the 19th century, which is why Červinka (1902, 118) has mentioned it in the first place as the rock of prehistoric querns in Moravia. Later on however there has been a discussion for some time whether such fragile and, at mutual friction, crumbly rocks could have at all served the same purpose as the classical, hard rock querns, and whether they were rather used perhaps for obtaining mica into pottery (see reasoning in the work by Černohorský 1957, 496). Yet an evident prevalence of mica schist rotary querns in the territories of both Moravia and Silesia in the Early Middle Ages excludes seeking of other explanations.

Location: A number of mica schist outcrops appear in the Bohemian Massif. In the first place it is necessary to mention the Moravian Mica Schist Zone that emerges as a belt of isolated occurrences at the contact of the Moldanubicum and the Moravicum, respectively on the western edge of both Moravian domes (the Svratka and the Thaya Domes). Concretely it may be traced from Svojanov in the north through Březník, Čučice, and Oslavany in the south of the Svratka Dome; with the Thaya Dome it appears north of Plenkovice and continues through the northern vicinity of Hluboké Mašůvky to Rudlice, Němčičky, and Horní Dunajovice; mica schists may also be found near Kadov, Dobelice, and Rybníky. If we continue alongside the Thaya Dome to the south, we come across mica schists in the area of the Vranov Dam resorvoir, in Austrian Waldviertel near Langau, Horn and in the southern part of the Kamp River as far as to Langenlois.

The occurrences of mica schists to two-mica gneisses form several belts even within the Moldanubicum: mica schists of the Královský les in Šumava Mts., Kaplice mica schists in southern Bohemia, and Chýnov mica schists in central Bohemia. They are also markedly represented in the Crystalline Unit of Kutná Hora; especially in its Šternberk-Čáslav Group and its possible equivalent in the SE part of the Svratka Crystalline Unit. Minor resources of mica schists also exist in the Hrubý Jeseník Mts., e.g. on the Zlatý Chlum Mt. near the town of Jeseník, or in the area of Červenohorské Pass. Further on to the west they are found in the surroundings of Staré Město pod Králický Sněžníkem (the Staré Město Crystalline Unit) or in the Stronie Group of the Orlice – Snieznik Crystalline Unit in Poland. They are also a part of the Strzelin Crystalline Unit. In the Krušné hory Mts. they form the highest mountain, Klínovec, and they also emerge in the surroundings of Mikulov and Moldava.

In the Western Carpathians mica schists are not very abundant. We are aware of mica schist e.g. from the Selec block of the Považský Inovec core mountains, and there are large outcrops of mica schists in the Kohút Zone of the Veporicum, e.g. in the NE surroundings of Kokava nad Rimavicou.

Prehistoric Use: Moldanubian gneisses having partly similar qualities as mica schists were already used for saddle querns at the Bronze Age stronghold Dívčí Kámen near Křemže, southern Bohemia (Fig. 134). Mica schist saddle quern appeared e.g. in the late Hallstatt Period: one of the three saddle querns of Wankel's "altar" in the Býčí skála Cave is a garnet mica schist. An overview of the raw materials of rotary querns used prior to the Early Middle Ages including the corresponding literature has been elaborated by Černohorský (1957), who has mentioned finds of mica schist querns from an early Hallstatt settlement Lengenfeld in Lower Austria, or a part of a mica schist rotary quern from a Hallstatt pit at Hradisko in Brno-Obřany.

Mica schist has become the most favourite rock in the Early Middle Ages when it featured the prevailing rock at the fortified settlements of Mikulčice, Pohansko,

and Brno-Líšeň. They are also represented at Staré Město near Uherské Hradiště, Velehrad and Pavlov-Horní Pole. Garnet-muscovite-biotite schist was also described from the Slavic hillfort at Chotěbuz-Podobora near Český Těšín (Přichystal 1995; Supplement/Photo 354).

Petrographic studies of early medieval rotary querns and their confrontation with the geological situation in Moravia have led to the conclusion that the most probable source territory is the Mica Schist Zone at the boundary between Moravicum and Moldanubicum. Indeed in the last quarter of the 20th century two sites of their extraction have been discovered in this geological unit, namely Čučice near Oslavany (SW Moravia) and Altenhof near Gars am Kamp (Lower Austria).

VI.13.1. Tourmaline mica schist from Čučice near Oslavany, SW Moravia

Background: In 1975 a former miner, B. Fráňa from Čučice, has pointed out to S. Zacherle, an employee of the Moravian Museum in Brno, that when digging above the Oslava River to pick up flat stones to pave his yard he also found unused mica schist rotary querns with holes, their fragments and roughouts (Zacherle 1977, 165). According to the statements by a now deceased eyewitness, querns used to be found at the same site earlier on too, and boys used to bowl them down the slope into the Oslava (Fig. 132).

Location: The site of discovery is located to the WSW of the village Čučice (4 km west of Oslavany, 20 km southwest of Brno), on a spur-shaped ledge above a sharp meander of the Oslava River, in a wooded part called „Na spáleném". In this part 2 to 5 m high rocky outcrops of mica schists and mica gneisses protrude, and there are large rock debris on the slope. Back in 1975 a marked depression was noticeable a few steps towards west.

Geological Setting: In the geological map 1 : 50 000, sheet 24–33 Moravský Krumlov (Matějovská ed. 1991) mica schists near Čučice together with amphibolites, occasional marbles and two-mica orthogneisses are considered the highest part of the Svratka Dome situated in the tectonic underlier of the Moldanubian overthrust

Petrographic Description: The rock features an intense metamorphic foliation with minor folds in places and a silver glossy, brownish white-grey colour. In comparison with samples from Altenhof it is darker, which is related to the higher representation of biotite on the one hand, and to its weathering during which iron compounds were released on the other. Small black columns of tourmaline, in places reaching the size of 2 to 3 mm, are visible with the naked eye. Porphyroblasts of muscovite do not occur as isolated sheets as is the case of Austrian samples but they cover the entire foliation plane. Up to 2 cm big lenses of white secretory quartz present another dissimilar feature (Supplement/Photo 353).

Prehistoric Use: Exploitation of rocks for rotary querns near Čučice had a different character than in Altenhof, Austria. Numerous flat fragments forming a sea of rock on the steep slope to the Oslava River were used as raw materials, so roughouts were not directly broken out of the rocky outcrop. Unfortunately, no suitable artefacts have been found so far at the site of the workshop to enable its temporal classification; however ranking to the Early Middle Ages is probable.

VI.13.2. Tourmaline mica schist from Altenhof near Gars am Kamp, Lower Austria

Background: From the viewpoint of prehistoric settlement, the Kamp River valley belongs to the most important territories in Lower Austria. There are long lasted archaeological excavations of an early medieval fortified settlement at Gars am Kamp where numerous mica schist

Fig. 132. Roughouts of mica schist millstones close to the source outcrop near the village of Čučice, district of Brno-country. Photo by S. Zacherle, around 1975.

Fig. 133. Roughout of rotary quern at a mica schist rocky outcrop at Altenhof near Gars am Kamp, Lower Austria. Photo by the author, 1994.

Fig. 134. Lower millstones from the fortified site of the Bronze Age at Dívčí Kámen near Křemže, southern Bohemia. There are made of local Moldanubian gneisses. Photo by J. Poláček.

rotary querns have been unearthed. A search for their source has resulted in ascertaining the extraction site at the nearby Altenhof.

Location: The village of Altenhof is located about 7 km south of the well-known resort Gars am Kamp, or 15 km south of the district town Horn in Lower Austria. The Kamp River is the main stream of Waldviertel; at first it flows through it crosswise between Zwettl and Rosenburg in the W-E direction, near Rosenburg it turns by 90°, and as far as its confluence with the Danube, i.e. in the length exceeding 30 km, it has the north-south orientation prevalently. Altenhof is situated roughly in the middle of the valley of the north-south course.

Geological Setting: According to the geological map 1: 200 000 of Lower Austria (Schnabel ed. 2002) Altenhof is situated at the eastern edge of the Moldanubicum, close to its thrusting over the Moravicum. The local mica schists, amphibolites, and a minor body of serpentinite are a part of the Gföhl Unit of the Moldanubicum. It is apparent from the comparison with the geological map 1: 500 000 of the Bohemian Massif including its Austrian part (Fusán et al., eds. 1967) that the mica schists from Altenhof may be understood as an equivalent of the Moravian Mica Schist Zone.

Petrographic Description: A marked schistose rocks of silver glossy and white-grey colour with large porphyroblasts of muscovite. Moreover, the stereomicroscope observation enables noticing of small black columns of tourmaline of the size up to 1 mm.

Prehistoric Use: Exploitation of querns at various stages has been corroborated on the mica schist rocky outcrops directly at the locality (for more details see Friesinger & Vacha 1987). There are either only oval shapes outlined, or rounded-off roughouts the lower parts of which have not been separated from the rock yet, but also circular depressions left after broken off querns (Fig. 133; Supplement/Photo 350, 351). This early medieval extraction is dated back to the second half of the 9th century.

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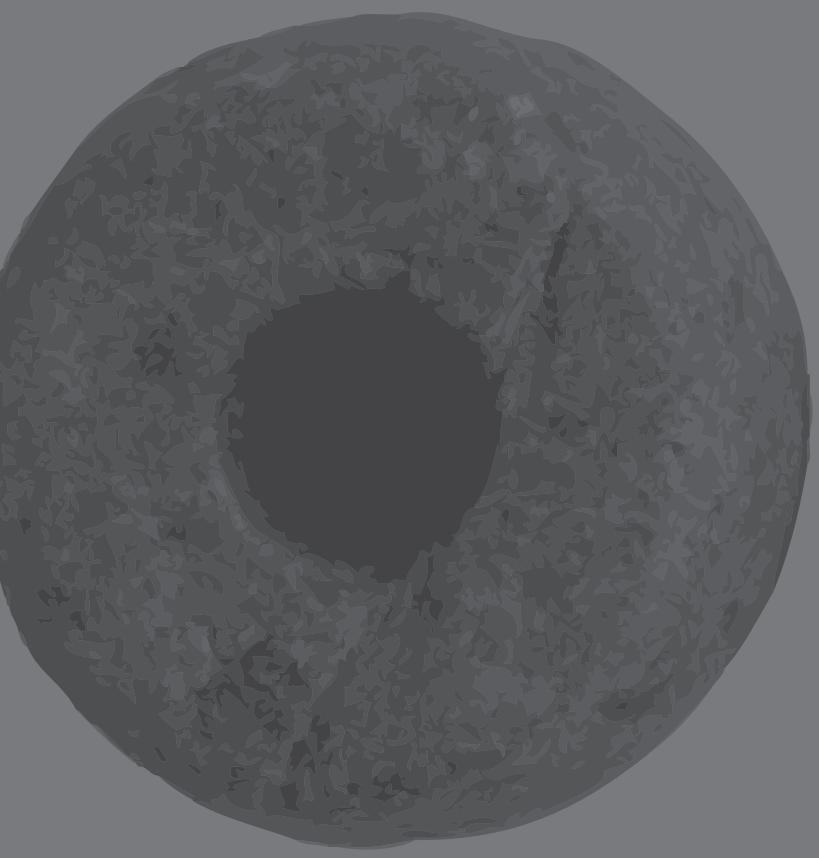
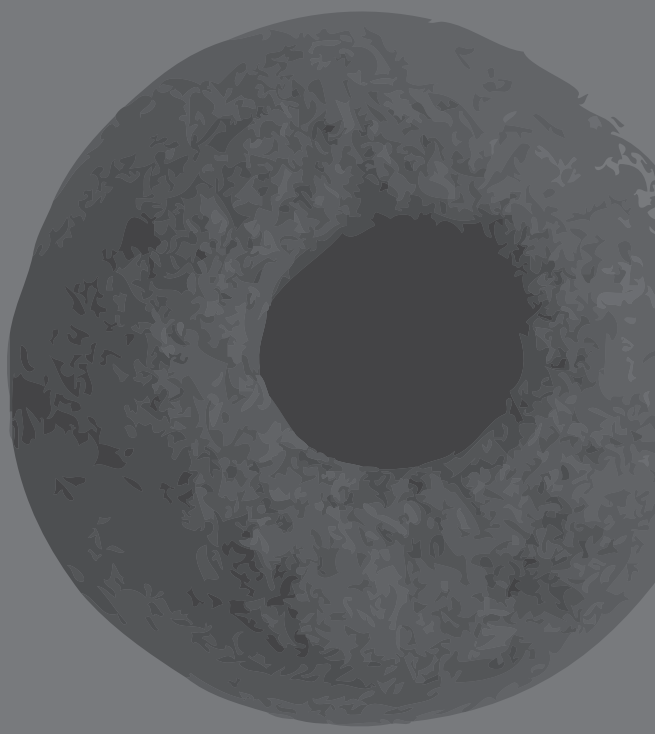
VII.
RAW MATERIALS OF STONE SPINDLE WHORLS





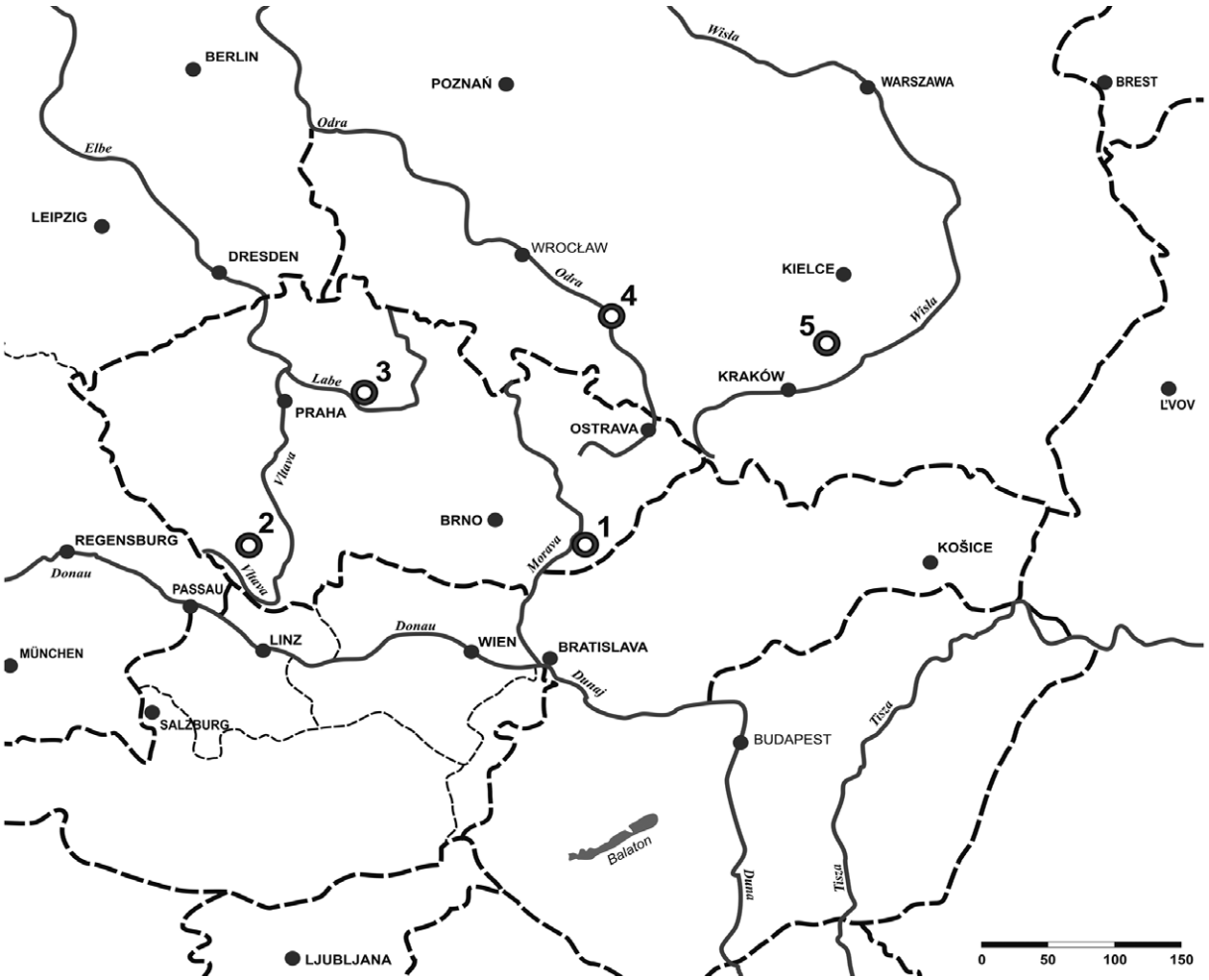


Fig. 135. Sources of raw materials for prehistoric and early medieval stone whorls mentioned in the text. 1 – Uherské Hradiště, 2 – Strakonice, 3 – Opolánky, 4 – Opole, 5 – Stradów.

Background: Spindle whorls are small (usually up to 5 cm diameter) ceramic, stone or bony discoid objects with a hole, used as flywheels, and bobs of shafts. Newly spun yarn was wound around the shaft and the whorls eased its twisting. They came into use in the Neolithic (usually ceramic whorls, often a drilled pot shard ground into a disc) and in the Late Middle Ages were replaced by better technologies (the spinning wheel was invented in the 15th century). Whorls evidence fabric production and are usually found in women's graves as a symbol of womanhood. As they were sometimes found in men's graves, other functions cannot be eliminated. They could be used as amulets or magical objects. Mareš and Waldhauser (2004) conducted experiments and concluded that they could be used for making fire.

In the Neolithic age the spindle whorls were usually ceramic; stone whorls occur rather unique. Stone whorls came into favour in the eastern part of Central Europe in the Early Middle Ages. Whorls were often produced from soft rocks such as claystone, silty shale, siltstone to sandstone, limestone, opoka, talc schist, and serpentinite (Fig. 135). In the Czech Republic, Kaván (1957) was the first to pay the attention to stone whorls, found in four Bohemian and three Moravian medieval finding places. He dated them to the 10–13th centuries with the majority clustered to the end of the 10th and into the 11th centuries.

The most widespread stone whorls were found in Great Moravian strongholds at Mikulčice, Pohansko near Břeclav and Staré Město near Uherské Hradiště. Research by the author and his students showed that it is not easy often to distinguish stone whorls from ceramics ones. The reason was that there were different kinds of paintings or coatings, and sometimes whorls were fired. This makes raw material determination very difficult. The prevalent raw materials for stone whorls in south-eastern Moravia are fine-grained clastic sediments, whose composition can resemble ceramics in some cases.

Because the studied assemblages have been large, it was necessary to divide them under the stereomicroscope in groups of the same or similar raw material and then prepare petrographic thin sections for each group. Magnetic susceptibility was measured by KT-5 kappameter and the higher values obtained result from readings on fired ceramics. The largest assemblage was collected in Mikulčice. Kostelníková (1980) studied it for the first time

and examined 380 whorls acquired during four seasons, from 1967 to 1970. She identified 346 (91 %) as made of stone and 14 whorls from Mikulčice and Přítluky provided for the petrographic analyses (F. Obr in Kostelníková 1980). The artefacts were studied using differential thermal analyses, X-ray diffractometry and two thin sections. Except for one sample, they were all natural sandy siltstones and claystones with calcareous admixture. As is mineral composition concerned, quartz dominated. Plagioclase formed a subordinate mineral in some samples; a cementing component was represented particularly by clay minerals, mainly illite, sometimes montmorillonite and occasionally calcite. Occurrence of gypsum and anhydrite can be considered as a typical sign.

The last comprehensive study was prepared in Benedová's (2006) master thesis of 2,124 whorls. She defined 1,705 stone, 419 ceramic and 3 lead pieces. Whorl raw materials were markedly similar to those from Pohansko. Thin sections of 19 pieces were made and 8 samples were studied by X-ray difractograph. Fine-grained clastic and clayey sediments dominated, and were divided into 10 petrographic types according to clastic fraction abundances (pelite, aleurite, psammite) and fossil presence. The most widespread rock type was clay siltstone (906 pieces), then silty claystone (350 pieces), clay siltstone with microfossils (182 pieces) and others. Two whorls from talc and six from limestone were found together with clastic and clayey rocks.

The most widespread grey clay siltstone has a high abundance of mica (muscovite, biotite), whose bedding arrangement cannot be seen macroscopically. Quartz and alkali feldspars dominate among clastic components; carbonate and foraminiferans are present as well. Magnetic susceptibility of ceramic whorls was generally higher. The average value of 28 pieces was 1.65 x 10^{-8} SI, but with a big spread from 0.07–7 x 10^{-3} SI. Stone whorls averaged 0.28 x 10^{-3} SI with a spread of 0.01–1.62 x 10^{-3} SI.

Přichystal & Richterová (2003) described early medieval whorls from Pohansko at Břeclav with similar findings. They studied an assemblage of 197 pieces and identified 148 stone whorls (75%) on the basis of stereomicroscopic research and several thin sections. The rest were ceramic whorls, one was made of blue-green glass matter. Clay siltstone (42 %), silty claystone (20 %) and claystone (26 %) were again dominant. Siltstone and claystone containing fossils are especially interesting. They are represented mainly by siliceous sponge spicules, orbicular foraminiferans and rarely little shells of mollusc. Serpentinite was found once. In addition, Benedová (2006) also identified a talc whorl.

Very similar sedimentary rocks such as siltstone, claystone and clay or silty shale dominated for production of spindle whorls at both important early medieval strongholds in southern Moravia: Pohansko at Břeclav and Mikulčice near Hodonín. These raw materials very probably come from one or more similar sources of the same geological unit. Tertiary sediments of the Carpathian Flysch Belt, it means the Magura or the Ždánice Groups of flysch nappes are likely candidates.

Workshops with specific whorl manufacturing technology are known in the Czech Republic (Uherské Hradiště-Sady, southern Moravia), Poland (Opole) and Ukraine. The whorls manufacturing in Ukraine has been described by Rybakov (1948, 112). At first, they drilled a hole into a stone base, after that they made a rough form of a whorl by washover around the hole with a help of an annular bit. The final form was obtained by polishing with whetstone on a lathe-like tool. Half-finished products found in Uherské Hradiště-Sady (Marešová 1977) differ from those in the Ukraine. At first, they carved a rough "whorl" from a compact stone (slaty claystone) that was then drilled and finished on a lathe. According to K. Marešová, the whorls from Uherské Hradiště-Sady were also fired, increasing their resistance and strength because slaty claystone weathers quickly in contact with moisture. Unfortunately, a secondary effect of firing is that it makes it difficult to differentiate stone from ceramic whorls.

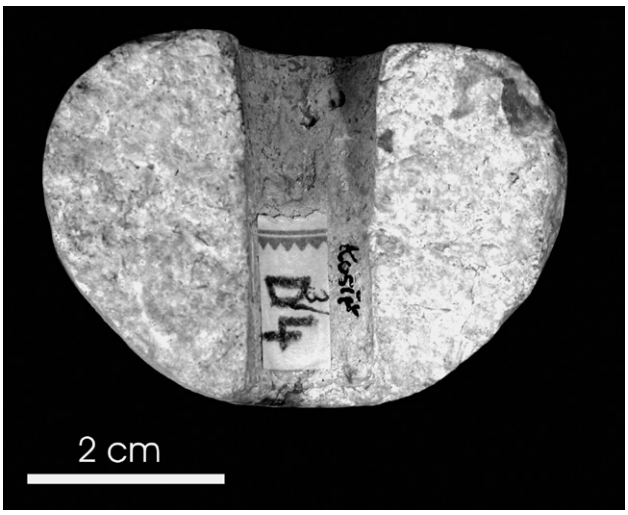


Fig. 136. Half of mace or whorl(?) made of limestone. Diameter 5 cm. Eastern slope of the Velký Kosíř Hill, district of Prostějov, central Moravia. Photo by the author.

VII.1. Proterozoic pink slate from Ovruch (Ukraine)

Location: The town of Ovruch (Owrucz, Wruczyj) upon the Narynia River, the branch of the Usza, 160 km north-west of Kiev was an Early Medieval centre for the gem-cutting industry, and manufactured local pink (sometimes violet) slate whorls. Many workshops operated in local villages and their products were exported all around the Slavic world in the 11th to 13th centuries. Apart from whorls they made sarcophaguses, crosses, whetstones, and moulds for gold casting. They traded also raw material, not only finished products (Labuda & Stieber, eds., 1967).

Geological Setting: The stone originates in the Ukrainian continental nucleus where it protrudes within the Tolkatchev Formation, part of the Ovruch Group, which is probably 1.2–1.7 billion years old. They are several thousand meters thick and weakly metamorphosed

sedimentary rocks, locally with pyroclastic material admixture or volcanic bodies about 1.4 billion years old.

Macroscopic Appearance: Deep-red, brown-red, pink-red to violet slate has extremely fine-grained texture. The individual mineral components are not usually visible to the naked eye, but more large-grained parts are present. Bedding or lamination are usually distinguishable, the rock sometimes has a semolina-like appearance. The stone is soft and can be scratch with one's nail, leaving a white mark.

Thin Section: According to Michalik et al. (2004), the rock show marks of multiple recrystallization even though relicts of original sedimentary textures are preserved. From the petrographic point of view, the Ovruch slate includes three rock types: sericite-pyrophyllite-quartz phyllite; quartz-muscovite-pyrophyllite metasiltstone and metatuffite with semolina-like appearance.

Early Medieval Use: The history of Ovruch whorl manufacturing began in the mid-10th century and lasted to the mid-13th, though religious icons were made into the 14th century. The whorls from Ovruch slate in the Kiev Russia area were widespread (Rybakov 1948). They were also exported into neighbouring areas. In southern Poland where an important trade route linked Prague, Cracow and Kiev (Woloszyn 2007) it was registered 424 whorls in 70 locations along the route. The amount in all of Poland is about 800. A few are found in Moravia and Bohemia, likely rare imports to the Přemyslid administrative centre of Prague, Olomouc and Znojmo, and to Levý Hradec, the centre of royal economic administration (Sláma 1990). The archaeological literature records rare finds in Scandinavia as well.

VII.2. Cretaceous limestone from Opole (southern Poland)

General Characteristics: Cretaceous limestone from the town of Opole and its vicinity was used for manufacturing different objects during the Middle Ages. Two limestone crosses from the mid-12th and early 13th centuries were found there. Crosses and whorls were mass produced from this soft easily worked material at Opole Castle. Process waste and half-finished whorls are found there.

Details about the workshop and manufacturing process are described by Hensel (1956). Later research at the castle found 611 limestone whorls and 94 half-finished whorls (Bukowska-Gedigowa & Gediga 1986), twenty Ovruch pink slate whorls and fifteen pieces from other slates or shales.

VII.3. Clay siltstone and silty shale from Uherské Hradiště-Sady (southern Moravia)

Background: Skutil (1937, 13) initially noticed that an early-medieval whorl from a burial site at Dolní Dunajovice in southern Moravia was not made from fired loam, but from a "crumbly breakable shale". Forty years later Marešová (1977) discovered a whorl manufacturing site at Uherské Hradiště-Sady, for local silty shale, dating it to the second half of the 8th century.

Location: The site of Uherské Hradiště-Sady is situated in the south-east part of the town near the Kunovice road. While rising only 40 m above its surroundings it offers a spectacular view of the whole central Morava River area to the Chřiby Highland and Napajedla Gateway. The foundations of a church complex from the beginning of the 9th century (now a National Cultural Monument) are preserved on the flat top part. A skeleton burial site was found around and under its floors. A settlement, where the whorl workshop was found in one of the largest objects, existed at Kotvice. Marešová (1977, 35) assumes that the raw material was obtained from the side of the road connecting the settlement with the church complex on the rise.

Geological Setting: Zacherle (1971) studied the local geology. The rise is formed by the Zlín Formation of the Rača Unit of the Magura Group (Carpathian Flysch Belt). The silty shale (aleuropelite) is a part of the Upper Eocene – Lower Oligocene Zlín Formation.

Macroscopic Appearance: The rock is predominantly yellowish grey (5Y 7/2) to light olive grey (5Y 5/2), occasionally to moderate yellowish brown (10YR 5/4). It disintegrates according to the bedding planes, and contains calcium carbonate (reacting to diluted HCl). The streak is the same colour as the rock and can be scratched by a nail though with difficulty (Supplement/Photo 372).

Stereomicroscopic Appearance: Tiny muscovite lamellae and darker quartz clasts of similar size can be identified on the bedding planes. It is not possible to distinguish particles of the groundmass even under stereomicroscope.

Thin Section: Alternation of fine clay and coarser silty laminae is visible. Quartz, muscovite and calcite can be recognized in the silty parts (Supplement/Photo 373).

Other Analyses: According to x-ray diffractive analyses (conducted by V. Vávra), the prevailing mineral is quartz (72–80 %), following by illite (about 10 %) and calcite (about 10 %). Chlorite can be present in a small amount. Magnetic susceptibility is very low (0.06×10^{-3} SI).

Early Medieval Use: The silty shale was used to make whorls in Uherské Hradiště-Sady and other parts of Uherské Hradiště. According to Bendová's (2006) preliminary results the raw material from Sady differs from the prevailing raw material used in Mikulčice and Pohansko which bear close similarity. It is highly probable that Mikulčice and Pohansko exploited another common source.

The assessment by M. Bubík, a specialist in Tertiary sediments from the Czech Geological Survey in Brno, contributed significantly to our knowledge of the raw material of the Mikulčice whorls. The grey siltstone with biotite and siliceous sponge spicules of the oxea and oxycaltrop type, centric diatoms *"Coscinodiscus"* sp., agglutinated foraminifers *Bathysiphon* sp., possibly also calcic benthonic foraminifers (*Cibicidoies?* sp., *Planulina?* sp., *Stilostomella* sp.) and planktonic foraminifers *Globigerina* sp. A thin-walled

compressed shell probably from a pteropod was also found. A high occurrence of empty shells from planktonic foraminifers *Globigerina* sp. (*G.* cf. *praebulloides*) is characteristic of grey silicified marlstone. Other finds include pteropods (*Limacina* sp.), fish bones and the rare sponge spicules. Light greyish brown marlstone contained empty shells of benthonic foraminifers *Nodosaria* and *Uvigerina*, and occasional sponge spicules again (Bubík 2006). The microfossils and lithology point to an origin in the Carpathian Flysch Belt. The marlstone with pteropods is similar to the marlstone of so called "spiratella" horizons in the subchert beds of the Menilite Formation in the Žďánice Unit (Oligocene). The rock may have come from occurrences of the Menilite Formation such as those near Mouchnice or Nemotice. The siltstone with biotite may represent unusual local facies of the subchert beds. The marlstone with foraminiferans might be compared to the Sheshory ("globigerina") marls, which form the underlying rocks of the Menilite Formation. Consequently, all the raw materials could possibly come from the same location in the Žďánice Unit of the Krosno-Menilite Group, whereas the siltstone from Uherské Hradiště-Sady was collected in the Rača Unit of the Magura Group of the Carpathian Flysch Belt.

VII.4. Cretaceous opoka (eastern Bohemia, Lesser Poland)

General Characteristics: During research of the 7th to early 9th century AD settlement site at Staré Badry near Opolánky, district of Nymburk, Princová-Justová (2004) found several stone whorls and fragments in four pits. Local Cretaceous opoka (silty marlstone with sponge spicules) had been used in their production. As opoka is a soft and easily processed stone, additional finds are expected in areas where opoka is found in the Bohemian Cretaceous Basin.

Another similar Cretaceous rock (opoka-like marlstone with sponge spicules and grains of glauconite) was used for whorls at the well-known early medieval stronghold at Stradów (south-west of Busko-Zdrój, Świętokrzyskie Voivodeship, Poland). Based on petrographic and micropalaeontologic research, Szmoniewski et al. (2006) identified the rock age as Albian to Upper Cenomanian and they presume a source in the vicinity of the village of Stradów.

VII.5. Talc schist from Prachatice (south-western Bohemia)

Background: Fröhlich (1988) described finds of medieval talc whorls from Prachatice and nearby Těšovice. The concentrations in the vicinity of Prachatice led him to speculate about the presence of a local manufacturing site. He supposed a possible talc extraction for whorls near the village of Běleč (about 5 km NNE from Prachatice). Nauš (1995) identified the talc source in the serpentinite body on the Šibeniční vrch Hill (682 m) at the north-west border of Prachatice.

Location: Kratochvíl (1962) called attention from the mineralogical point of view to the occurrence of talc in serpentinite on the Šibeniční vrch Hill near Prachatice and in marble bodies nearby Záblatí and Běleč. In the latter two localities we know only thin talc veinlets, which could have not been used in practice. A field research conducted by Benedová (2006) for her master thesis proved that the former serpentinite quarry found on the southern slope of Šibeniční vrch Hill, is now built up with housing (Budovatelská street 1076) and it is not possible to get samples of talc schist.

Geological Setting: Talc schist is connected with the serpentinite body that is a part of the Varied Group of the Moldanubian Region. The body is situated on the north-west border of the Prachatice Granulite Massif. The best local expert on such issues (Nauš 1995) found that the serpentinite stretches along a NNE to SSW direction from the VIth district of Nové Město in Prachatice up to the Bohemian Quartz Lode.

Based on the geological map by Hejtman (1984, Fig. 1), two small serpentinite occurrences crop out together with amphibolite bodies south-east of Prachatice in the area of sillimanite-biotite paragneiss or granulite.

Macroscopic Appearance: The samples described below are from the collections of B. Nauš, who has investigated the area of interest for a long time. The talc schist is dusky yellow green (5GY 5/2). Its schistosity is developed only locally (Supplement/Photo 374). It is greasy to the touch and can be scratched easily with a steel needle, which leaves a white line. It is difficult to scratch with one's nail. Magnetic susceptibility of whorl-sized fragments ranged from 0.14–0.16 x 10^{-3} SI, bigger pieces had 0.22 x 10^{-3} SI.

Thin section: Benedová (2006) studied the talc schist from the Šibeniční vrch Hill and the whorls from Prachatice under supervision of the author. The talc schist appears almost monomineral under the polarizing microscope. The talc scales are largely 0.025–0.2 mm. They are colourless in plane-polarized light and have high interference colours (pink, blue, green) during the observation with crossed polars. Small mica scales occur as accessories, and probably spinel is very rare (Supplement/Photo 375).

The talc raw material of a whorl does not have so strictly monomineral composition. Aside from the prevailing talc and small secondary mica scales, amphibole relicts are present. They are recognisable thanks to their characteristic cleavage. The original amphibole crystals have been replaced by talc.

Prehistoric and Medieval Use: South-Bohemian talc schist has been used since Early prehistory, as evidenced by the finds of early Bronze Age talc pearls and rings from a settlement site lying at the confluence of the Lužnice and Vtava Rivers in the area of the village of Hosty (Beneš 1984). Parkman (1995) provided evidence of talc items from the Prachatice area. He recorded more than twenty whorls, their fragments or semifinished products from ten medieval sites. Apart from different places in Prachatice

and Staré Prachatice, he also identified them in Horouty, Husinec, Netolice, Strunkovice nad Blanicí, Těšovice and Vitějovice. Other examples include three talc whorls from České Budějovice and one from the village of Křtětice (district of Strakonice). He ascertained that it would have been necessary to revise the findings obtained from the other South-Bohemian medieval sites to gain a comprehensive whole picture of their spread. He dates the production and use of talc items to a wider period from the Middle Fort Period to the High Middle Ages (9th – 13th century). They are primarily surface findings from multicultural sites, though seven talc whorls from Strunkovice nad Blanicí were found in the layer dated to the 12th – 13th century.

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VIII.
ROCK SALT (HALITE)

Rock salt (halite from the mineralogical point of view, chemically sodium chloride – NaCl, crystallizes into cubic or isometric system) is essential to human physiological processes. Its preservative effects were discovered early. It was also used for glaze and probably also glass production and leather processing. It was evaporated from sea water, probably since the Old Stone Age, which was not possible in eastern Central Europe. That is why the fossil rock salt had been mined in several places throughout prehistory. There are Permian to Triassic and younger Tertiary (Miocene) sources (Fig. 137).

VIII.1. Miocene rock salt from the vicinity of Prešov (eastern Slovakia)

Location: More rock salt deposits exist in eastern Slovakia. Only those which crop out on the surface or were been accompanied by salty springs were known in prehistory. The village of Solivar (Soľná Baňa) situated on the south-eastern border of Prešov is the most important. The rock salt deposit is created by an extensive body, which reaches the areas of the villages of Solivar, Soľná Baňa, Ľubotice, Ruská Nová Ves and Vyšná Šebastová.

Geological Setting: The deposit originated in the regional Miocene stage called the Karpathian (roughly 17,5–16,5 My ago). The rock formation having a thickness of about 500–600 m is formed by marly clays and clays with intercalations of rock salt, gypsum, rock salt breccia and sporadic layers of sandstone (Slávik et al. 1967, 266). Thickness of the salt beds is usually up to 15 m. The salt deposit is damaged by a few normal-slip faults with dipping both to the north and the east.

Prehistoric and Medieval Use: Slávik et al. (1967, 264) mentioned written records about the Prešov salt springs to 898 AD (web site gives the dates as 1223 or 1262 AD). The old Latin name of the village, Castrum Salis, supports the early us of local salt. The source must have been known in the Roman Period, when precious opal was mined in the Slanské vrchy Mts. only 15 km away. It is reputedly mentioned in the time of Marcus Antonius. Salt

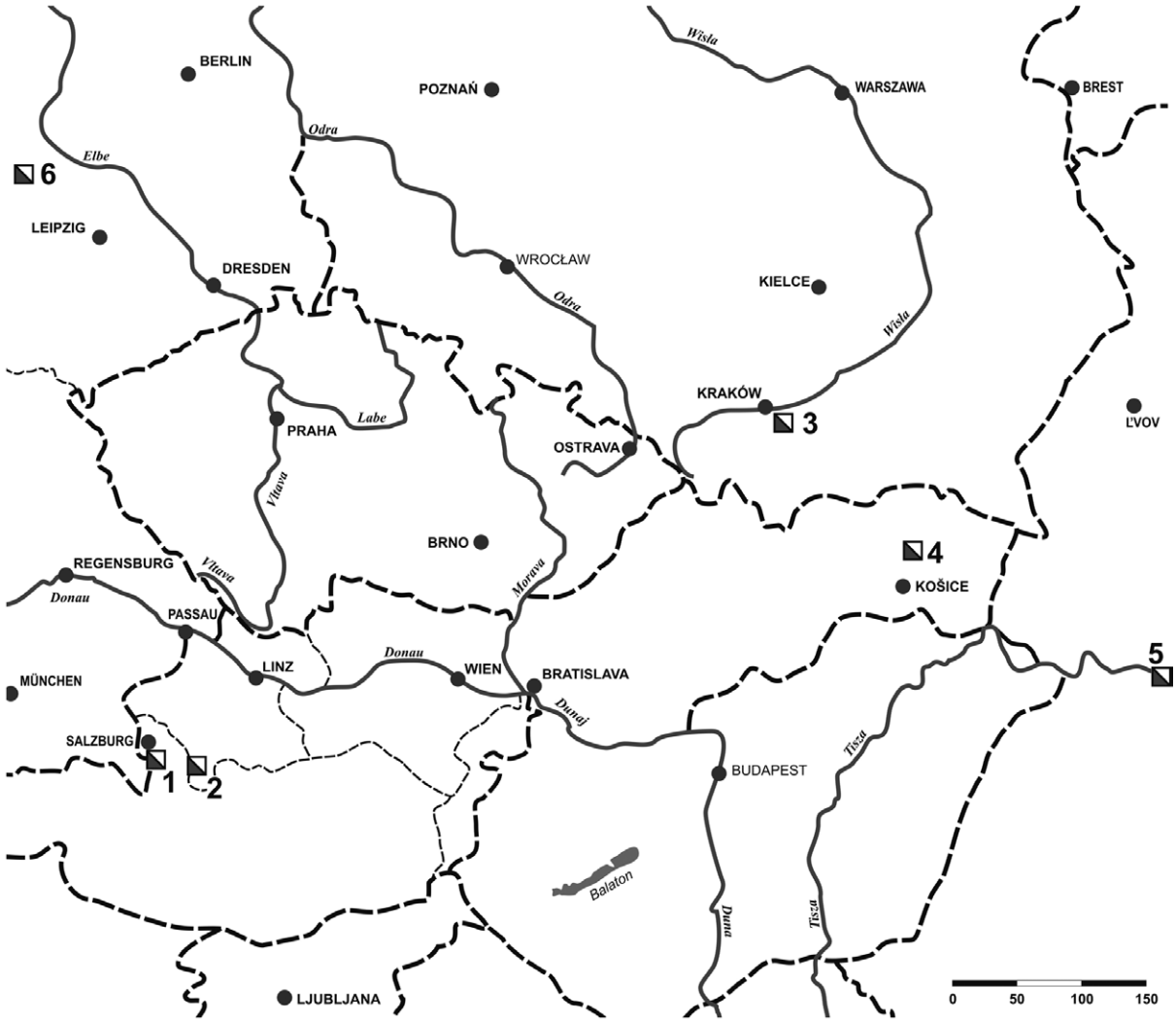

Fig. 137. The most important occurrences of salt in eastern Central Europe. 1 – Hallein, 2 – Hallstatt, 3 – Wieliczka, 4 – Solivar near Prešov, 5 – Solotvino, Sighetu Marmatiei, 6 – Stassfurt.

was mined from 1572 to 1752, when the galleries flooded and the salt dissolved into brine. Currently the mining complex is a National Cultural Monument of the technical objects used for drawing brine and boiling out the salt.

VIII.2. Miocene rock salt from Marmarosch Solotvino (Akna Slatina, Marmaroska ulohovyna Basin, Transcarpathian Ukraine)

Location: Salt sources are situated along the modern Romania – Ukraine border in a wide valley at the confluence of the Tisa and Iza Rivers some 50 km south-east of Chust. The area had been part of Czechoslovakia until World War II. In addition, the proximity of Hungary has led to large towns having several names in different languages. The centre of mining concentrated at the border couple towns of Solotvino (in Ukraine) and Sighetu Marmatiei (in Romania).

Geological Setting: The Miocene (Tertiary) rock salt is deposited under a 15–38 m think layer of Quaternary fluvial loams, gravels and sands. A 17–35 m thick layer of Tertiary blue-grey clay protects it from percolating water. Thanks to its relative plasticity the salt created a steep to almost vertical body (a diapir), which probably reaches a depth of 250–300 m. As a consequence of the geological structure the water sometimes percolated, causing the mine gallery ceilings to collapse and flood. The main 19th century shafts (Mikuláš's shaft and with it connected Kunigunda's one) flooded in this manner and were closed in 1906.

The salt mining was moved to the Ludvík and František shafts as Czechoslovak state property when Transcarpathian Ukraine was a part of former Czechoslovakia (during the 1920's and 1930's). The shafts reached their record depth of 167m. The salt was largely mined by hand; twenty to twenty five kg heavy blocks were carried to wagons and transported to the surface by human-power. Forty five trucks were mined daily and transported by train to mills in Olomouc in Czechoslovakia (Král 1921).

Prehistoric Use: Prehistoric salt use in this area of Transcarpathian Ukraine is evident from already rich Neolithic settlement in the area (Jankovich 1931, 15). There are also finds of Bronze Age gold in the area of Marmaroska ulohovyna Basin. An archaeological site from the Hallstatt Period was found just at the salt mines of Akna Slatina, and salt mining is presumed to have been conducted in the Roman Period.

VIII.3. Miocene salt from Wieliczka near Kraków (southern Poland)

Location: The town of Wieliczka is situated on the south-east border of Cracow, about 9 km far from its centre. Another well-known area with rock salt is Bochnia lying some 36 km east of Cracow.

Geological Setting: The salt deposit is a part of the sedimentary filling of the Carpathian Foredeep situated next to the face of the folded Carpathian Flysch Belt. In the upper part of the Lower Badenian, rock salt, gypsum and anhydrite precipitated from sea water in isolated bays due to suitable climatic and geological conditions. The rock salt deposits in the vicinity of Wieliczka and Bochnia were created in this way.

The deposit is an oval shape running 4 km along an east-west axis, and about 0.6–1 km wide (Gradziński 1972, 316). The salt bearing formation reaches depths of 300–400 m. Miocene clays and Quaternary sediments are in its top wall. Jurassic limestones form its underlying rocks. The upper part of the deposit contains huge blocks of coarsely grained green salt closed within "zubrach" (grey clays containing salt crystals). The green colour of salt is caused by tiny anhydrite and green clay inclusions. This salt was quarried from inside with left outer block edges. As a result large chambers were created, that are characteristic of the Wieliczka salt mine. The salt in the lower part of the deposit occur in layers, comprised of white middle- to coarse-grained pure salt, dark coloured salt resulting from sand and clay pollution, and green salt with the clay and anhydrite fillers. These lower layers have been folded in a complicated way.

Prehistoric use: The oldest traces of salt extraction in the vicinity of Bochnia and Wieliczka come from the Middle Neolithic and have been connected to the Pleszów group of the Lengyel culture. The remains of pottery containers (crucibles) used for the brines (salty solutions) evaporation and briquetting of the obtained salt have been found in the Bronze Age, Hallstatt and La-Tène-Roman Periods. A summary of prehistoric and early medieval salt exploitation in Lesser Poland can be found in the publication of Jodłowski (1988). Mining continued throughout the whole Middle Ages up to the present day (Fig. 140).

VIII.4. Permian to Lower Triassic salt from Salzkammergut (Austria)

Background: Salzkammergut is a scenic landscape at the border of two Austrian federal countries – Salzburg and Upper Austria. It was one of the most important exporters of salt in prehistory and in the Middle Ages. As central Europe has no sea it was necessary to exploit Permian or Lower Triassic fossil rock salt. Kern et al., eds. (2009) published a comprehensive study devoted to the prehistoric salt mining in Hallstatt.

Architectural monuments and the political and economic power of the city of Salzburg, the capital of Salzburg country, are connected to mining and the export of salt from nearby Hallein. Another centre of salt mining in Hallstatt became interesting for the professional public after the discovery of a prevalently Iron Age burial site above the town.

Location: Prehistoric and medieval mining is concentrated in two places, named after an ancient (probably

Fig. 138. Hallstatt. A view from the salt mines towards the cementery of the Early Iron Age. Photo by the author.

Celtic) word for salt. The first is Hallstatt, situated within the Salzburg Alps, about 60 km east of Salzburg. Salt deposits rise up above the town on the mountain of Salzberg. A glacial hanging valley is recessed into its upper part (Fig. 138). In the 19th century Early Iron Age burials of miners, with extraordinarily rich grave inclusions containing items from all around the then known world, were found at the edge of the valley. As a result the town has provided its name to the whole culture of the Early Iron Age. Twentieth century salt mines are located deeper in the valley, the opening of which led to the discovery of a prehistoric salt mining with wooden and metal tools, leather baskets used for taking out salt, wooden torches and clothes. Organic materials from this site have been preserved for more than two millennium as a consequence of the salt, which enclosed and preserved the prehistoric mining works and all the items present (Fig. 139, Supplement/Photo 376, 378).

The second salt mining centre is Hallein located several kilometres from Salzburg near the German border. The salt mines have been opened in the area of Dürrnberg Mt.

Geological Setting: In Hallein the salt is a part of rock formation called by old miners "Haselgebirge". It also contains gypsum or anhydrite and clays. The age of the rock formation falls between 260–244 million years, corresponding to the Late Permian and Lower Triassic (Lobitzer & Mayer in Kern et al., eds. 2009). The rocks were created by precipitation from sea water within an enclosed bay in a hot arid climate. As a consequence of the overthrusting Calcareous Alps pressure, the evaporite rocks being relatively plastic formed the special diapir tectonics; it means an upward directed columns or domes of salt. As a result of this special salt tectonics the two emergent Jurassic limestone rocks (Barmsteine) create the striking symbol of Dürrnberg. Huge boulders of limestones and dolomites fell into the drying bay probably as a consequence of an earthquake. In the recent salt mines they hang from the ceilings or lie at the bottom of leached out caverns.

Macroscopic appearance: Hallstatt salt is largely dark to black, coloured by organic material. In the main mass it is possible to observe red and white layers in some places (Supplement/Photo 379).

Prehistoric Use: Salt mining is presumed to have begun as early as the Neolithic at both sites, as suggested by the Neolithic axe found in Hallstatt (it is possibly made

of Jizerské hory metabasite, according to the author's macroscopic assessment). A burial site at Dürrnberg proves the existence of a settlement on the mountain as early as 800 BC. The oldest mines are dated to the 4th and 5th century BC and the salt was extracted as solid pieces. Underground mining was conducted with stone cudgels, various types of diggers and bronze bits. The mining reached its peak at the turn of the Hallstatt and La-Tène Periods. The mines reached depths of 120–200 m and the total length of the galleries is around 5 km. Hallein salt was distributed from the Baltic to Italy, and France to Hungary. As the influence of the Roman Empire grew, the significance of the Hallein and Hallstatt salt declined, as it was replaced by salt precipitating from sea water during evaporation, which the Romans were able to produce and distribute much more economically.

In prehistory, salt was carried in leather baskets hanging from the back or in pottery containers. A great deal of information is known about salt transportation in the Middle Ages. Firstly, it was shipped along the Salzach River to Laufen and then along the Inn River to Passau. Subsequently it was transferred to wagons and transported to Bavaria, Bohemia, Lower Austria, Moravia and occasionally to Silesia. Other traders carried the salt on the horses southward across the Taury Mts. to Carinthia and the eastern Tyrol. The most extensive area stretched from Slovenia to Silesia and from Franconia, Germany, to Vienna.

Fig. 140. Going of miners down the salt mine in Wieliczka near Cracow in the beginning of the 19th century could be probably partly similar to that in prehistoric times. Archives of the author.

Fig. 139. A basket used to curry up salt and wooden shovel from prehistoric mines represent a part of finds on exhibition in the Hallstatt museum. Photo by the author.

The most famous find from the prehistoric salt mines in Hallein was mentioned in the "Saltzburg Chronicle Anno 1666" written by Franz Dueckher von Haslau (according to W. Vetters, undated): "In the year 1573, on the 13th of the winter month, a shocking comet-star appeared in the sky, and on the 26th of this month a man, 9 hand-spans in length, with flesh, legs, hair and clothing in a state of non-decay, although somewhat flattened, the skin a smoky brown colour, yellow and hard like a codfish, was dug out of the Tuermberg mountain 6300 shoe-lengths deep, and was laid out in front of the church for all to see. After a while, however, the body began to rot and was laid to rest. Therefore he must have been buried alive in the mountain before living memory, deeply embedded, and preserved in appearance so long from decay by the salt, whilst his shoes, clothing and wooden pickaxe were also found embedded in the rock."

Another find of a well-preserved body of a Celtic miner was found in Hallein in AD 1616. Similar find is also known from the Hallstatt mines in 1734 (Kern et al., eds. 2009, 40).

VIII.5. Permian salt of the Stassfurt – Halle area (eastern Germany)

Prehistoric use: Salt was obtained by boiling down brine in pots, in both the central Elbe valley and Sála River areas. Müller (1988) describes finding ceramic pots for salt briquetting, from the Neolithic Bernburg culture, in the town of Halle-Langer Berg. He mentiones also other examples of pots for obtaining salt in that area in connection with the Early Bronze Age Únětice culture and other later periods.

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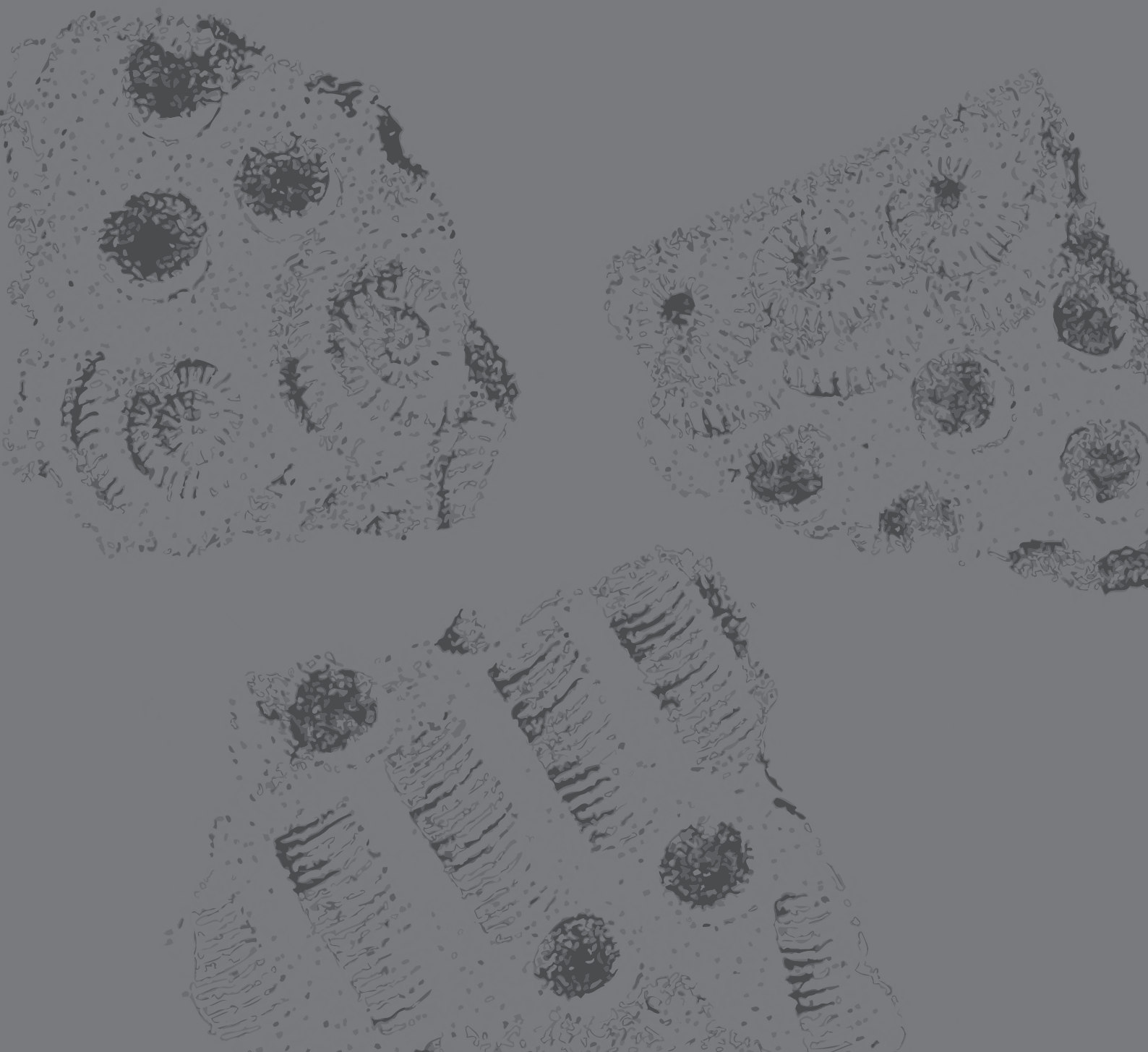
IX.
USING OF FOSSILS AND OTHER LITHIC RARITIES IN PREHISTORIC TIMES



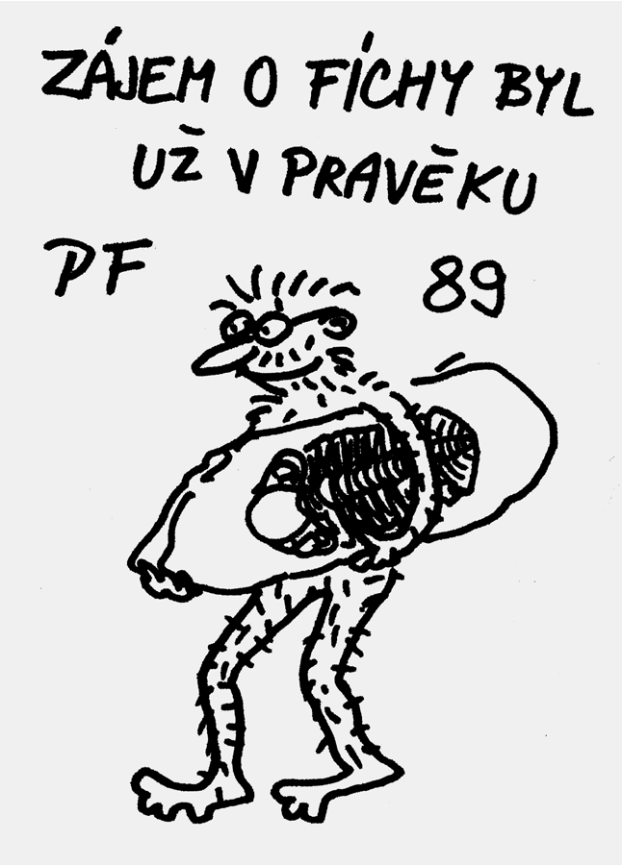


Fig. 141. Transport of the trilobite found in the Arcy-sur-Cure Cave in France according to the idea of J. Hladil (a Czech palaeontologist and geologist). The picture has been send to the author as PF 1989 with the text: Already the prehistoric man was interested in fossils.

Fossils as natural rarities have been the subject of interest for thousands of years. They were used as amulets and talismans due to their interesting shapes and mystery. Until the mid-18th century the origin of fossils was not clear and Aristotelian perspectives predominated. They were thought to have been formed from slime and sediment by neomorphism (this thought was probably connected with the unusual formation of some concretions). In ancient times and in the Middle Ages fossils were usually compared with some commonly used things. Greek geographer and historian Strabo regarded large nummulites (foraminiferans), weathered out from Tertiary limestone in Giza plateau, Egypt as petrified lentils which slaves ate while building the pyramids. Nummulite limestones are also widespread in the area of Liptov in Slovakia where there are legends about petrified lentils as well. Elsewhere they are compared to small petrified coins (Augusta 1955).

What did prehistoric man think when he found these strange natural subjecs? We know that they were collected as earlier as the Palaeolithic. A unique find of a trilobite with a drilled hole together with Tertiary gastropod shells comes from the Palaeolithic (Magdalenian) layer at Arcy-sur-Cure Cave in the Yonne River valley, France. It is kept in the Musée de l'Avalonnais. Some ochre coloration remains can still be seen on the artefact. Palaeozoic sediments with trilobites do not occur near the cave, local Tertiary sediments represent geological filling of the Paris basin. Trilobites from nearby Bretagne and Languedoc are not well preserved. The find was widely discussed (Schmider et al. 1995, 106–107; in the Czech literature Gregorová 2006, 12). One early thought was that the trilobite fell into the species of *Dalmanites hawlei* with origin in the Barrandien, Bohemia, about 2,000 km away. Later it was reclassified as genus *Zeliszkella, Guichenia* or *Ormathops* and dated to the Ordovician period. This unusual find is a record of the collection of trilobites 15,000 years ago. Today the cave has been renamed Grotte du Trilobite (Cave of Trilobite, Fig. 141).

Another use of fossils was found in a Palaeolithic grave at the town of Dunstable Downs in England, where the skeleton of a young woman with a child in her arms was found. Both skeletons were enclosed by a ring of almost two hundred pieces of free, fully preserved Mesozoic sea urchin shells (*Anonchytes ovatus* and *Micraster coranquinum*). The fossils were collected in Upper Cretaceous sediments in the vicinity of the grave (Prokop 1989, 9–10, including the picture). An unusual use of Mesozoic fossils for prehistoric pottery decoration is known from the Neolithic Sokolskoe I site, on the left bank of the Volga River in Ivanovskaya region in the European part of Russia (Korobkov & Križevskaja 1958). The Balachninskaya culture ceramics are covered by a structure of hollows, cuts and spirals (Fig. 142) which were created by embossing with a belemnite rostrums (genus *Pachyteuthis* and *Cylindrateuthis*) and fossilized ammonite shells (*Cosmoceras, Perisphinctes*). The fossils come from Upper Jurassic sediments (probably Callovian) which occur in the Neolithic site area as well as in wider area of the Volga and Oka Rivers.

In Moravia, Miocene fossils (gastropods, pelecypods, tusk shells, sessile worm tubes, and rarely coral and shark tooth) with artificial or natural perforation were found at Milovice, Dolní Věstonice, Pavlov and Přerov-Předmostí (Gravettian sites). They were used as pendants and sometimes there are red or yellow colour remains and cutting marks on them. The fossils are mostly of Badenian age, with some Sarmatian and Pannonian finds as well (Hladilová 1994, 1997) and they likely originate from the Miocene filling of the Carpathian Foredeep and Vienna Basin, it means from the surroundings of mentioned Upper Palaeolithic sites. Š. Hladilová thinks that the contents of some assemblages show purposeful and systematic prospecting of some fossils.

One unique artefact is an erratic flint full of holes, used as a prehistoric signal whistle (Pavelčík 1993), now deposited as number A 1008 in Krnov Musem, Czech Silesia. It was found in Šelenburg at the village of Úvalno, about 5 km south-east of Krnov. It might be related to the local Lusatian Urnfield culture hillfort. It is a piece 62 x 40 x 32 mm with four holes (Fig. 143) arranged so that you can play several tones while placing fingers over some

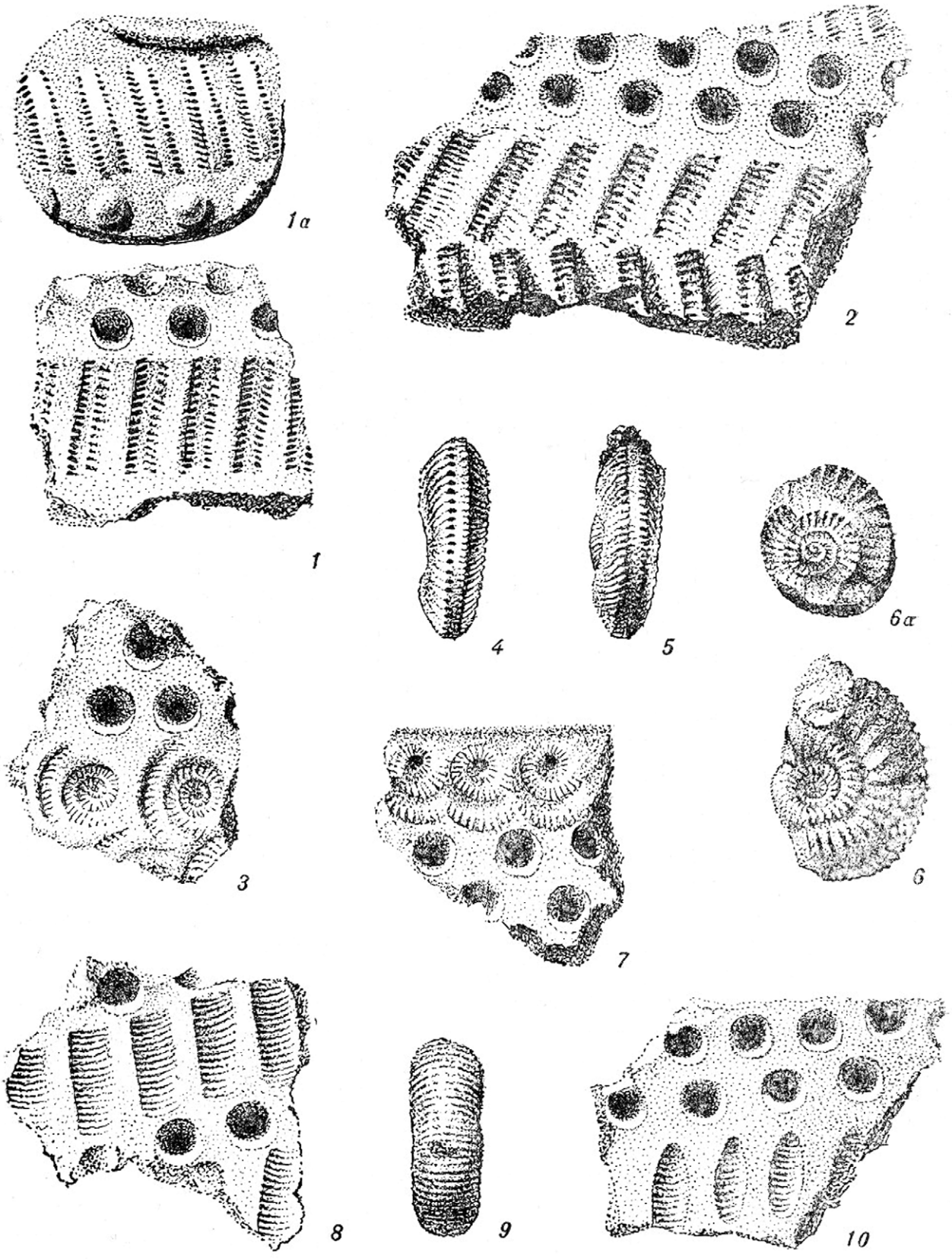


Fig. 142. Chips of Neolithic pottery from the village of Sokolskoe (Ivanovsk region, Russia) with ornaments made using fossils of belemnites and ammonites. 1, 2, 3, 7 – used ammonite of genus *Cosmoceras*; 8, 9 – used ammonite of genus *Perisphinctes*; 4, 5, 6 – fossilized ammonite of genus *Cosmoceras*; 9 – abdominal part of ammonite *Perisphinctes bernensis.* Small pits were done apllying the belemnite rostrum *Pachyteutchis* a *Cylindrateuthis*. After Korobkov & Križevskaja (1958).

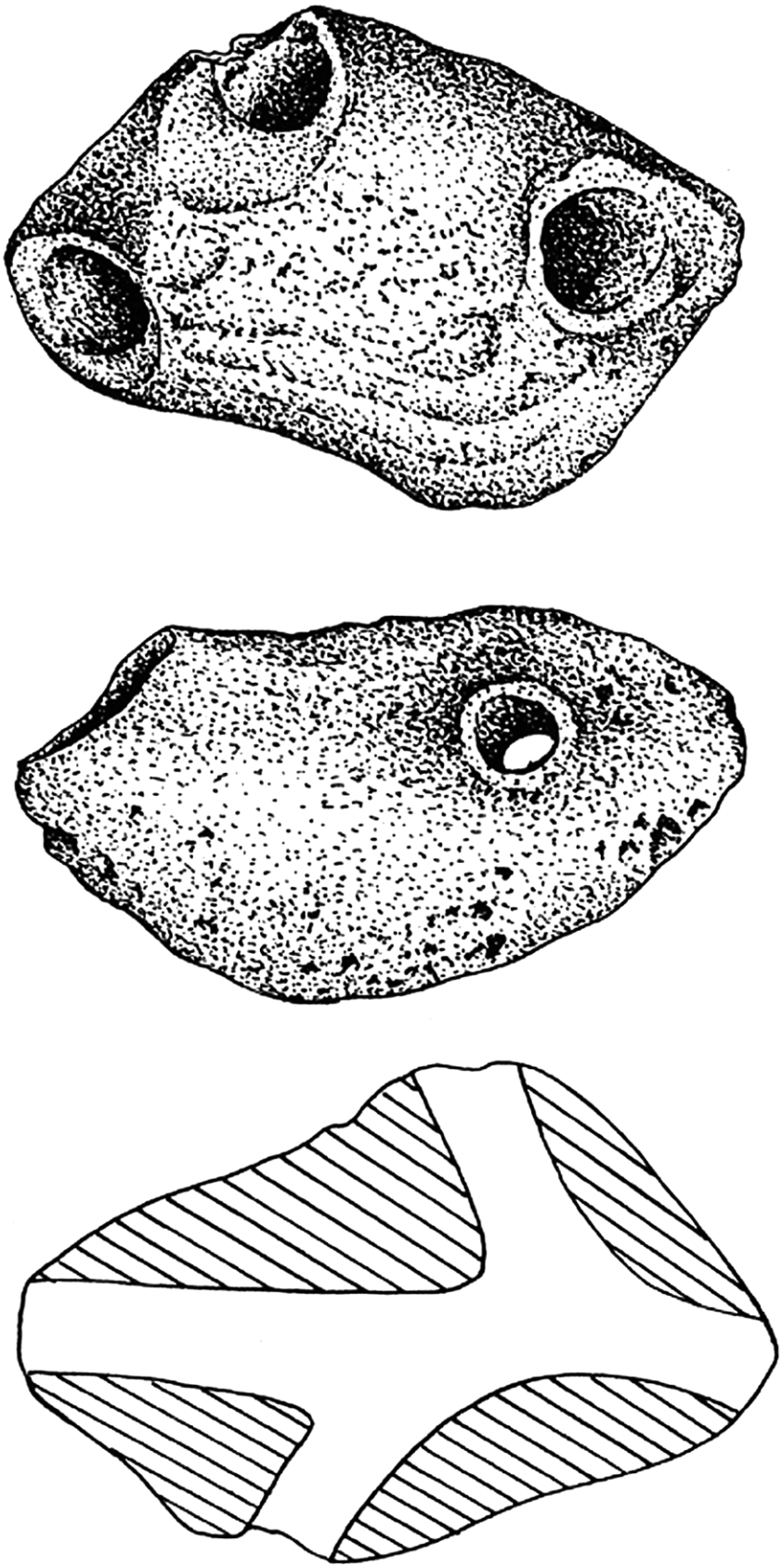


Fig. 143. Flint whistle from Úvalno near Krnov, Czech Silesia. Probably Lusatian Urnfield culture. After Pavelčík (1993).

Fig. 144. Chipped core prepared from the chert of Krumlovský les in such way to show the void with small rock crystals. Height 6.5 cm. Vedrovice near Moravský Krumlov, Linear Pottery culture. Photo by the author.

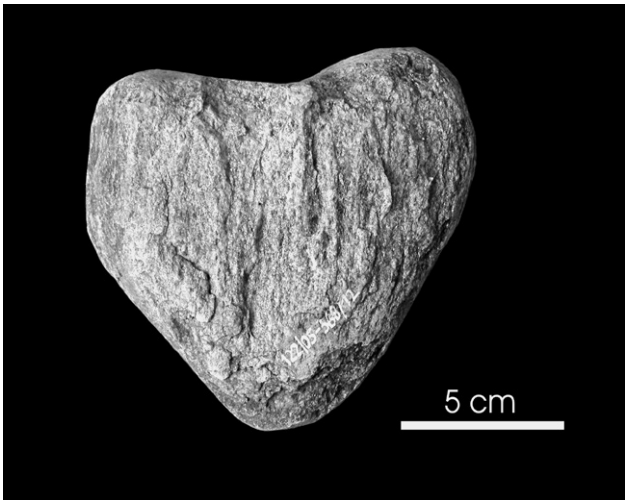


Fig. 145. Pebble of biotite gneiss artificially shaped as a heart. Brno – Starý Lískovec, object 646, artefact no. 122/05-368/12. Dimensions 11,4 x 9,4 x 3,5 cm, magnetic susceptibility 0,07 x 10^{-3} SI. Linear Pottery culture. Excavations of M. Přichystal in 2005.

holes and blowing air over the blow hole. Gába & Pek (1993) noted that the holes are not artificial but natural (most likely after weathered out fossils or burrowing marine animals). The uniqueness of the find is in the raw material, which differs from the usual prehistoric bone whistles reporting in the archaeological literature.

Because of its black coal occurrences, northern Moravia is high in the global ranking of coal use. Klíma (1953) determined that Palaeolithic hunters burnt black coal in their fires, during his research of an important Pavlovian site on the Landek Hill in Ostrava-Petřkovice. Layers of black coal on the Landek Hill are vertical due to tectonic movement and coal crops out on the surface some 200 m far from the Palaeolithic site.

There is no doubt that prehistoric people were interested in crystals of some minerals because of their regular arrangement of smooth glazed faces. Unique crystals of columnar quartz to 5 cm long were found at the Aurignacian site at Slatinice, district of Olomouc. An 8 x 6.5 cm chipped core made of Krumlovský Les chert was found during surface survey at the Linear Pottery culture site at Vedrovice. The core is flaked in such fashion that the void with little rock crystals, embedded in the core, is exposed. Even today it remains a beautiful decorative object (Fig. 144). Another interesting stone artefact, a heart-shaped pebble of biotite gneiss (Fig. 145) was acquired by M. Přichystal during excavation at the Linear Pottery culture site in Brno-Starý Lískovec.

One of the most remarkable finds is the collection of meteoritic irons from the Kylešovice Hill at Opava, discovered in 1925. In older literature it was connected with a local Palaeolithic site, dated to the Aurignacian or Solutrean cultures. Modern evaluation classifies it as mostly Epigravetian even if the assemblage of chipped tools is not probably homogeneous (Svoboda et al. 2000, 218). In the first half of the 20th century several sand pits (Lundwall's, Cooperative, Municipal ones) were opened on the Kylešovice Hill, south of the Opava-East railway station. Brick clay and sand were mined in the sand pits. On 3rd July 1925 workers noticed three stones in fine glacial sand at the Cooperative sand pit on the north slope of the hill. They were conspicuous by their weight as well as appearance – thick limonite crust. The conditions of the finds were described in detail by Drahný (1926a, 1926b). The stones lay close together in a one square meter area. The workers informed civil ingineer G. Stumpf who had assembled more prehistoric finds (stone or bone artefacts, bones of Pleistocene animals) from the sand pits previously. G. Stumpf assumed from the beginning that they were either iron meteorites or prehistoric smelted iron. He obtained another small piece after a careful inspection of the place although according to information of the sand pit supervisor there had been more small pieces removed from the sand pit by the workers. The weight of individual stones was 7.39–5.79–1.15–0.11 kg. The two biggest stones were etched with HCl on polished planes to confirm the meteoritic origin.

Subsequently it was ascertained that three more pieces of meteoritic iron (5.43–0.67–0.47 kg) were picked up by a student named Pokorný about 60 steps to the north-west of the first find. In total the collection from the sand pit contained 7 pieces with a total weight of just over 21 kg. Patinated flint artefact was found in the same location, another 7.4 cm patinated flint blade comes from the loess over the sand. Twenty three years later Brenner (1949) announced one more piece of meteoritic iron weighting 0.34 kg along with Palaeolithic artefacts from the Lundwall's sand pit on the south-east slope of the Kylešovice Hill, about 400 m away.

Most iron meteorites from the Kylešovice Hill are deposited at the Silesian Museum in Opava nowadays, four smaller cut off plates are at the National Museum

in Prague and one is at Czech Technical University in Prague (Tuček 1981). According to studies of Rost (1964), the Opavian meteorites are mostly hexahedrites, partly recrystallized octahedrites probably influenced by prolonged heat effect from a Palaeolithic fire around which they had been laid. All Opavian iron meteorites have very similar chemical composition which shows that they come from one meteorite fall. Observed data indicate that Palaeolithic hunters witnessed a meteorite fall and used collected pieces for fireplace lining. In this way they created the oldest meteorite assemblage in the world.

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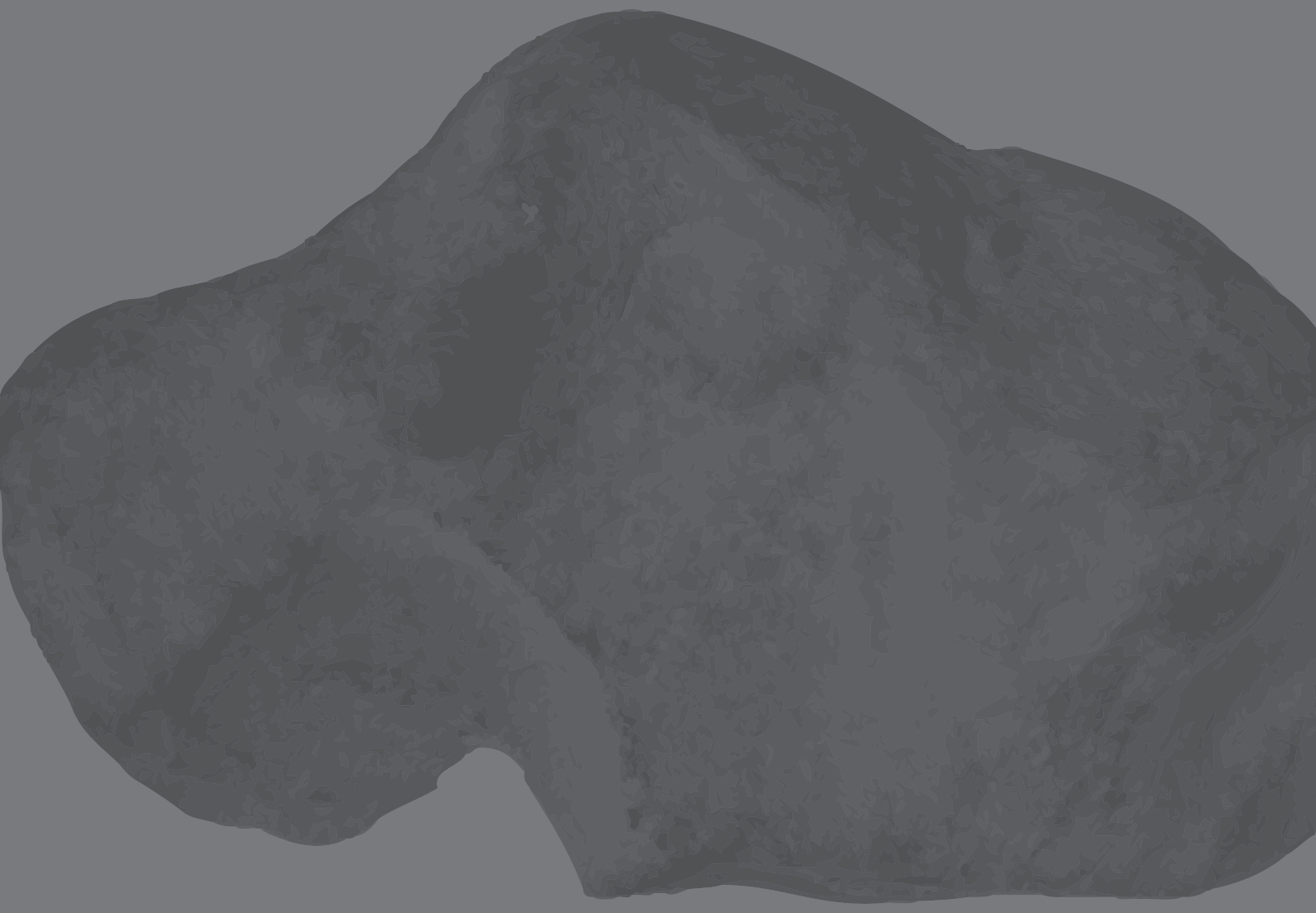
X.
STONE PSEUDO-ARTEFACTS AND FAKES



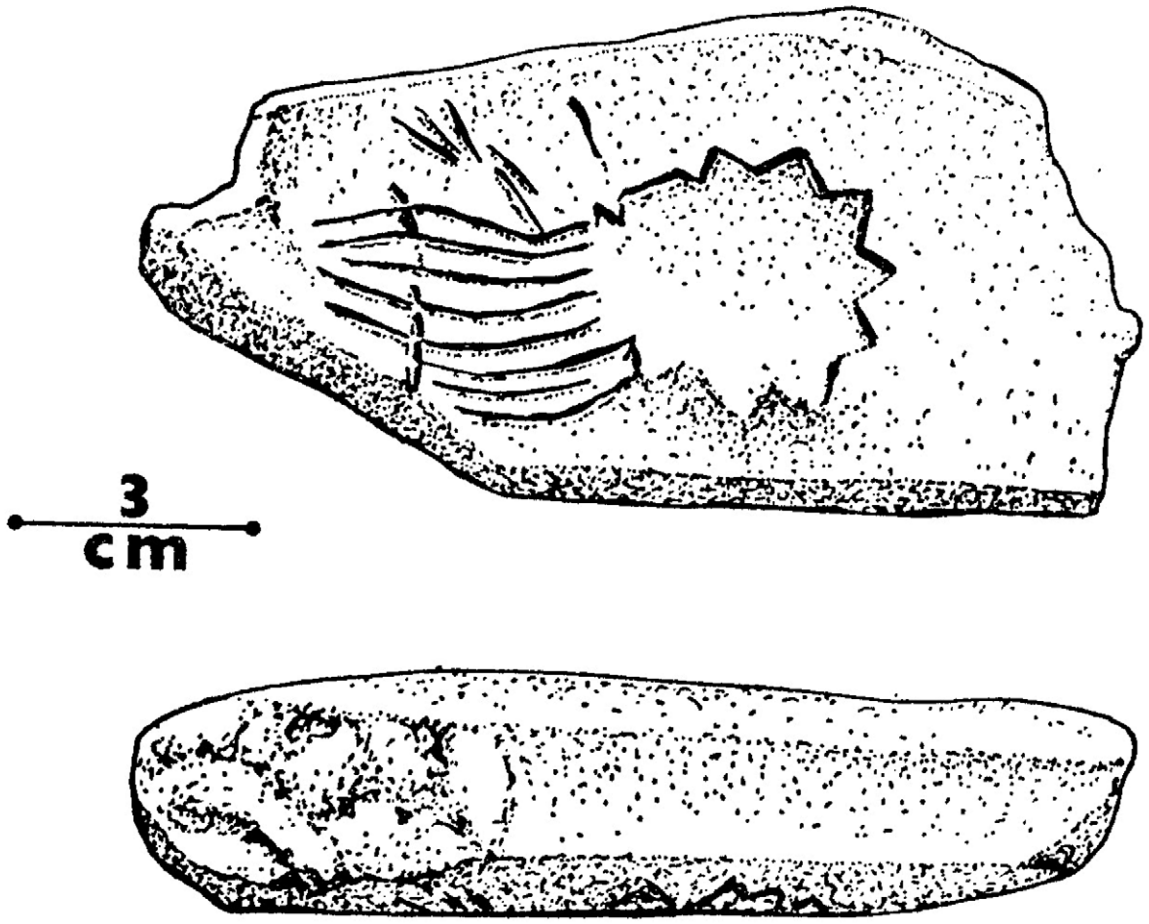


Fig. 146. Neolithic axe from Lhánice (district of Třebíč, western Moravia) with additionally engraved picture of a comet. After Koštuřík et al. (1986).

Pseudo-artefacts are an interesting problem for archaeology. They appear often among erratic silicites thought it is not usually a problem for specialists to recognize them. In the Czech Republic pseudo-artefacts from Miocene (Tertiary) sediments in the vicinity of Jurassic limestone outcrops in Brno and in the area of Krumlovský les Highland in southern Moravia (Supplement/Photo 380, 381) are worthy of special notice. Some shapes look like chipped cores after blade's striking or flaked fragments, but all faces are covered by dark desert varnish. It is thought that the varnish originated at the eastern border of the Bohemian Massif in the Lower Tertiary. These pseudo-artefacts occur in Miocene (Ottnangian or Lower Badenian) gravels. The origin of pseudo-artefacts relates to the processes that formed the Krumlovský les cherts because different marks (nail scratches to multicentimetre cuttings) after other pebble strikes are distinguishable on the pebble surface. A thinner film of desert varnish comparing the original pebble surface still created on the faces after fragments, but they have markedly less striking marks. It is obvious that processes leading to pseudo-artefact formation proceeded at the same time when the desert varnish was created on the pebbles and chert fragments. The cherts probably filled up erosion furrows or dry river valleys – wadis (the Arabic term for a dry river valleys) where water rushed through only during winter or spring rains and caused multiple strikes between cherts and in such way the pseudo-artefacts were formed at the same time. The wadis are typical for arid and semi-arid regions where desert varnish forms as well.

Two to five cm big phthanite pebbles with strike marks are found in Miocene gravel near the Ládví Hill. This phthanite node near Prague 8–Kobylisy was studied by K. Žebera in 1975. The finds are also considered to be pseudo-artefacts. These and similar findings on the Bílá hora plateau in Prague are described by Mikula (1983, 33) who believes them to be authentic small tools. The recurrence of some (very simple) shapes is the main evidence.

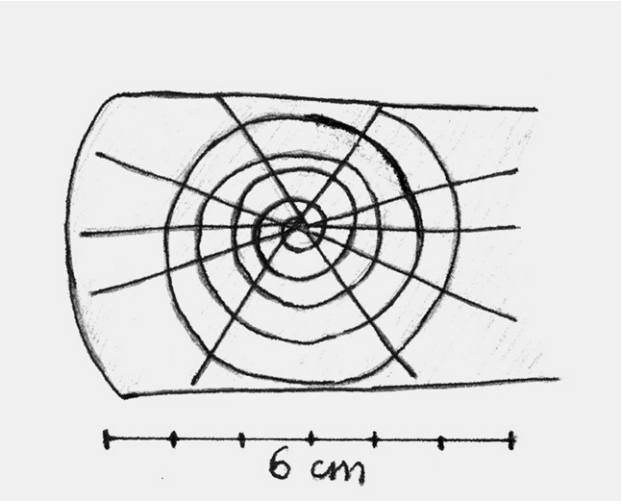


Fig. 147. Stone axe from the Museum of Eggenburg (Lower Austria) with engraved picture. Approximate appearance.

The problem of pseudoindustries is certainly more complicated the deeper we move into the geological past and the more primitive the human technologies become. But it is necessary to take into account that the many times repeated natural processes of silicite or quartz pebble strikes on the cliff coast by breakers, pebble strikes in streams, or frozen silicite pushed by a glacier over hard underlying rock can often lead to the formation of simple tool-like shapes. The vast majority of praplastics, described by Mikula (1983), should be included in the group of pseudo-artefacts. He believes that they are Palaeolithic and Mesolithic works of art. These mostly orthoquartzite cobbles or fragments, collected on Pleistocene terraces of the Ohře River, resemble human head or animal statues in many cases. According to J. Mikula, they were formed by simple cuts into the quartzite cobbles and fragments. There are tens to hundreds items in the Libochovice area, central Bohemia. But it is necessary to point out that shapes resembling human or animal sculptures can be found on basically every natural location of orthoquarzites ("sun boulders") or cherts in Moravia as well (Supplement/Photo 382, 383).

Numerous amateur collectors have attempted to local Palaeolithic art. K. Simota from the town of Třešť has collected a small interesting assemblage of Mesolithic and Neolithic knapped silicite, rock crystal and quartzite artefacts around the town. These finds were concentrated on the north-west slope of the Šibeniční vrch Hill, the slopes around Vaňov Pond, over Valcha Pond and in the northwest area of Lovětín Hill (614 m). Nobody searched for such an industry in the heart of the Bohemian-Moravian Highlands so his findings are all the more remarkable. Furthermore he collected a large assemblage of "sculptures" of Pleistocene animals and people supposedly carved and engraved in gneisses, quartz and other rocks of the local crystalline complex (Simota 1994). There is no doubt that they are pseudo-artefacts as a result of the periglacial weathering, natural movements in the slope due to gravity or rainwash effect, or perhaps as a result of modern human activity. Another collector F. Markus (Markus 1948) found figural engraving on stones at Moravian Palaeolithic sites. The figures were in fact a system of small natural bulges and depressions, cracks and small natural defects or they were directly fakes.

There are also pseudo-artefacts that resemble the perforated or polished industry. Some of them are described and photographed by Želízko (1936) because they resemble half-finished hammer axes. There are several possibilities for their formation, either through the mechanical action of water (sometimes sharpened by circular movements of drift sand) or chemical action (excretion of dilute HCl) by marine molluscs and gastropods. The perforation of rocks together with pebbles and fragments, sometimes resembling an axe or hammer axe in a shape, is often caused by date mussels – *Lithophaga lithophaga*. They are wide-spread along coast lines such as the Adriatic Sea (Supplement/Photo 384).

In central Europe this type of pseudo-artefacts is known from the Upper Tertiary, the last time there was a sea in the region. Holes were drilled by boring molluscs. They were formed mainly on the margin of Miocene sea where cliffs, built by older limestone, protruded. Boulders were formed in the surf and then drilled by *Pholas*. Specific cases can be given from Jurassic limestones on the southeast slope of the Svatý kopeček Hill at Mikulov (Pavlovské vrchy Highland), Devonian limestones at Čelechovice in the area of Prostějov (central Moravia) and at Hranice. In Slovakia nice flat pebbles of Triassic limestone with drilled holes occur in Tiesňavy in Vrátna dolina Valley (the Malá Fatra Mts.) – Supplement/photo 385, 386.

The increased interest of researchers in stone polished artefacts from the Leskoun Hill near Moravský Krumlov at the end of the 19th century even led to the emergence of a local forging industry in Zábrdovice (Woldřich 1890). Currently it is a part of the famous archaeological village of Vedrovice. Dark-coloured stone buds were produced by children and the raw material was taken from a quarry at Moravský Krumlov. Polished stone tools as well as chipped artefacts have also been recently made experimentally in Central Europe (Supplement/Photo 387).

Later interesting patterns were carved in some of prehistoric polished tools in connection with the superstition of thunder stones which always accompanied finds of polished stone axes. Probably the most famous is the image of a comet on a Neolithic axe from Lhánice, western Moravia (Fig. 146). There is also a complicated pattern on a stone axe deposited in the museum in Eggenburg in Lower Austria (Fig. 147).

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XI.
PICTURE SUPPLEMENT

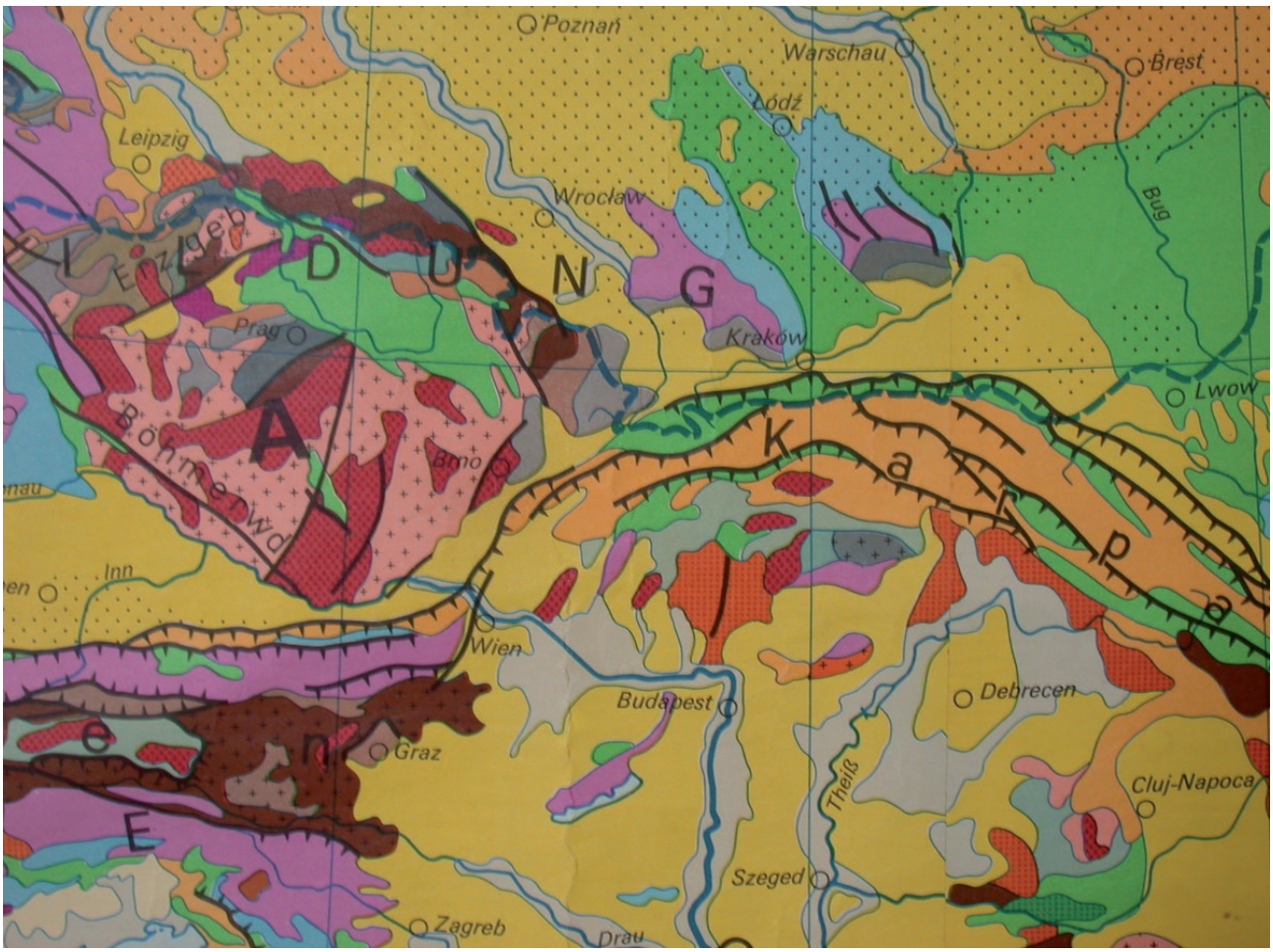


Photo 1. Geological map of eastern Central Europe. After Teschke, ed. et al. (1978). Explanations of colours and signs: crosses – metamorphic rocks; rose with crosses – metamorphic rocks of the Bohemian Massif; red with fine spots – granitoide plutons; orange with fine spots – acid and intermediate volcanic rocks; dark violet with fine spots – basic volcanic rocks; dark brown – Proterozoic and Cambrian, non-distinguished; dark grey – Lower Palaeozoic, non-distinguished; light grey – Carboniferous; light brown – Permian; violet – Triassic, blue – Jurassic; green – Cretaceous; yellowish brown – Lower Tertiary; yellow – Upper Tertiary; light blue – Holocene sediments connected with big river; blue dashed line – southern limit of continental glaciation; spotted area to the north of the blue dashed line – Pleistocene glacial deposits; thick black line – important fault; thick black line with triangles – important overthrust.

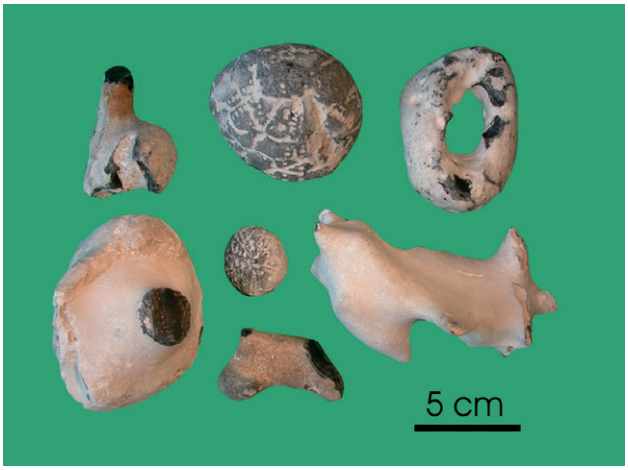


Photo 2. Flints of the Upper Cretaceous (Maastrichtian) age from the Rügen coast in northern Germany.

Photo 3. Maastrichtian flint and silicified rostra of belemnites. The Rügen coast, Germany.

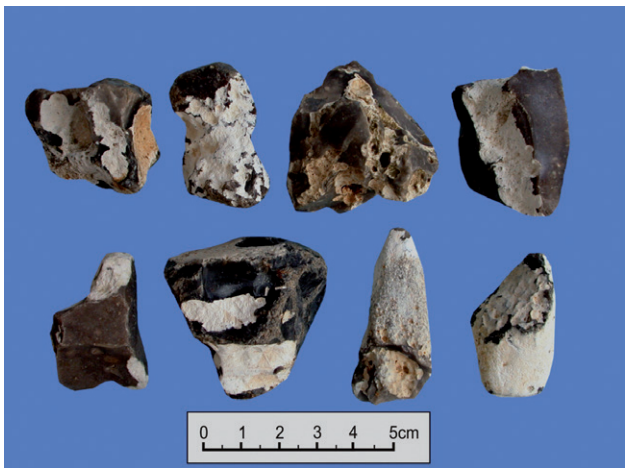


Photo 4. Erratic flints of the Maastrichtian age from glacial sediments in northern Bohemia.

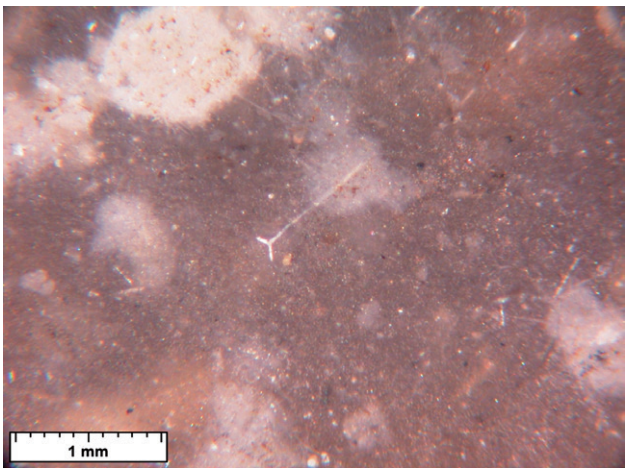


Photo 5. Maastrichtian flint in water immersion under the stereomicroscope. A conspicuous sponge spicule is situated in the middle of the picture.

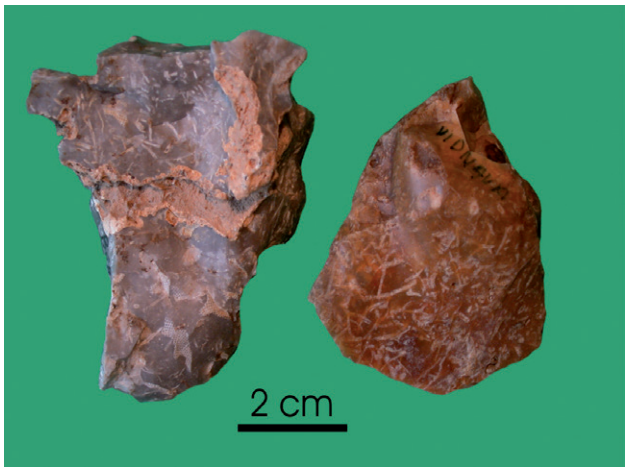


Photo 6. Erratic silicites of the Danian age from sediments of continental glaciation at Vidnava in Czech Silesia, the right one with typical yellowish-brown patina. The both samples contain numerous relics of moss animals (Bryozoa) visible with the naked eye.

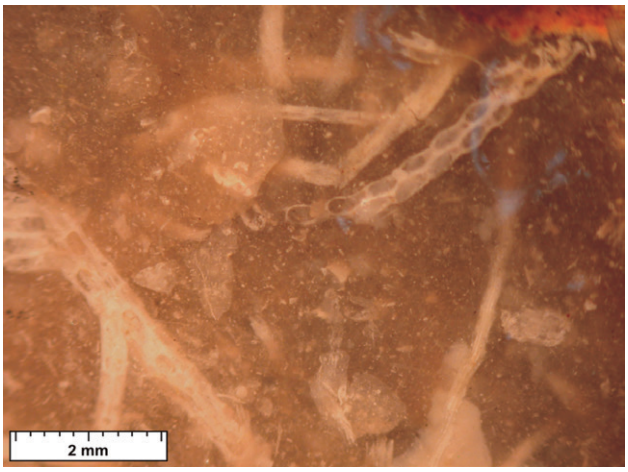


Photo 7. Erratic silicite of the Danian age from sediments of continental glaciation at Vidnava. Numerous parts of Bryozoa are well visible in water immersion under the stereomicroscope.

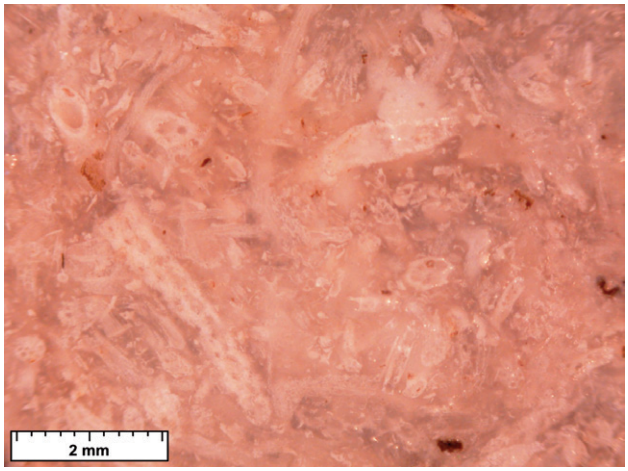


Photo 8. Chipped artefact made of erratic silicite of the Danian age in water immersion under the stereomicroscope. Linear Pottery culture, Bukovany near Olomouc.

Photo 9. Erratic banded silicites of the Danian age. Surroundings of Frýdlant, northern Bohemia.

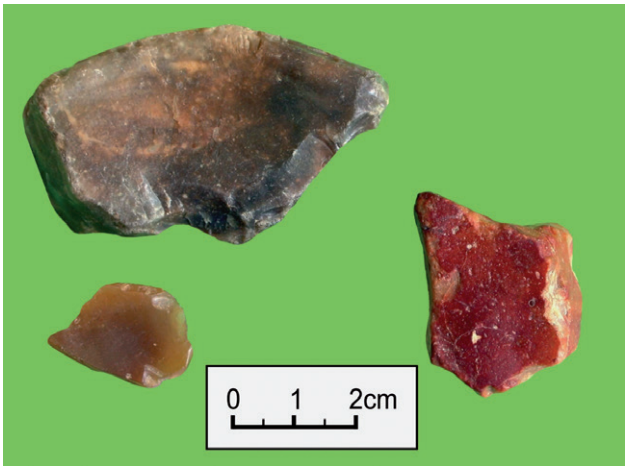


Photo 10. Various types of patina on erratic silicites of the Danian age, northern Bohemia.

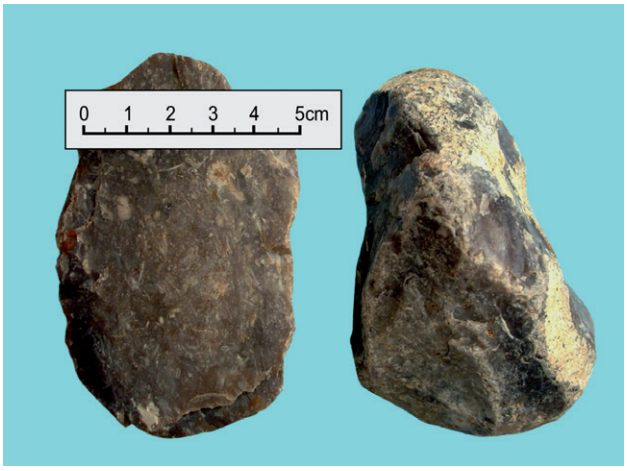


Photo 11. Erratic silicites of the Danian age with typical iron-like shape. Surroundings of Frýdlant, northern Bohemia.

Photo 12. The second heaviest erratic silicite (21,5 kg) found in the Czech Republic. Sand pit at Libhošť near Nový Jičín, northern Moravia.

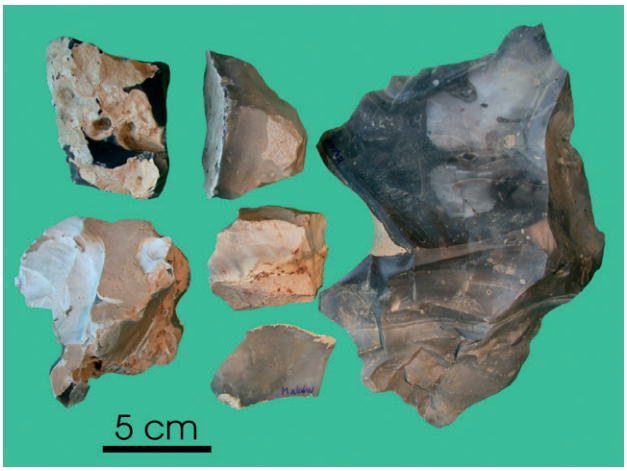


Photo 13. Erratic silicites from the surroudings of Maków near Racibórz, southern Poland.

Photo 14. Non-patinated Neolithic artefacts made of erratic silicites, the Velký Kosíř Hill near Prostějov, central Moravia.

Photo 15. A Neolithic core made of erratic silicite. Benešovský vrch Hill near Brumovice, west of Opava, Czech Silesia.

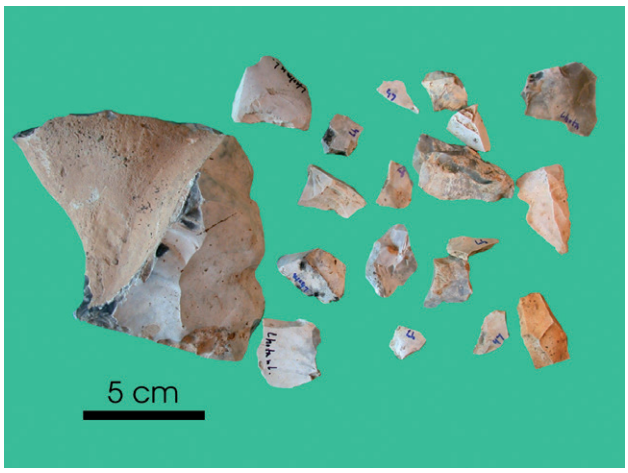


Photo 16. Patinated artefacts made of erratic silicites from the Palaeolithic site Lhota near Lipník nad Bečvou. The locality is situated above the Moravian Gateway depression, about 25 km to the SW from the sources of erratic flints in glacial sediments.

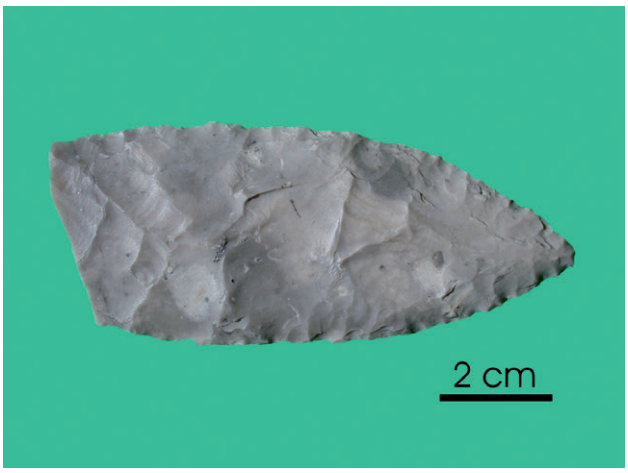


Photo 17. A Late Eneolithic dagger from Klenovice na Hané, central Moravia. Erratic silicite from glacial sediments or from primary sources at the Baltic coast.

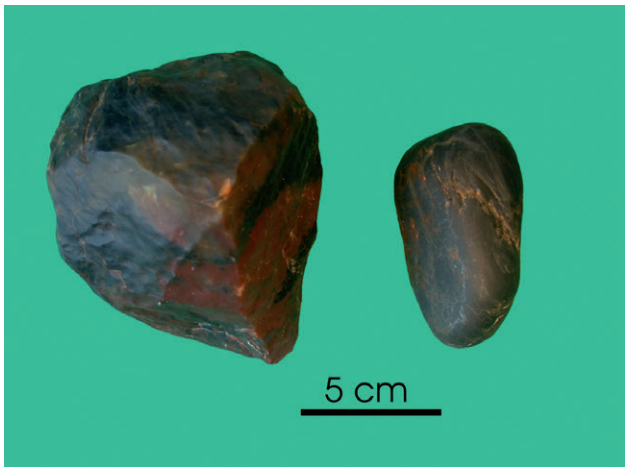


Photo 18. Ventifact and pebble of the Proterozoic phthanite from the Vltava terrace gravels in Prague.

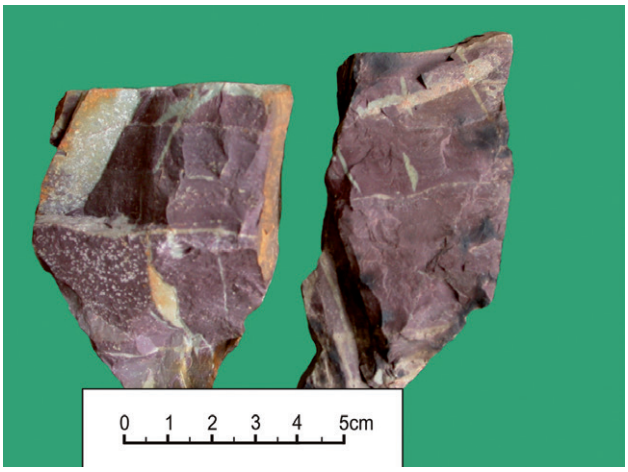


Photo 19. Ordovician spongolite from the Mílina Hill near Olešná, northwest of Příbram, central Bohemia.

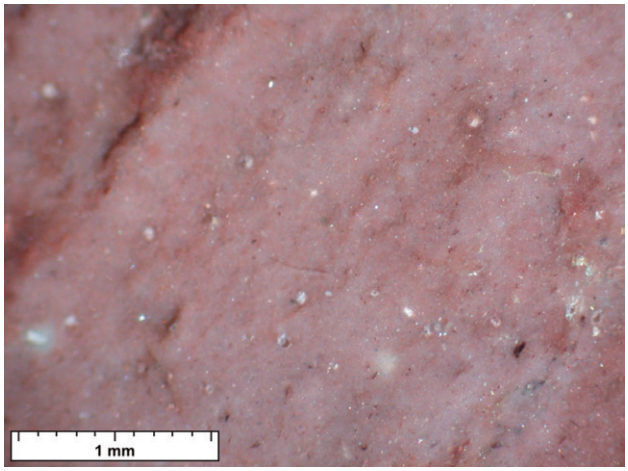


Photo 20. Ordovician spongolite in water immersion under the stereomicroscope.

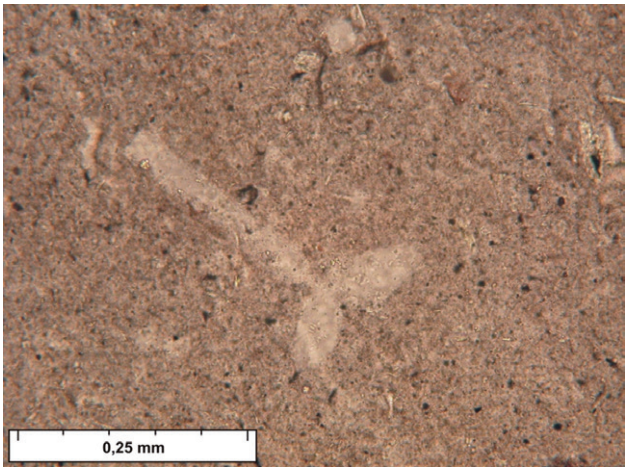


Photo 21. Ordovician spongolite in thin section. Plane-polarized light. Siliceous mass contains dispersed brown organic pigmentation, a large sponge spicule can be seen in the central part.

Photo 22. Silurian silicified shale of the Liteň Formation. Karlík, northwest of Karlštejn, central Bohemia.

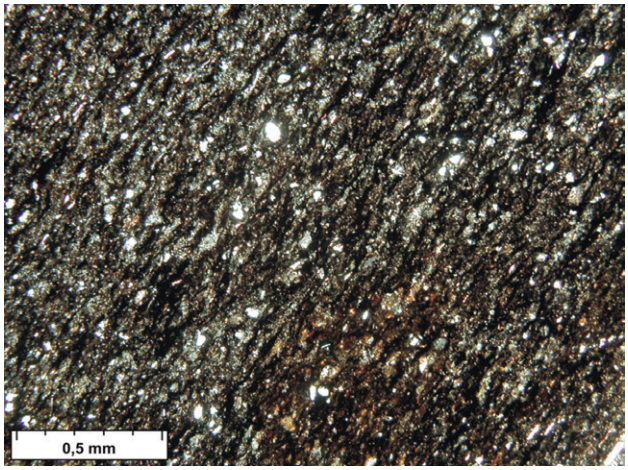


Photo 23. Silurian silicified shale of the Liteň Formation with silty admixture prevalently of quartz. Thin section, crossed polars.

Photo 24. Devonian chert of the Zlíchov Formation. Prague-Zlíchov.

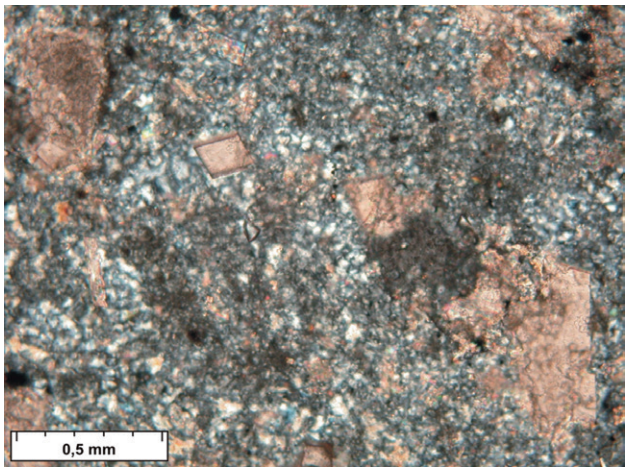


Photo 25. Devonian chert of the Zlíchov Formation in thin section. Siliceous mass contains small islands of carbonates or their rhombohedral shaped crystals. Crossed polars.

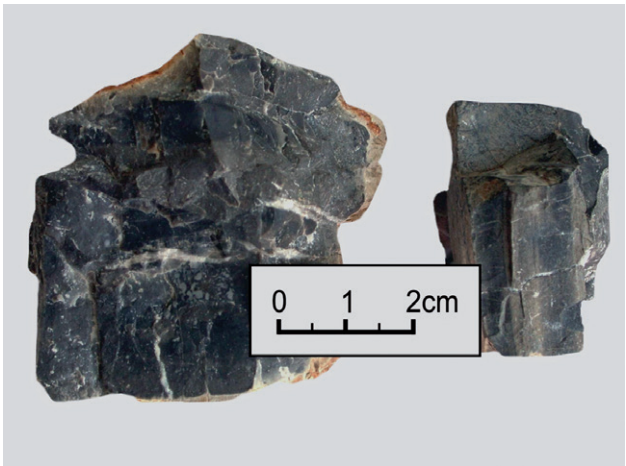


Photo 26. Devonian chert of the Bohemian Karst type. Tetín, district of Beroun (left) and Prague-Hlubočepy, Vysoká quarry (right).

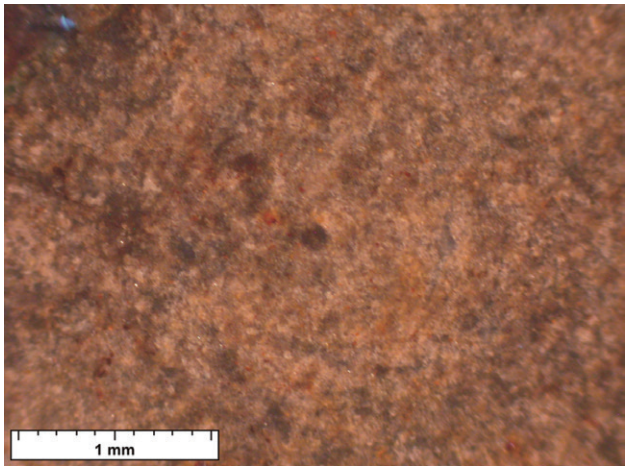


Photo 27. Devonian chert of the Bohemian Karst type in water immersion under the stereomicroscope.

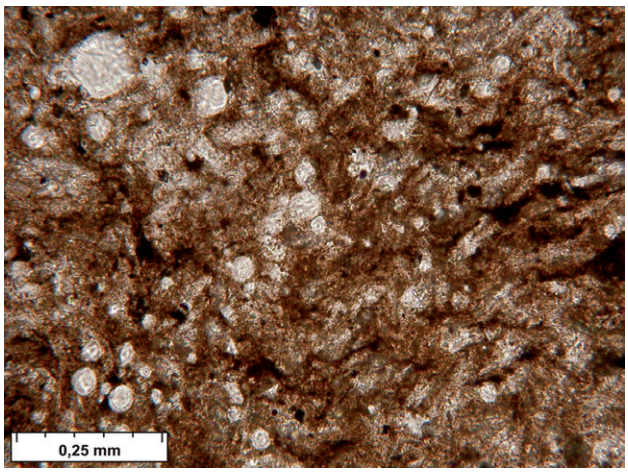


Photo 28. Devonian chert of the Bohemian Karst type in thin section. Crossed polars.

Photo 29. Permian limnic silicite (so called “masák”) from Ploužnice near Semily, Krkonoše Piedmont Basin.

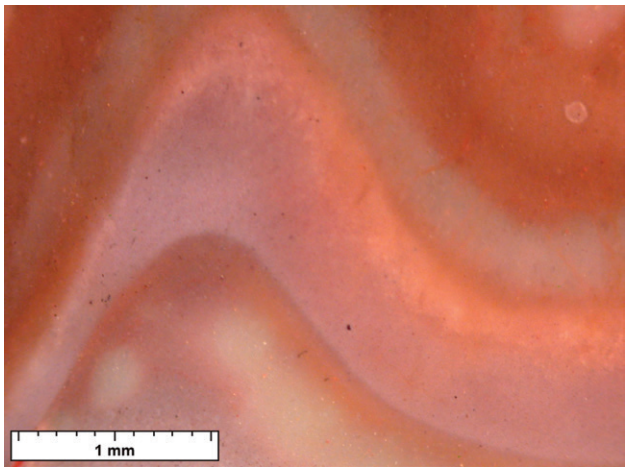


Photo 30. Permian limnic silicite in water immersion under the stereomicroscope.

Photo 31. Permian limnic silicites from Líně near Plzeň.

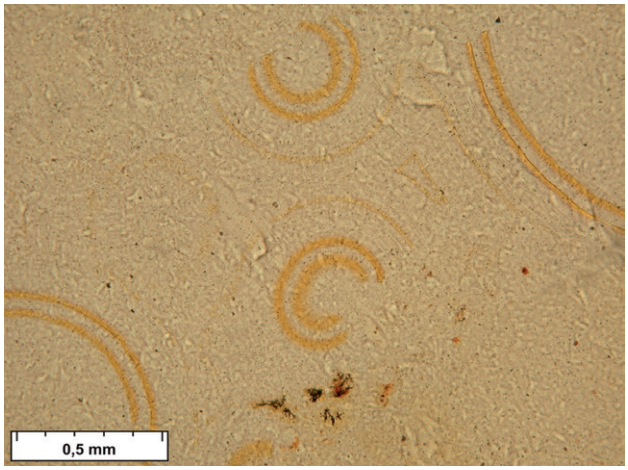


Photo 32. Permian limnic silicite from Líně in thin section, plane-polarized light. Plant relics are conspicuous because of their colouring by iron compounds.

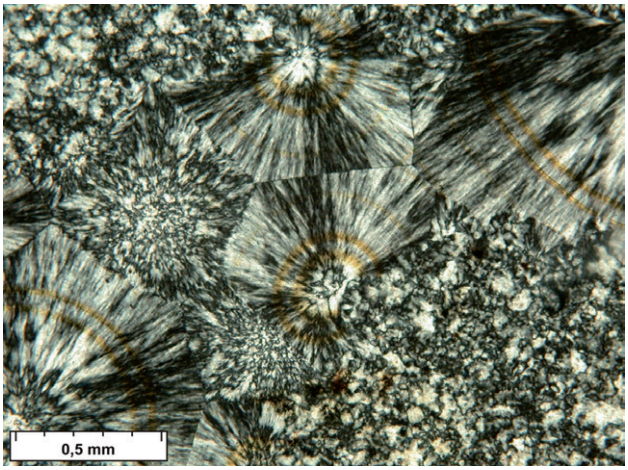


Photo 33. Permian limnic silicite from Líně in thin section, crossed polars. Coarse fibrous chalcedony fills up plant relics.

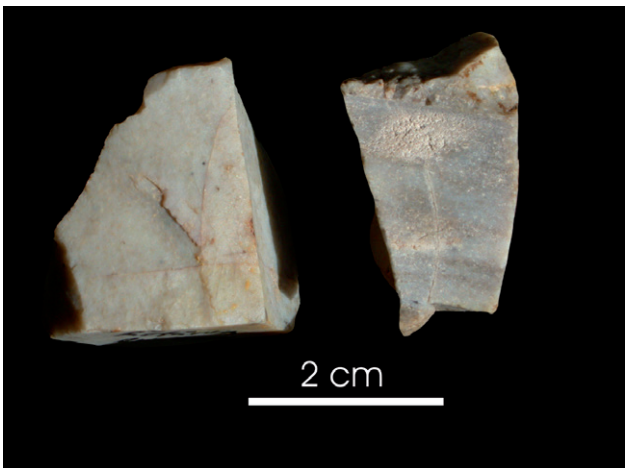


Photo 34. Cretaceous spongolite of the Ústí nad Orlicí type. Řetůvka, district of Ústí nad Orlicí, eastern Bohemia.

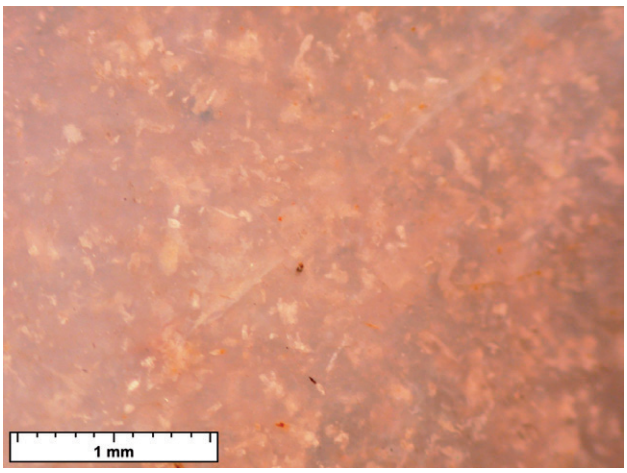


Photo 35. Cretaceous spongolite in water immersion under the stereomicroscope. It is possible to recognise relics of non-soluble detrital particles, smudges of iron oxides and simple sponge spicules (monoaxons).

Photo 36. Tertiary limnic silicite from the Mesolitic site at Pardubice, eastern Bohemia. Provenance of the raw material is probably in the Pardubice region.

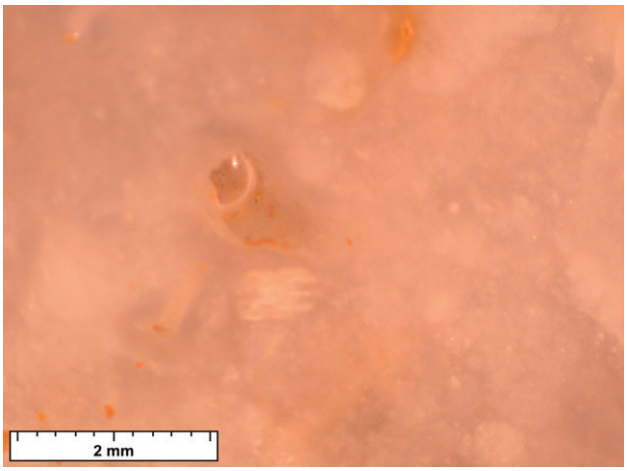


Photo 37. Tertiary limnic silicite from Pardubice in water immersion under the stereomicroscope. Porous structure and plant relics are characteristic for the specimen.

Photo 38. Chert of the Ražice type from the cluster of pre-Neolithic sites at Ražice – Putim, southern Bohemia.

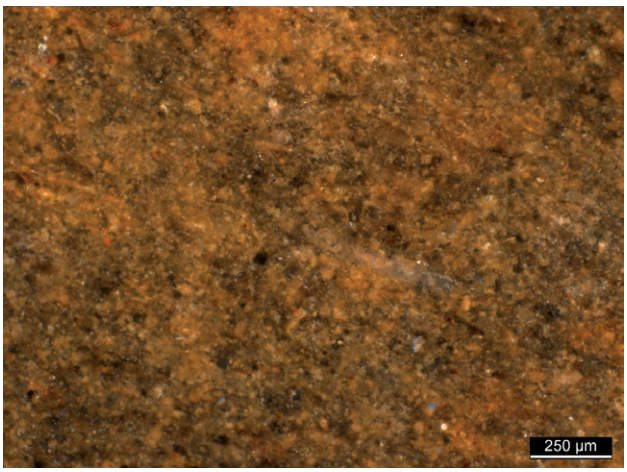


Photo 39. Chert of the Ražice type in water immersion under the stereomicroscope.

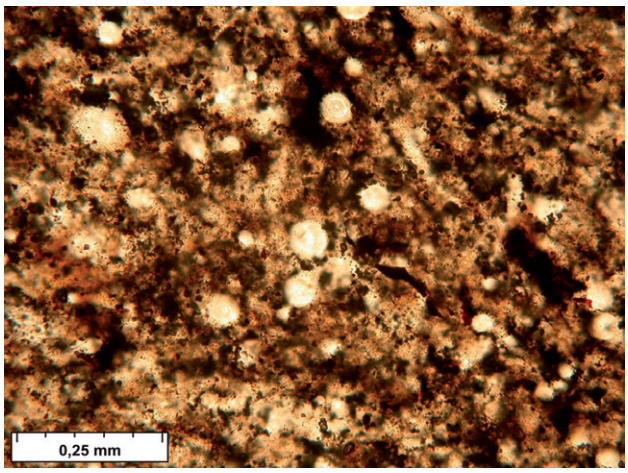


Photo 40. Chert of the Ražice type in thin section, plane-polarized light.

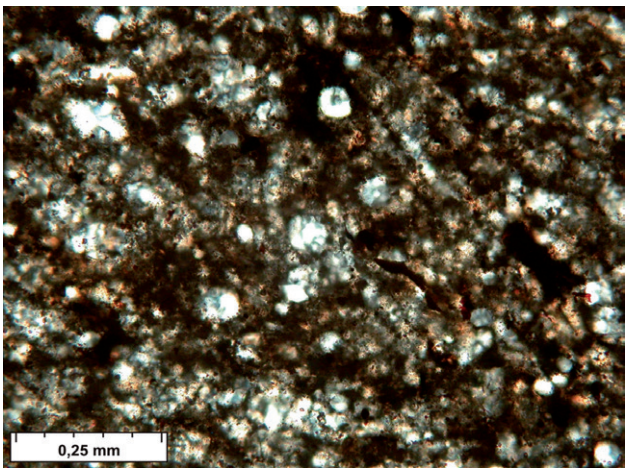


Photo 41. Chert of the Ražice type in thin section, crossed polars.

Photo 42. Devonian radiolarite of the Ponikev Formation. Left and central specimens are from the Benešov Hill near Brumovice, the right one is from Láryšov near Krnov, Czech Silesia.

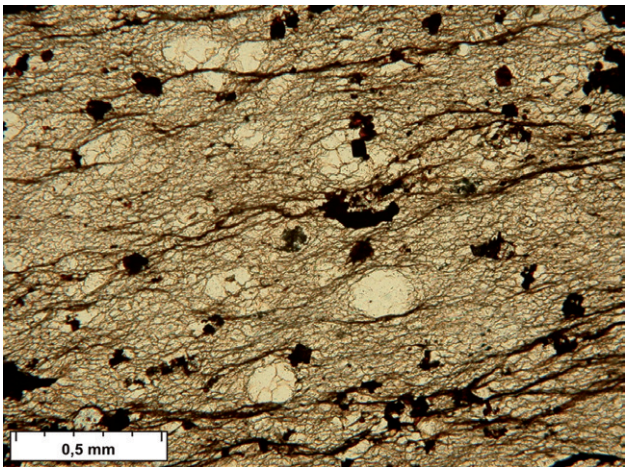


Photo 43. Devonian radiolarite of the Ponikev Formation in thin section, plane-polarized light. Mladějovice near Šternberk (central Moravia).

Photo 44. Chert of the Hády – Říčky limestone in a wall of the restaurant Velká Klajdovka near the abandoned quarry at the Hády plateau in Brno.

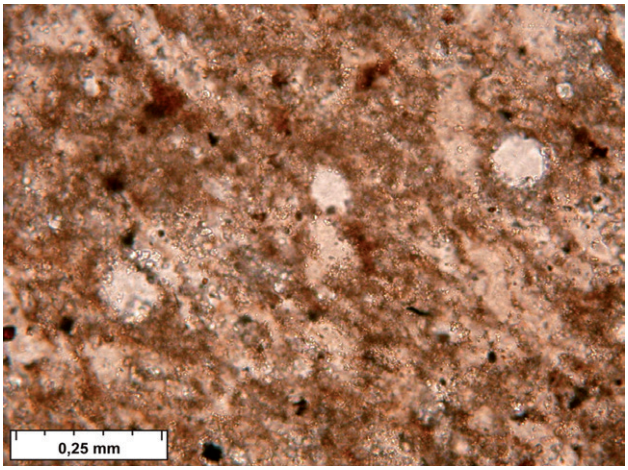


Photo 45. Chert of the Hády – Říčky limestone in thin section, plane-polarized light. The Mokrá quarry, east of Brno.

Photo 46. Concretions of chert in Jurassic limestone, Stránská skála Hill in Brno.

Photo 47. Chert varieties from the Stránská skála Hill in Brno.

Photo 48. Print of crinoidal stem in a chert from the Stránská skála Hill in Brno. Length of the print is 7 mm.

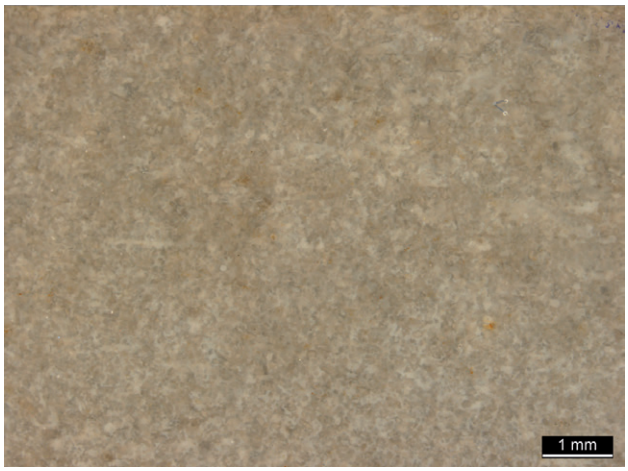


Photo 49. Chert from the Stránská skála Hill in water immersion under the stereomicroscope.

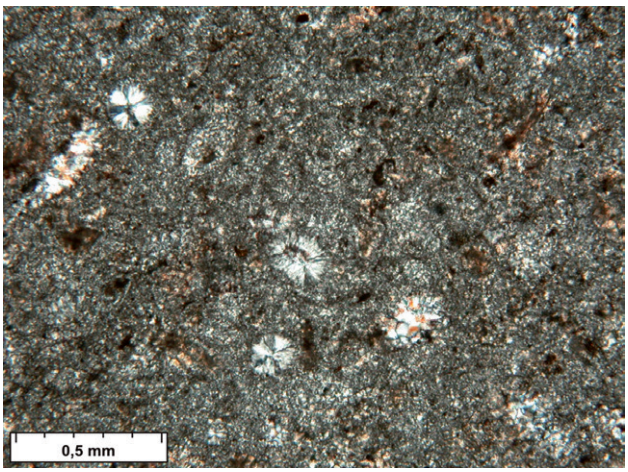


Photo 50. Chert from the Stránská skála Hill in thin section, crossed polars. Relics of fossils are filled by fibrous chalcedony.

Photo 51. Cherts from other Jurassic limestone occurrences in Brno. Hády plateau (left), Bílá hora Hill (middle), Švédské valy Hill (right).

Photo 52. Excavation trench to archaeologically verify a geophysical anomaly found above prehistoric mining pit at Olomučany in the Moravian Karst, 2004.

Photo 53. Quartz and chert hammerstones used for percussion and collected in the workshop at the Olomučany prehistoric mining pits.

Photo 54. Varieties of the Olomučany chert. Remarkable are the included geods. Dimensions of the left lower specimen are 6 x 6.5 cm.

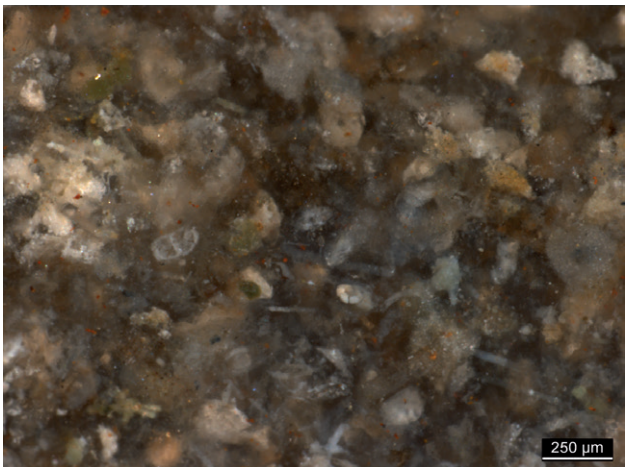


Photo 55. Olomučany chert in water immersion under the stereomicroscope.

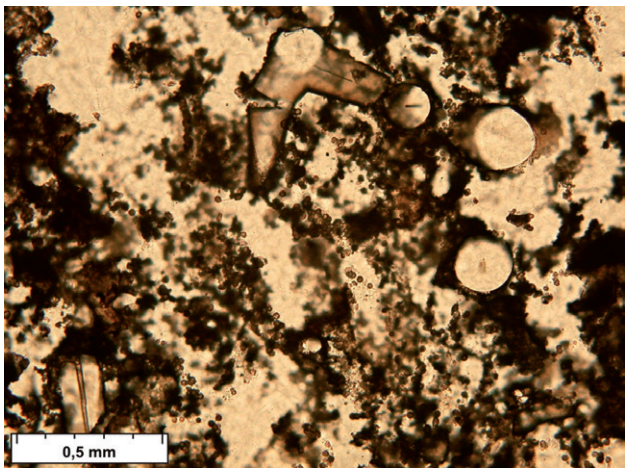


Photo 56. Olomučany chert in thin section, plane-polarized light.

Photo 57. Cherts of the Lower Cretaceous Rudice Formation from the plateau between the village of Rudice and the Býčí skála Cave. Chert with print of ammonite (left), banded concretional variety (upper in the middle), specimen with cavity after sea urchin spine (lower in the middle) and layered variety of the Býčí skála type.

Photo 58. Faced granodiorite block (probably a menhir) in the area of prehistoric chert mining in the Krumlovský les Highland. Excavation of M. Oliva in 1998.

Photo 59. Faced granodiorite outcrop in the area of prehistoric chert mining in the Krumlovský les Highland. Excavation of M. Oliva in 1998.

Photo 60. Outcrop of Tertiary gravel with cherts of the Krumlovský les type (variety I) at Jezeřany-Maršovice, Krumlovský les Highland.

Photo 61. Outcrop of gravel with cherts of the Krumlovský les type (variety III) lying on Jurassic limestone of the Stránská skála Hill in Brno.

Photo 62. Chert of the Krumlovský les type (variety I), characteristic appearance. Vedrovice, Krumlovský les Highland.

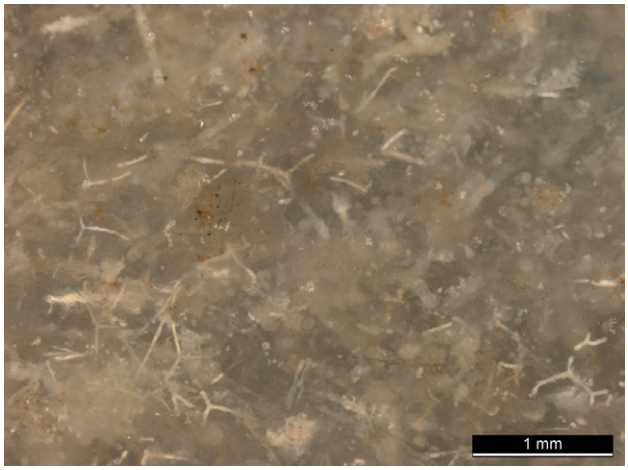


Photo 63. Chert of the Krumlovský les type (variety I) in water immersion under the stereomicroscope. Jezeřany-Maršovice, Krumlovský les Highland.

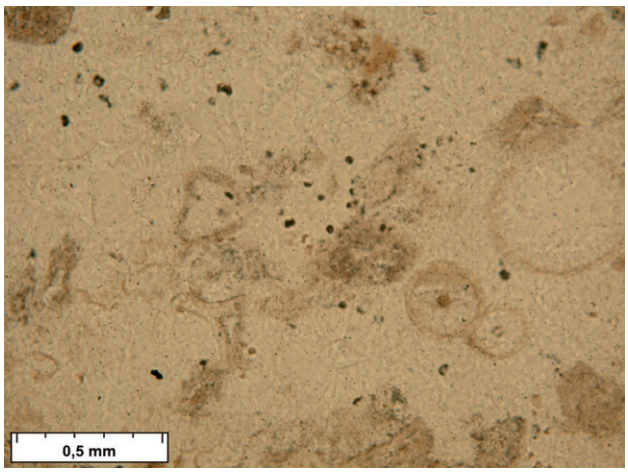


Photo 64. Chert of the Krumlovský les type (variety I) in thin section, plane-polarized light.

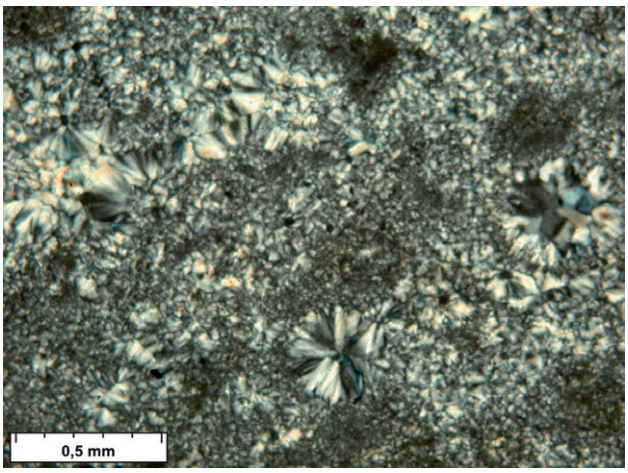


Photo 65. Chert of the Krumlovský les type (variety I) in thin section, crossed polars.

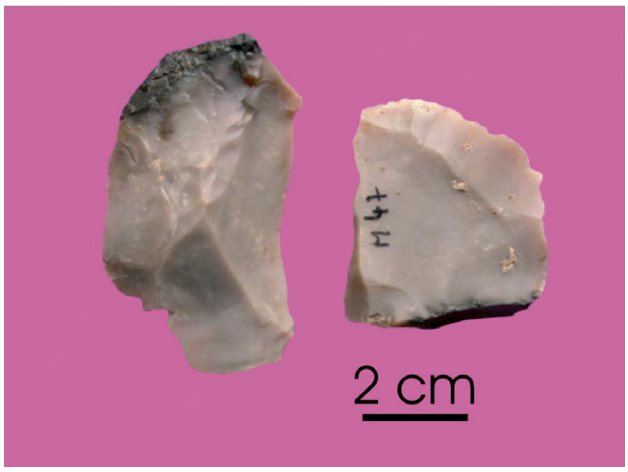


Photo 66. Artefacts made of the Krumlovský les chert (variety II). Lengyel culture – Moravian Painted Ware, Jezeřany-Maršovice.

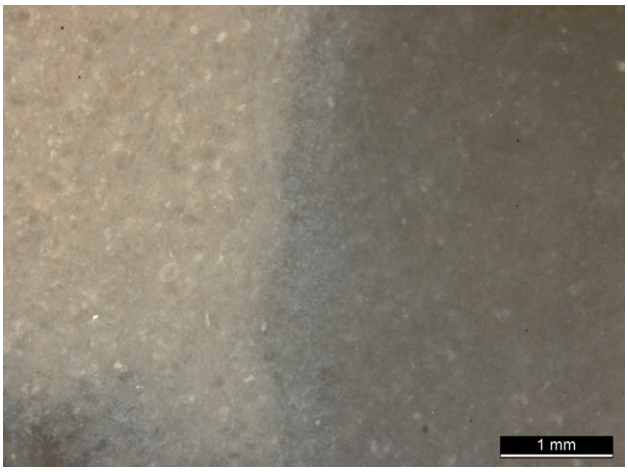


Photo 67. Chert of the Krumlovský les type (variety II) in water immersion under the stereomicroscope.

Photo 68. Cherts of the Krumlovský les type (variety III), Brno-Vinohrady.

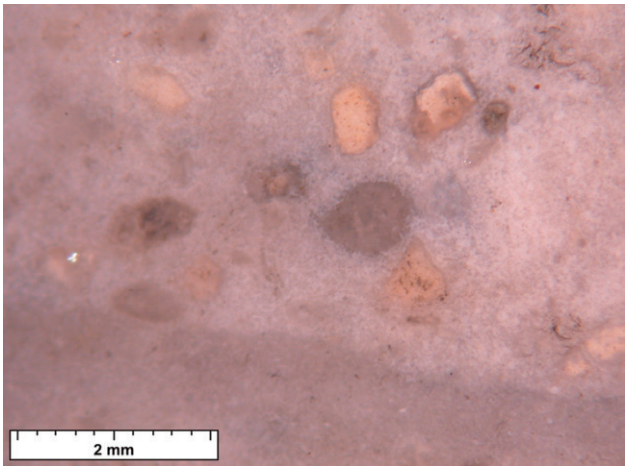


Photo 69. Chert of the Krumlovský les type (variety III) in water immersion under the stereomicroscope.

Photo 70. Cherts of the Krumlovský les type from the Vienna Basin, surroundings of Uherské Hradiště.

Photo 71. Cretaceous honey-brown spongolites from the Bořitov area (western Moravia).

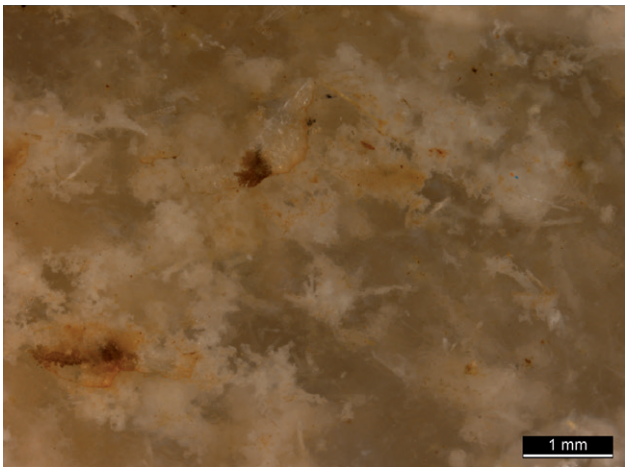


Photo 72. Cretaceous honey-brown spongolite in water immersion under the stereomicroscope.

Photo 73. The biggest Moravian Jurassic chert weighting 59 kg. It was found during construction of the housing estate in Brno-Líšeň in 1981.

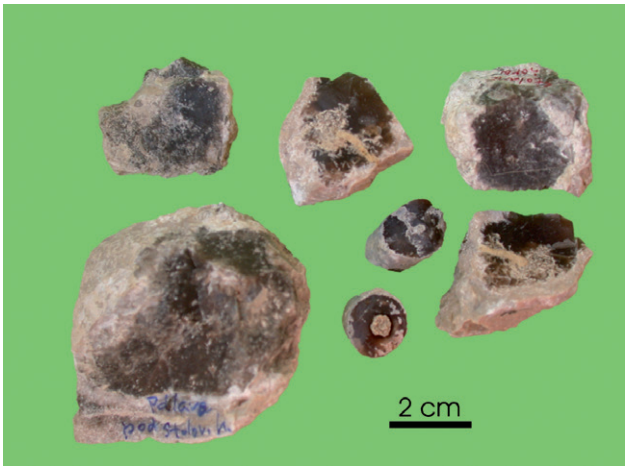


Photo 74. Cherts of the Klentnice Formation at the southern foot of the Stolová hora Hill, Pavlovské vrchy Highland.

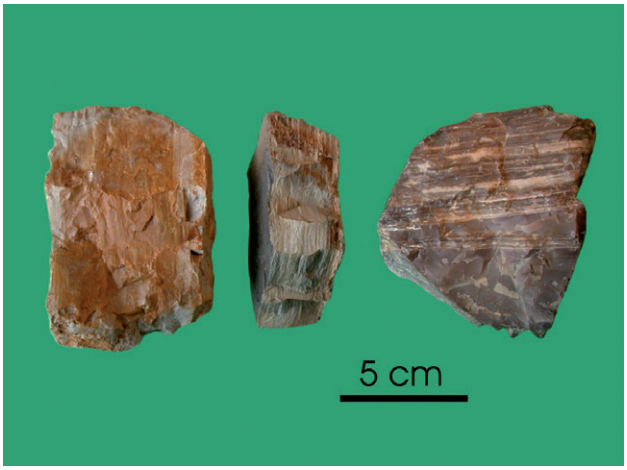


Photo 75. Menilite cherts of the Ždánice and Subsilesian Units (the Carpathian Flysch Belt) in Moravia. Moutnice (left and central specimens), Špičky near Hranice (right specimen).

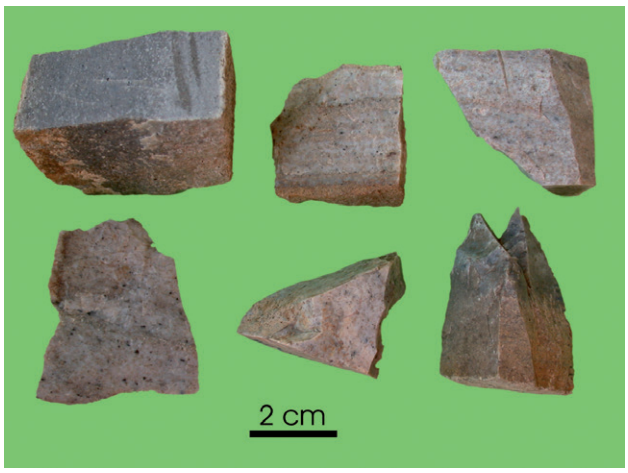


Photo 76. Baška cherts of the Silesian Unit (the Carpathian Flysch Belt) in Moravia. Slope under the Hukvaldy castle, NE Moravia.

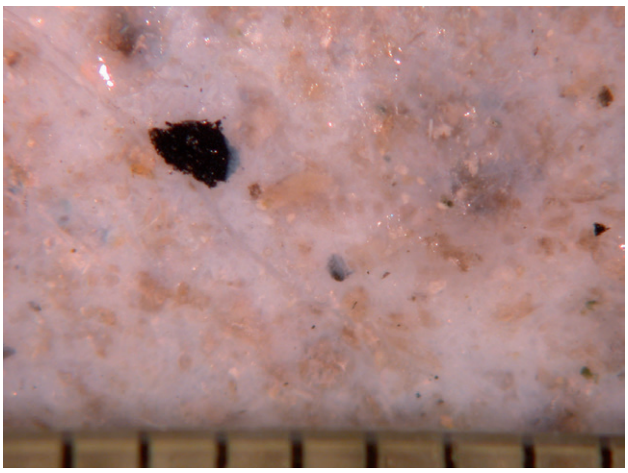


Photo 77. Baška chert (with a chip of hard coal) in water immersion under the stereomicroscope.

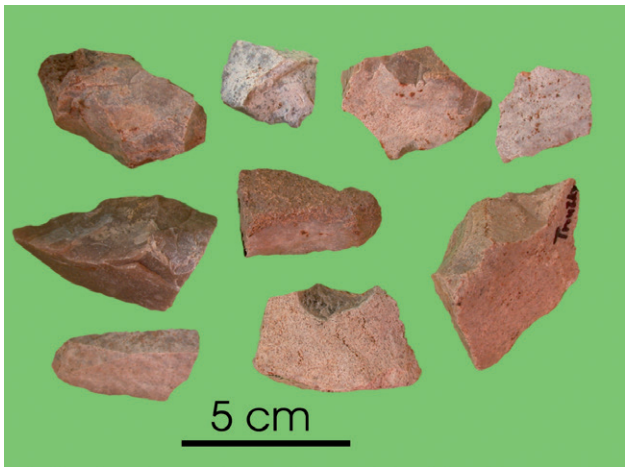


Photo 78. Cherts of the Troubky-Zdislavice type collected at the Zadní Kuče site near Troubky, southern Moravia.

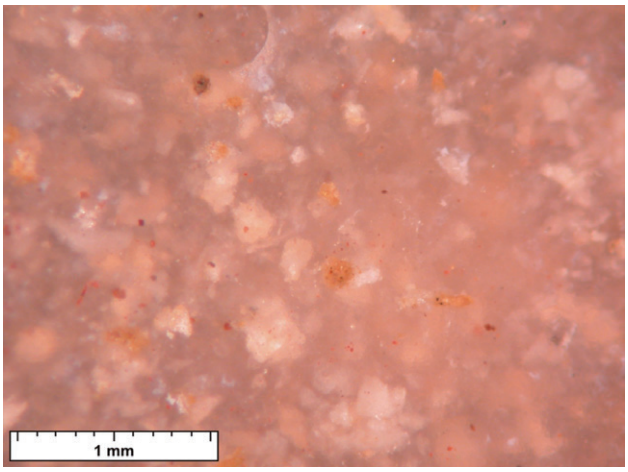


Photo 79. Chert of the Troubky-Zdislavice type in water immersion under the stereomicroscope.

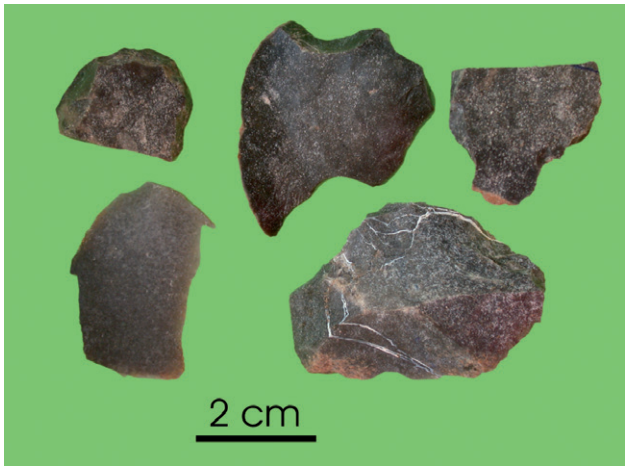


Photo 80. Cherts of the Boršice type collected in gravels in the area of Uherské Hradiště (Vienna Basin, southern Moravia).

Photo 81. Radiolarite pebbles from Miocene gravels at the extinct village of Mušov near Pasohlávky (Carpathian Foredeep) and Násedlovice near Kyjov (Vienna Basin).

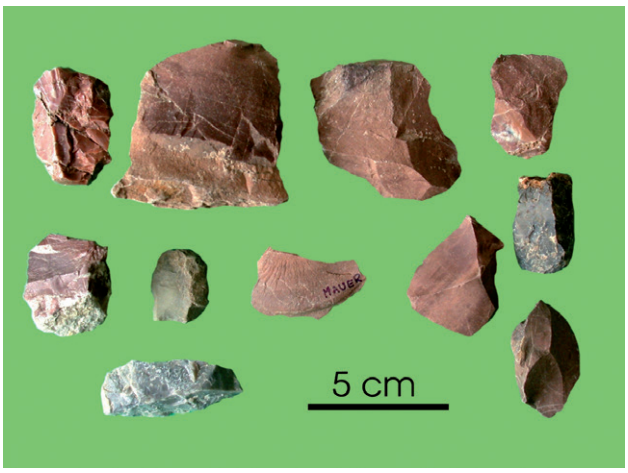


Photo 82. Jurassic radiolarites from the Antonshöhe Hill in Wien-Mauer.

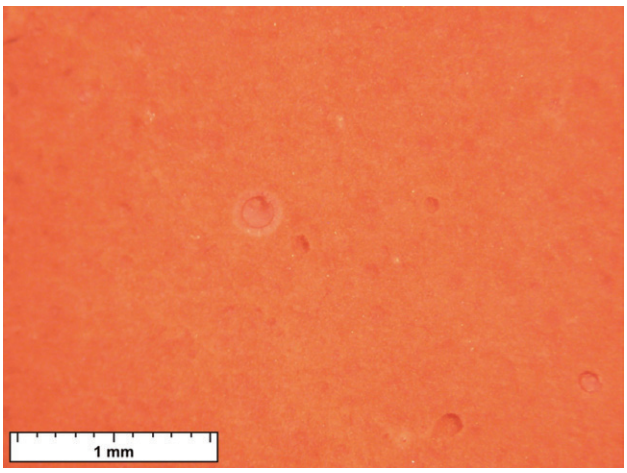


Photo 83. Radiolarite from Wien-Mauer in water immersion under the steromicroscope. The small cavities in places represent weathered out calcite filling of radiolarians.

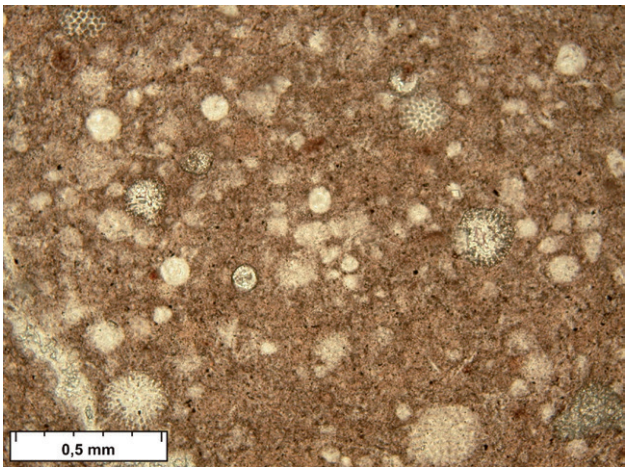


Photo 84. Radiolarite from Wien-Mauer in thin section, plane-polarized light. Radiolarian tests are very well preserved.

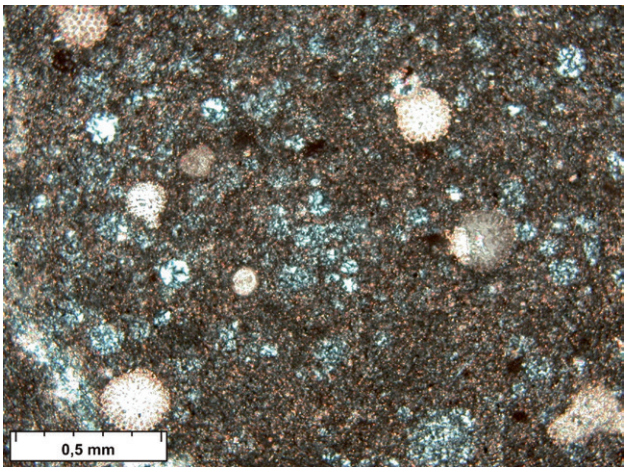


Photo 85. The same picture with crossed polars. Radiolarians are undoubtedly filled up with calcite.

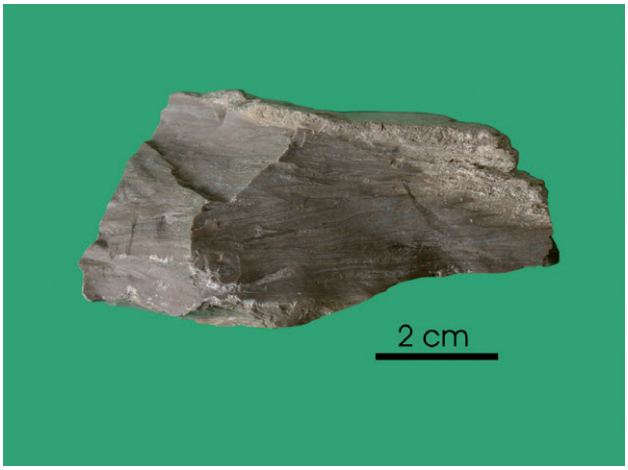


Photo 86. Menilite chert from the Zellerndorf Formation (Carpathian Foredeep). Limberg near Eggenburg, Lower Austria.

Photo 87. Hollabrunn gravels contain especially quartz pebbles, radiolarites are present only extraordinary. Stranzendorf north of Tulln, Lower Austria.

Photo 88. Bardo chert. Morzyszów north of Kłodsko, southern Poland.

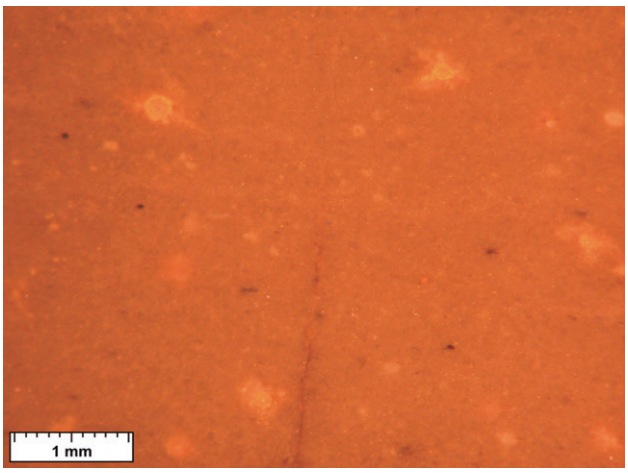


Photo 89. Bardo chert in water immersion under the stereomicroscope. Small cavities after original radiolarians are filled with iron oxides, capsules with preserved spines are well visible in places.

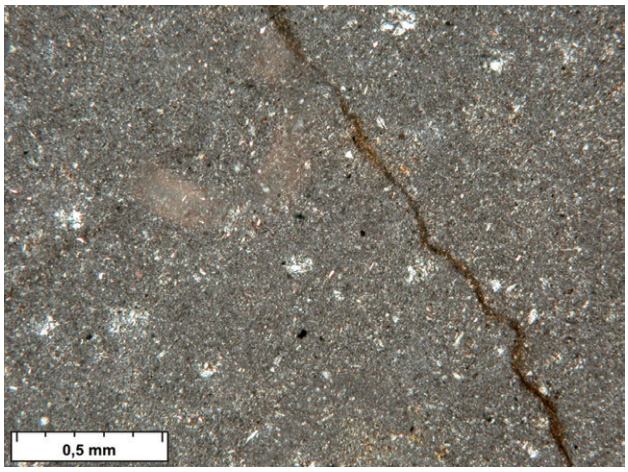


Photo 90. Bardo chert in thin section, crossed polars.

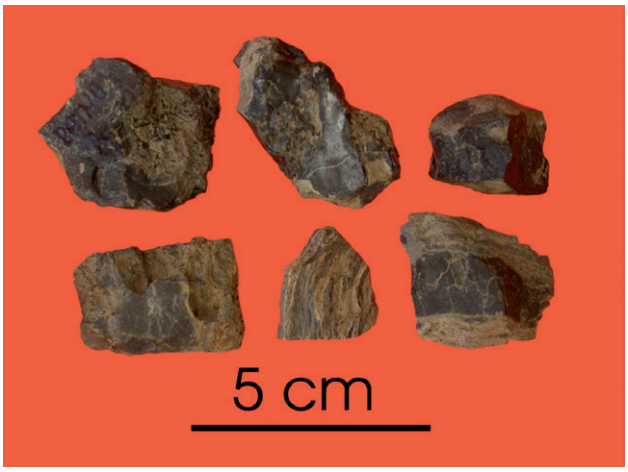


Photo 91. Permian limnic silicites from the Intra-Sudetic Basin in SW Poland.

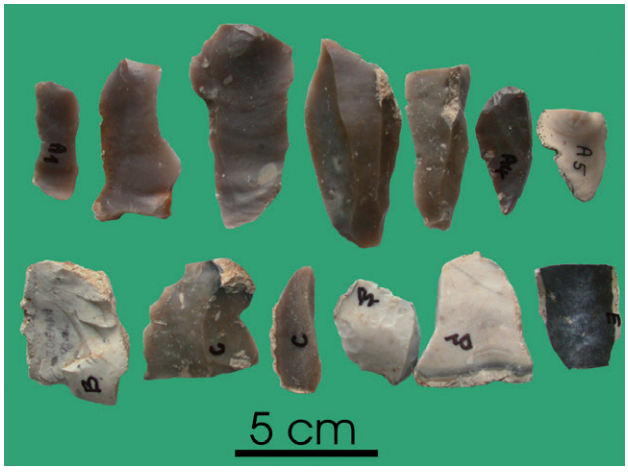


Photo 92. Varieties of the silicites from the Cracow-Częstochowa Jurassic in Poland, the most important variety A is shown in the upper row. Collected in the surroundings of Cracow.

Photo 93. Silicites of the Cracow-Częstochowa Jurassic. Left and central specimens represent variety A from Brzoskwinia east of Cracow, the right sample is transitional one between varieties A and C from Wierzchowie north of Cracow.

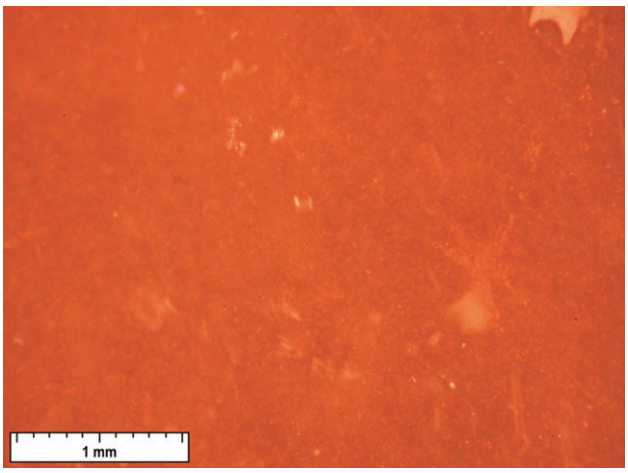


Photo 94. Silicite of the Cracow-Częstochowa Jurassic, variety A, in water immersion under the stereomicroscope.

Photo 95. Silicite of the Cracow-Częstochowa Jurassic, variety G. Locality of Pradła, central part of the Cracow-Częstochowa Highland.

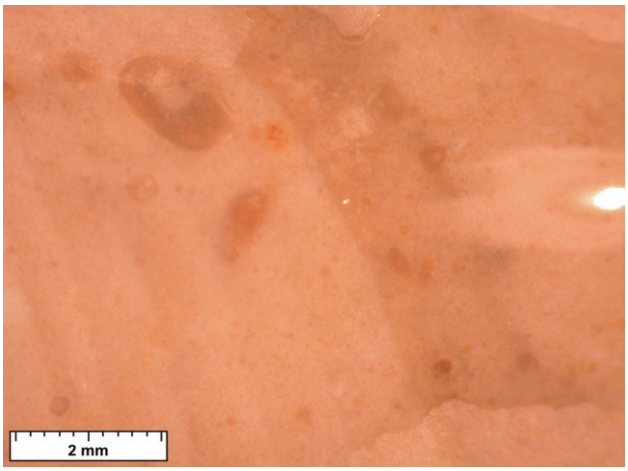


Photo 96. Silicite of the Cracow-Częstochowa Jurassic, variety G, in water immersion under the stereomicroscope.

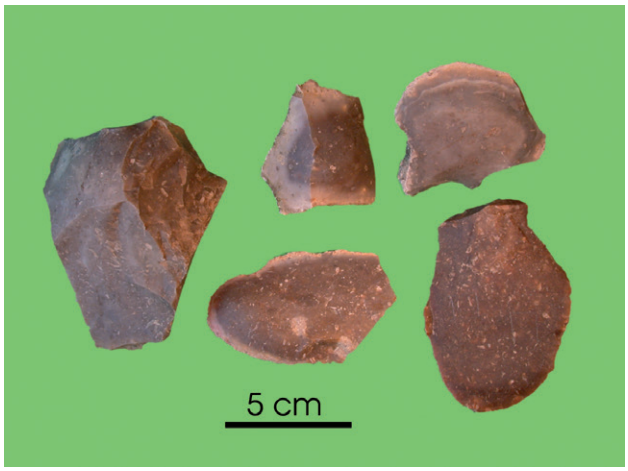


Photo 97. Silicite of the Cracow-Częstochowa Jurassic, variety Gojść.

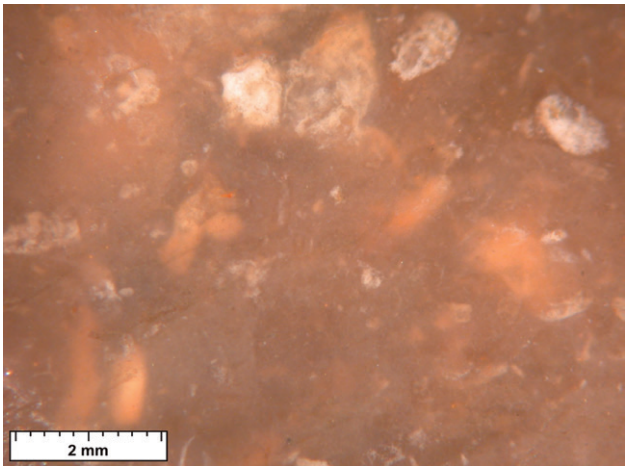


Photo 98. Silicite of the Cracow-Częstochowa Jurassic, variety Gojść, in water immersion under the stereomicroscope.

Photo 99. An axe made of the silicite of the Cracow-Częstochowa Jurassic, variety G. Found at Slatinice, district of Olomouc, central Moravia.

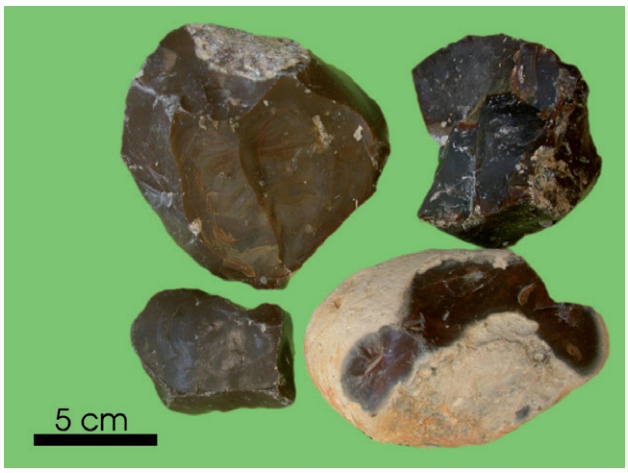


Photo 100. Jurassic(?) silicites from glacifluvial deposits in the sandpit Opole-Groszowice.

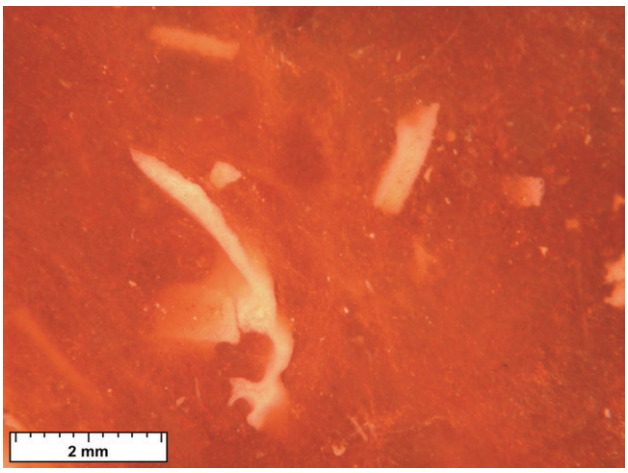


Photo 101. Jurassic(?) silicite of the Opole-Groszowice type in water immersion under the stereomicroscope. Red pigmentation of siliceous mass and parts of white microfossils are well visible.

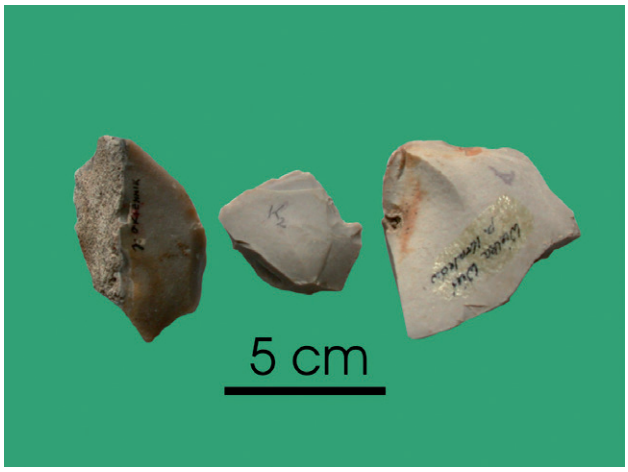


Photo 102. Cretaceous chert of the Wielka Wieś type. Collected at Wielka Wieś and the Okiennik Cave.

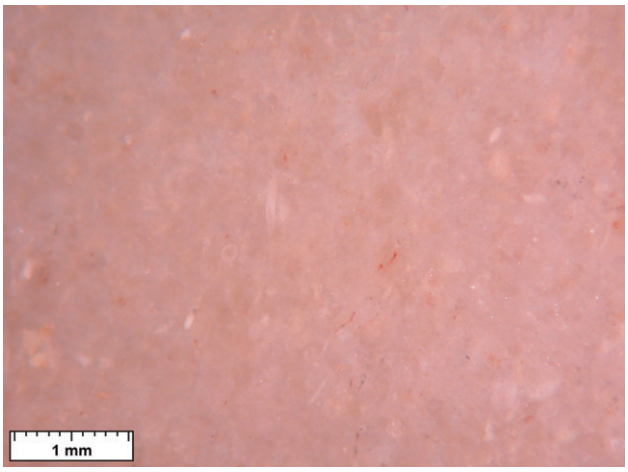


Photo 103. Cretaceous chert of the Wielka Wieś in water immersion under the stereomicroscope.

Photo 104. A horizon with big nodules of Jurassic banded silicite in a modern passage tunnel between two prehistoric mines at Krzemionki Opatowskie.

Photo 105. A chamber after prehistoric mining with a supporting column and partly filled up with mined waste. Krzemionki Opatowskie.

Photo 106. Appearance of the Jurassic banded silicite from Krzemionki Opatowskie (upper two pieces) and from a grave of the Bell Beaker culture at Samborzec in the Little Poland (lower three artefacts; provided by P. Włodarczak from Cracow).

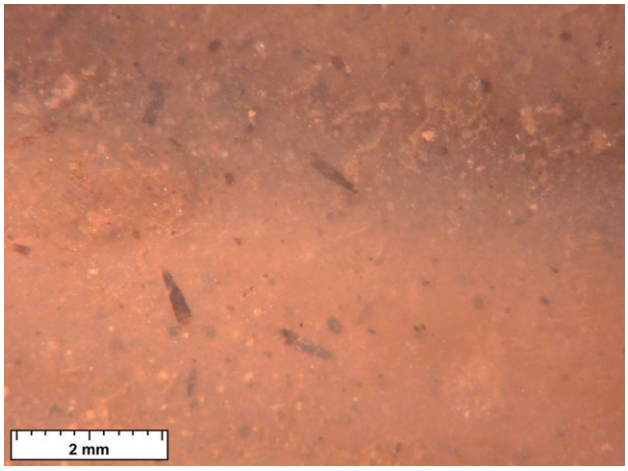


Photo 107. Jurassic banded silicite from Krzemionki Opatowskie in water immersion under the stereomicroscope. Black tubular and conical microfossils are typical for this raw material.

Photo 108. An axe made of the banded Krzemionki silicite. Found in SE Moravia and deposited in the museum of Rožnov pod Radhoštěm. Globular Amphorae culture probably.

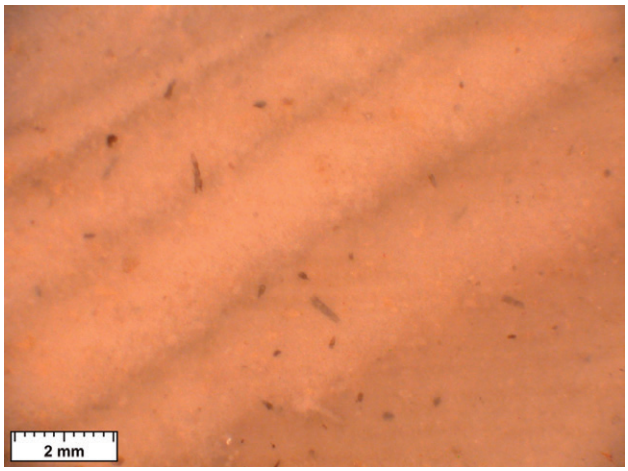


Photo 109. Axe from Prusinovice (district of Kroměříž, central Moravia) is made of the banded Krzemionki silicite. Its raw material in water immersion under the stereomicroscope shows characteristic black tubular and conical microfossils.

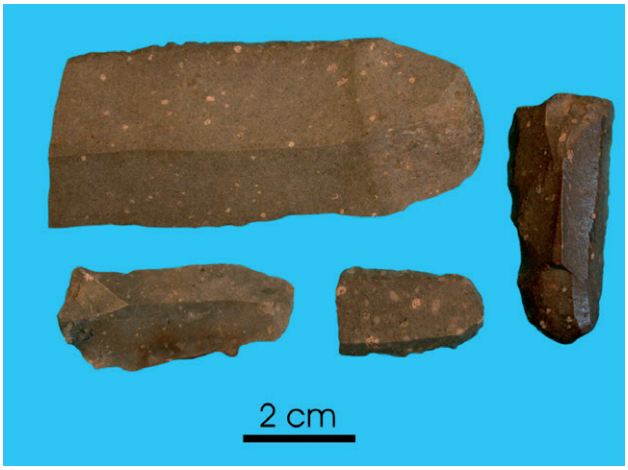


Photo 110. Chipped tools made of the Cretaceous Świeciechów spotted silicite found at the hillfort of the Baden culture at Hlinsko near Lipník nad Bečvou (above the Moravian Gateway).

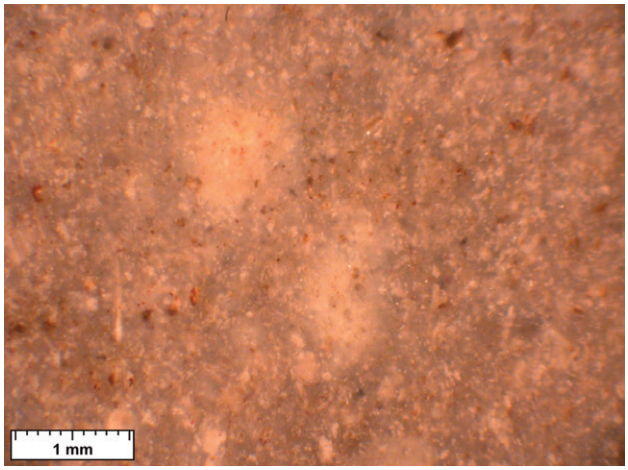


Photo 111. Cretaceous Świeciechów spotted silicite in water immersion under the stereomicroscope. Silicite axe from Velehrad, district of Uherské Hradiště, southern Moravia.

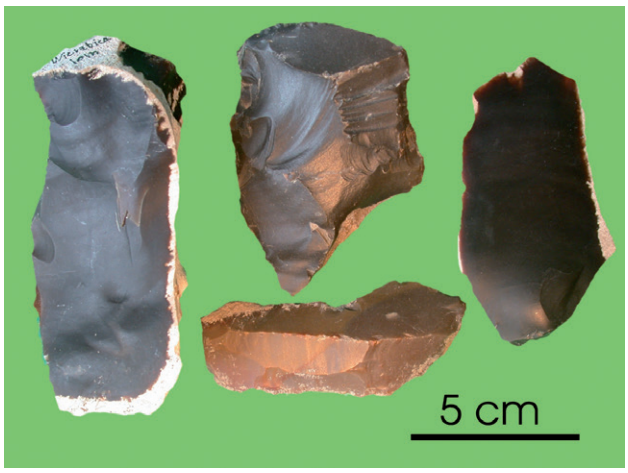


Photo 112. Jurassic chocolate silicite (krzemień czekoladowy), Wierzbica, central Poland.

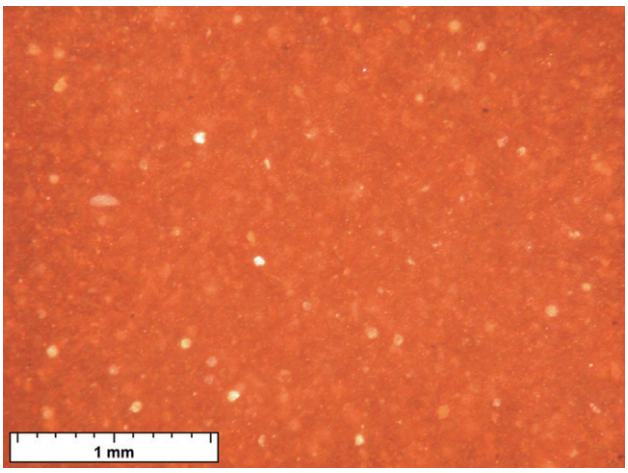


Photo 113. Jurassic chocolate silicite in water immersion under the stereomicroscope.

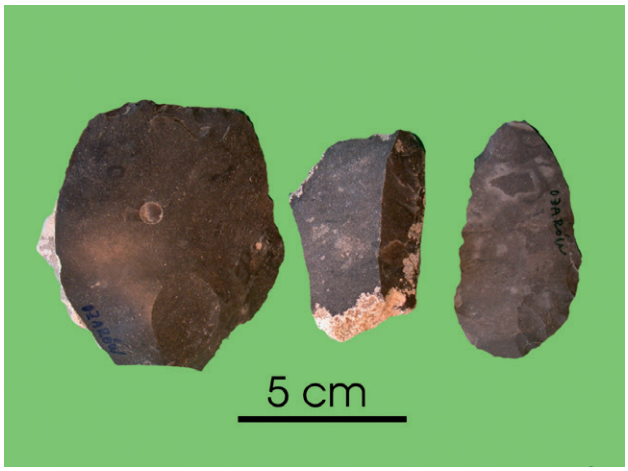


Photo 114. Cretaceous Ożarów silicite, central Poland.

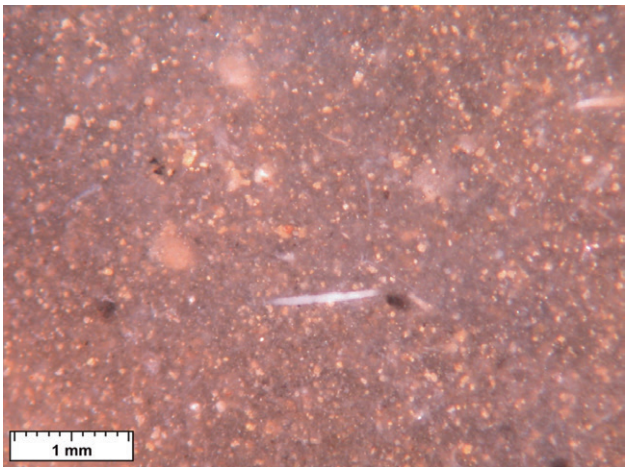


Photo 115. Cretaceous Ożarów silicite in water immersion under the stereomicroscope.

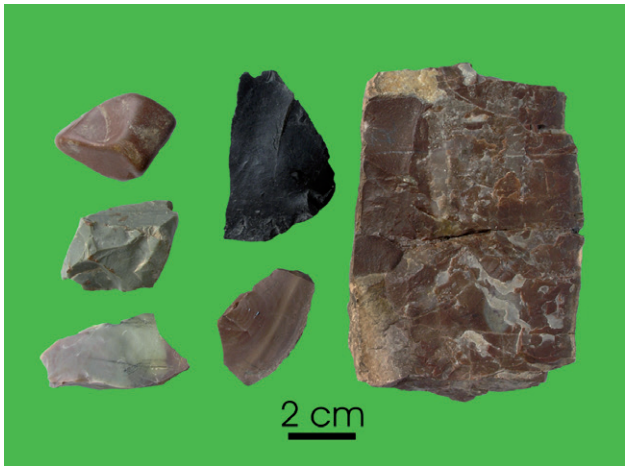


Photo 116. Jurassic radiolarites from the Pieniny Mts. in southern Poland. Small pebble is from the Dunajec River, other specimens from natural sources at Niedzica, Falsztyn and Szczawnica.

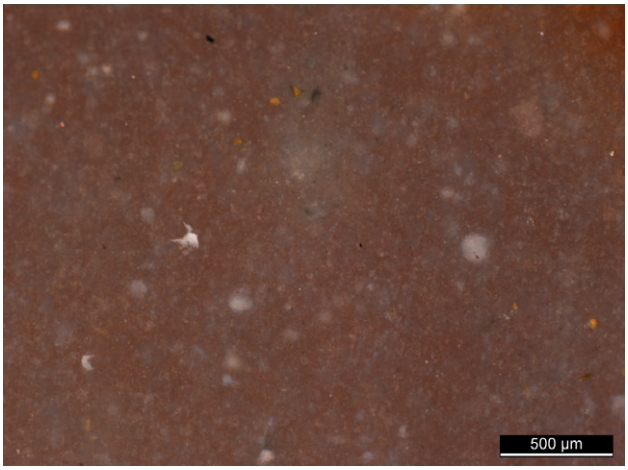


Photo 117. Jurassic radiolarite from Czorsztyn (the Pieniny Mts.) in water immersion under the stereomicroscope.

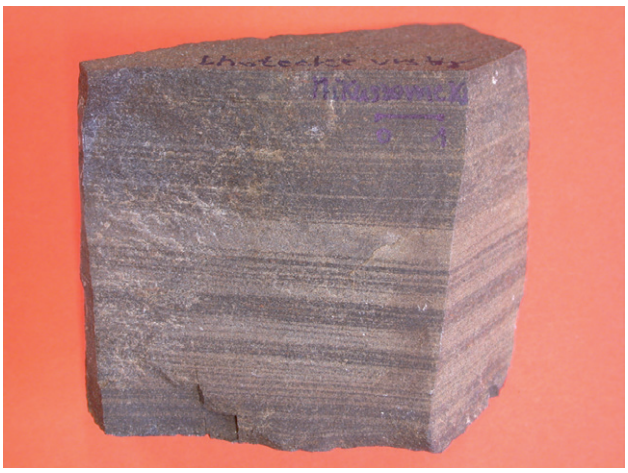


Photo 118. Lower Cretaceous Mikuszowice chert collected at natural source Świnna Poręba south of Wadowice, Carpathian Flysh Belt in southern Poland.

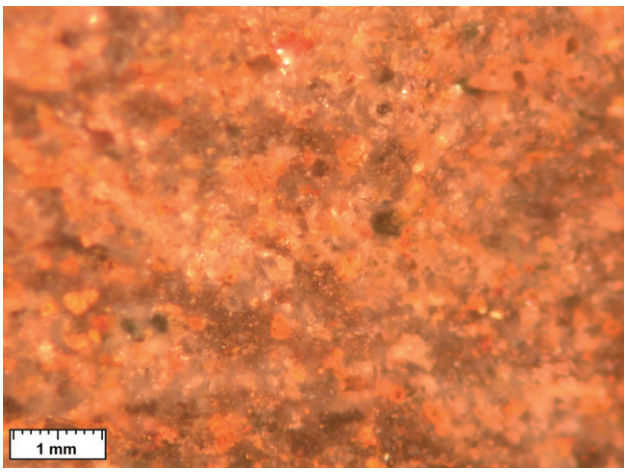


Photo 119. Mikuszowice chert in water immersion under the stereomicroscope.

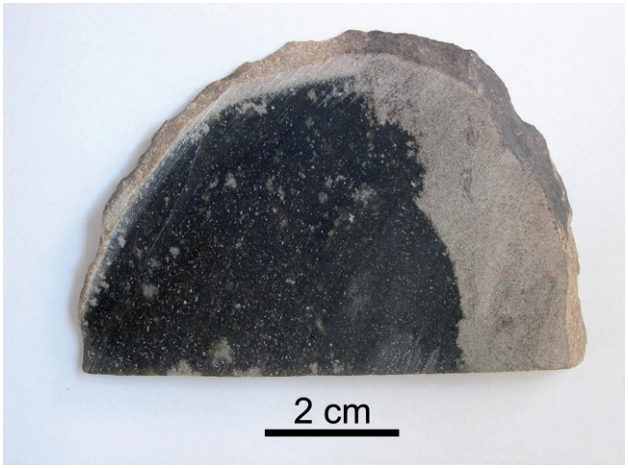


Photo 120. Bircza silicite (krzemień z Birczy). Skodów – Bunacz (sample provided by P. Walde-Nowak).

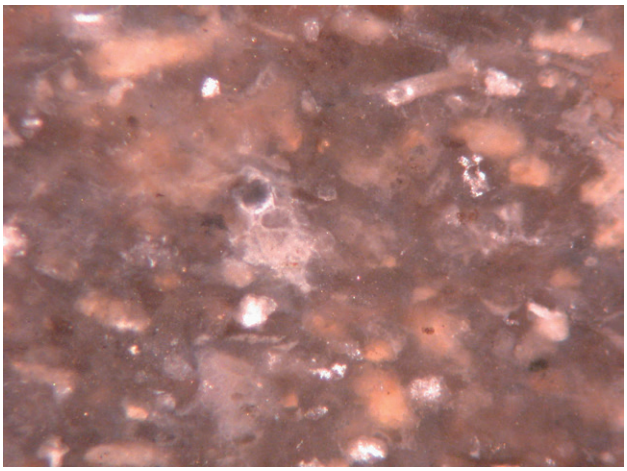


Photo 121. Bircza silicite in water immersion under the stereomicroscope. Length of the picture is 4 mm.

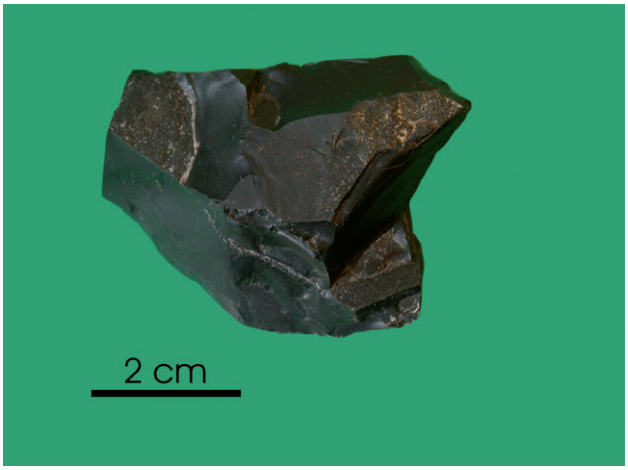


Photo 122. Tertiary black menilite chert from the Dukla Unit, Carpathian Flysch Belt. Natural source at Nová Sedlica in NE Slovakia near the Slovakian, Polish and Ukrainian borders.

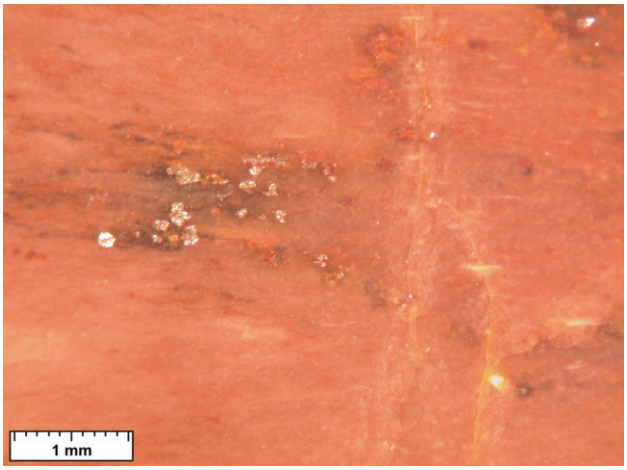


Photo 123. Layered brownish menilite chert in water immersion under the stereomicroscope. It contains cluster of small pyrite crystals. Carpathian Flysch Belt, SE Poland.

Photo 124. Radiolarite pebbles from gravels of the Danube in Bratislava.

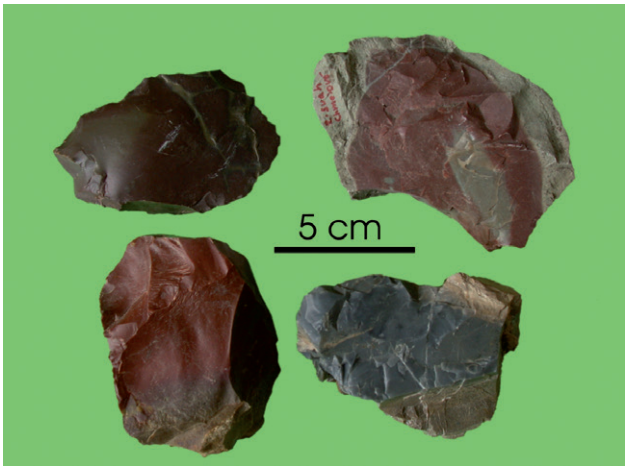


Photo 125. Radiolarite artefacts and natural chips in the vicinity of a radiolarite source on the SW slope of the Chmeľová Hill. Prehistoric mining area at the village of Vršatské Podhradie in the Bílé Karpaty Mts., Slovakia.

Photo 126. Radiolarites from the prehistoric workshop at Slavnica, 7 km south of Vršatské Podhradie.

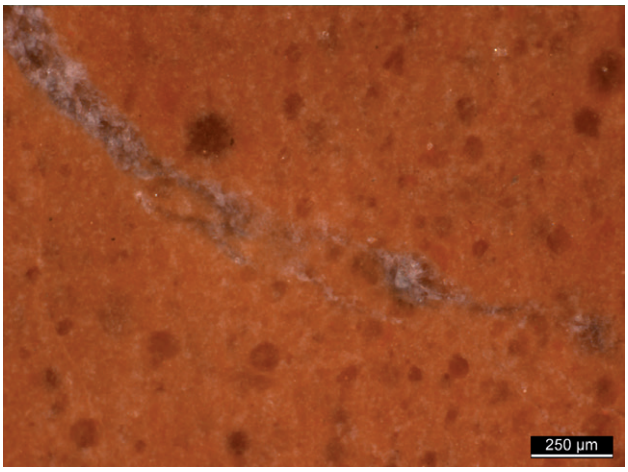


Photo 127. Radiolarite from the SW slope of the Chmeľová Hill in water immersion under the stereomicroscope.

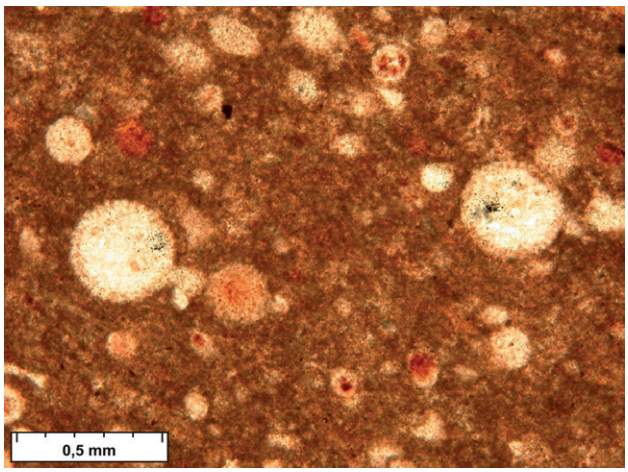


Photo 128. Radiolarite from the prehistoric mining area at Vršatské Podhradie in thin section. Plane-polarized light.

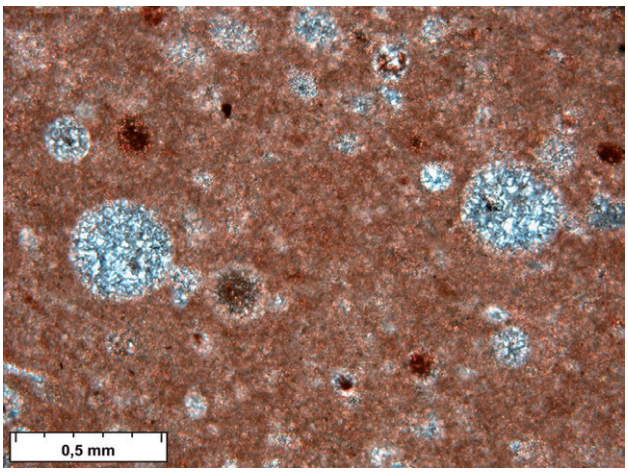


Photo 129. Radiolarite from the prehistoric mining area at Vršatské Podhradie in thin section. Crossed polars.

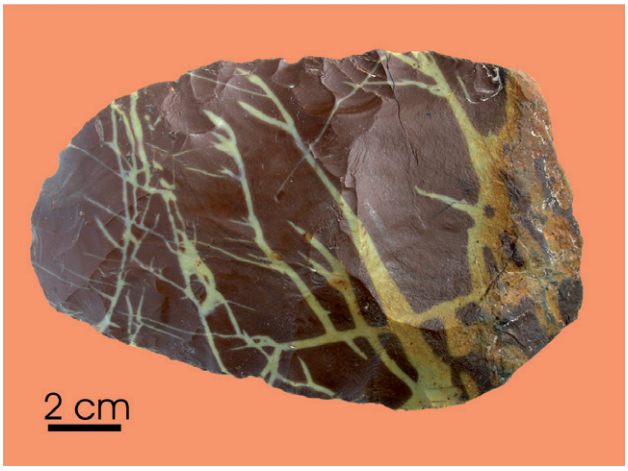


Photo 130. Middle Palaeolithic handaxe from Karolín near Kroměříž, central Moravia. Deposited in the Institute Anthropos, Moravian Museum in Brno.

Photo 131. Radiolarite artefacts from the Aurignacian site at Tvarožná near Brno. Collection of the author.

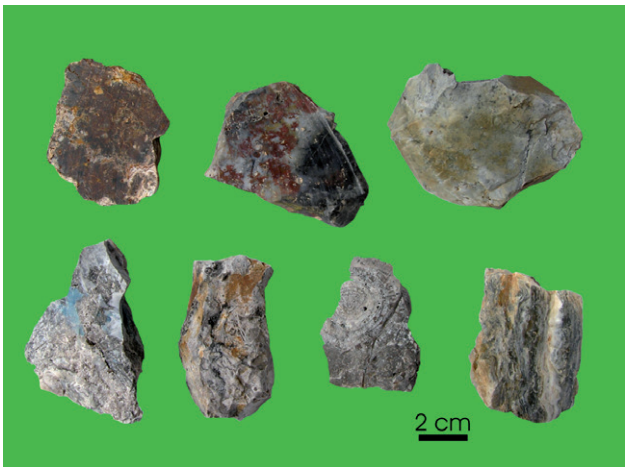


Photo 132. Varieties of Tertiary limnic silicites from Stará Kremnička, NW of Žiar nad Hronom, central Slovakia.

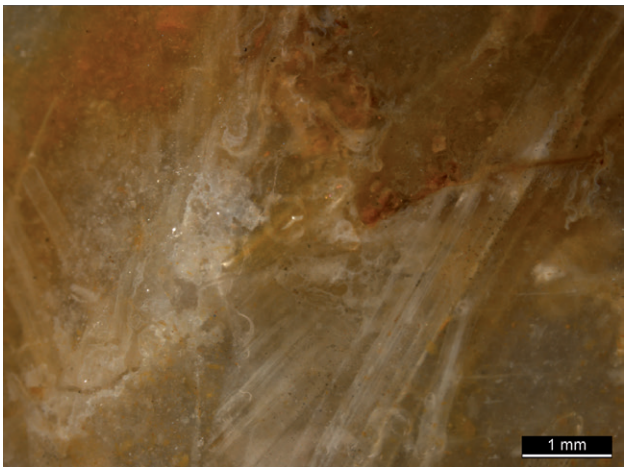


Photo 133. Limnic silicite from Stará Kremnička in water immersion under the stereomicroscope.

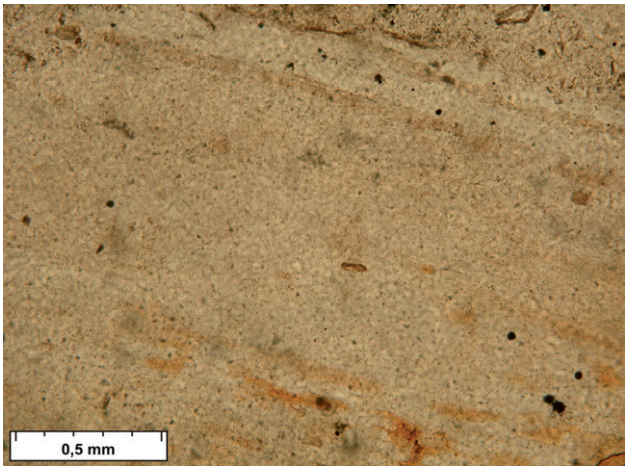


Photo 134. Limnic silicite from Stará Kremnička in thin section, plane-polarized light.

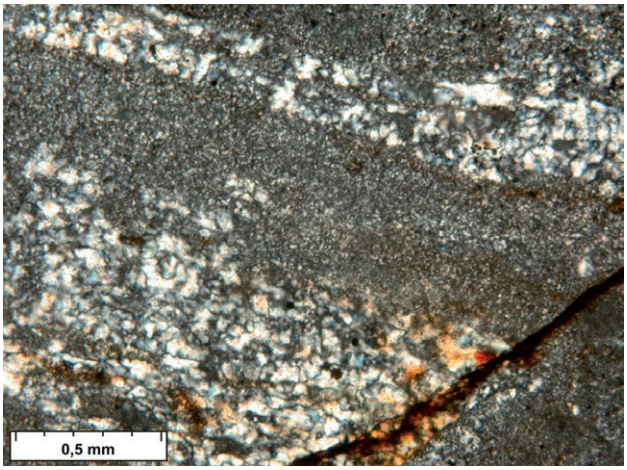


Photo 135. Limnic silicite from Stará Kremnička in thin section, crossed polars.

Photo 136. Cut pebble of the Tertiary nummulitic chert from Panické Dravce near Lučenec, southern Slovakia.

Photo 137. Artefact made of the nummulitic chert in water immersion under the stereomicroscope. Aurignacian site at Kvasice near Kroměříž, Moravia.

Photo 138. So called Ondava or brown cherts (silicified claystones to cherts) from gravels of East-Slovakian rivers.

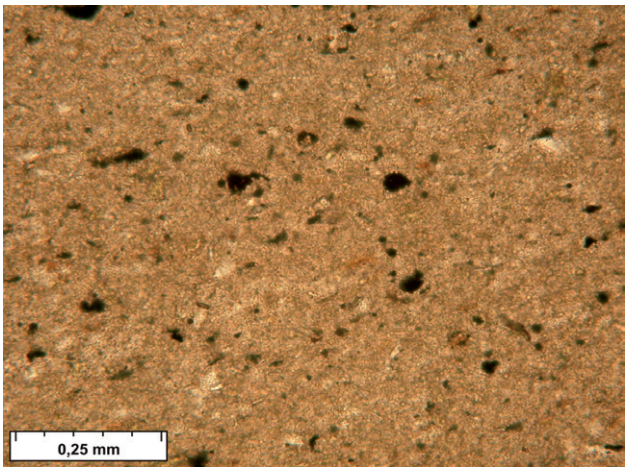


Photo 139. Ondava chert in thin section, plane-polarized light.

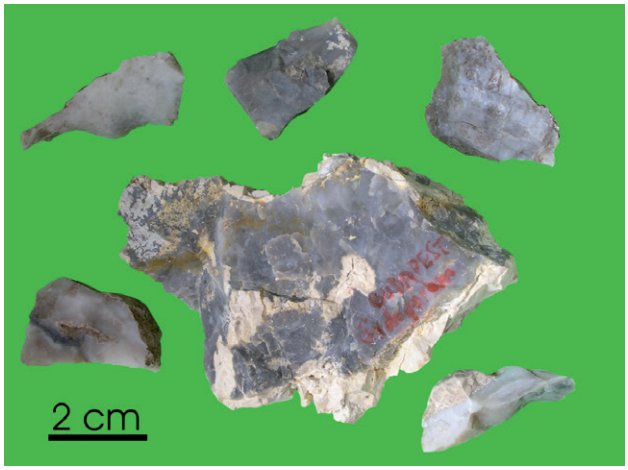


Photo 140. Triassic Budín chert. Budapest-Ördögorom, Hungary.

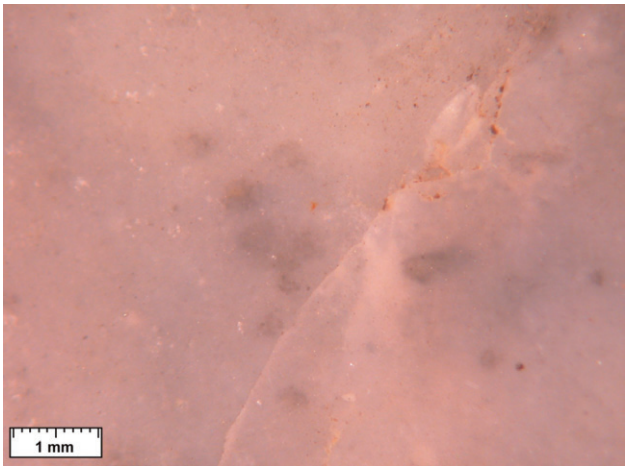


Photo 141. Triassic Budín chert in water immersion under the stereomicroscope.

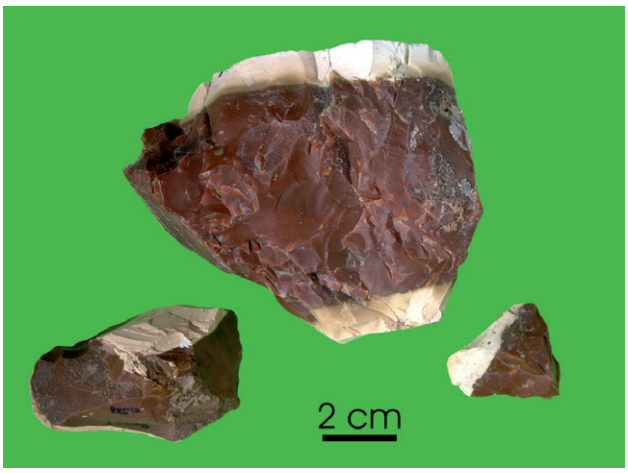


Photo 142. Jurassic Szentgál radiolarite, Hungary. The big piece is from the source at Szentgál, Tüzköveshegy; the left small sample is an artefact No. L 5208 from Těšetice-Kyjovice, a locality with the Moravian Painted Ware in southern Moravia; the right small sample is a flake (surface find) from a Neolithic settlement on the eastern slope of the Velký Kosíř Hill (district of Olomouc, central Moravia).

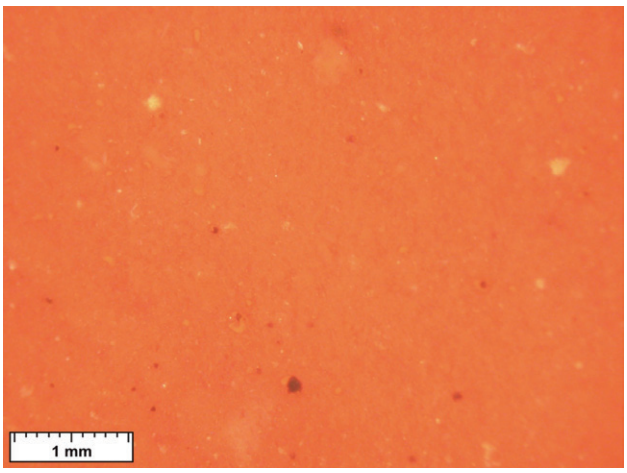


Photo 143. Szentgál radiolarite in water immersion under the stereomicroscope. An artefact from the vicinity of Ajka near Szentgál.

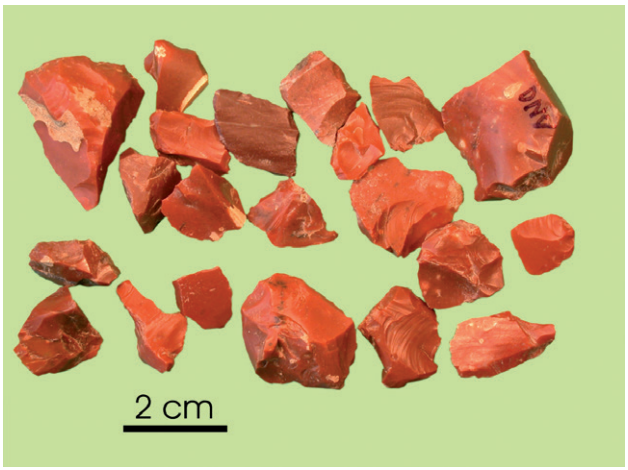


Photo 144. Artefacts made of the Szentgál radiolarite from the settlement of the Linear Pottery culture at Děvínská Nová Ves near Bratislava (the finds were provided by Z. Farkaš from the Slovak National Museum in Bratislava).

Photo 145. Szentgál radiolarite from the Lengyel locality Wultendorf-Flur, Lower Austria. Photo by G. Trnka.

Photo 146. Jurassic Hárskút radiolarite. Édesvízmajor near Hárskút, Hungary.

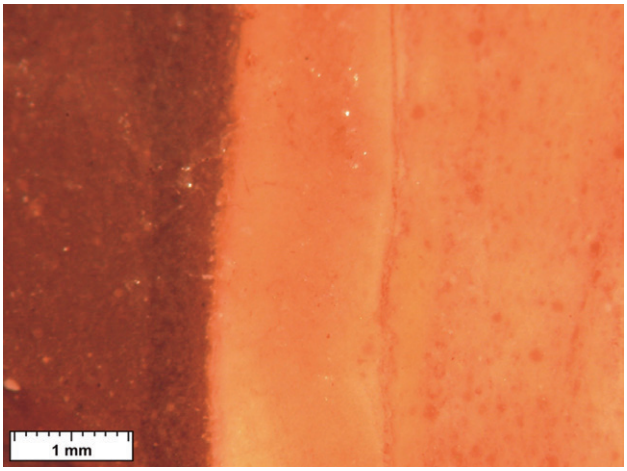


Photo 147. Hárskút radiolarite in water immersion under the stereomicroscope.

Photo 148. Jurassic radiolarites from the Gerecse Mts., Hungary.

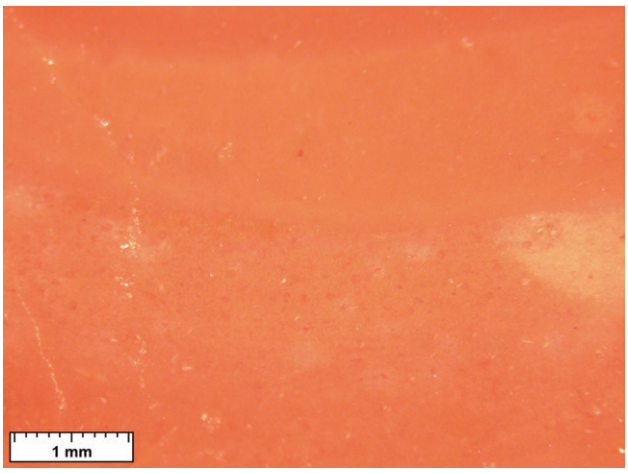


Photo 149. Radiolarite from the Gerecse Mts. in water immersion under the stereomicroscope.

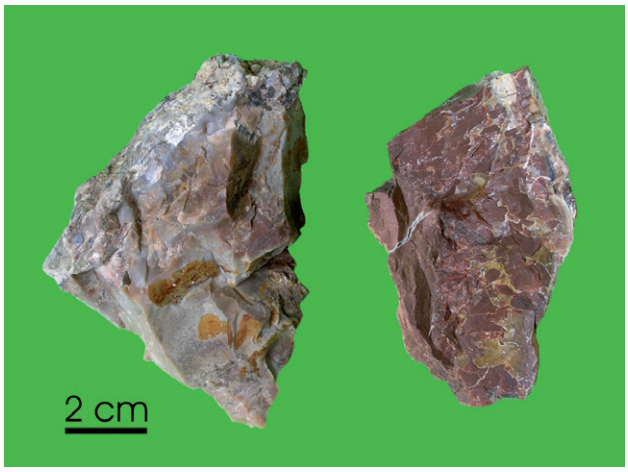


Photo 150. Jurassic radiolarite to radiolarian chert from Tata-Kalvariadomb, Hungary.

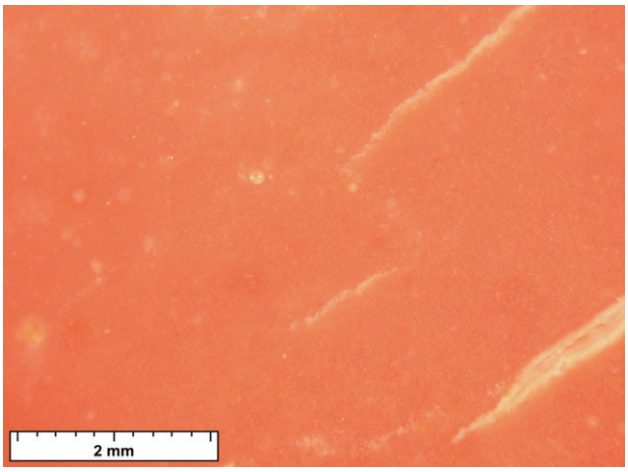


Photo 151. Radiolarite to radiolarian chert from Tata in water immersion under the stereomicroscope.

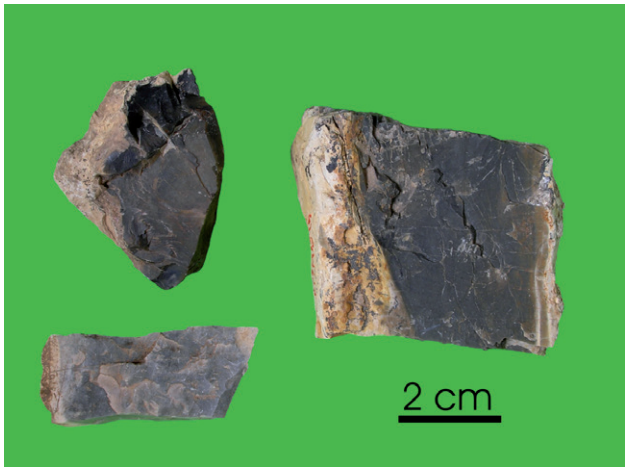


Photo 152. Upper Jurassic to Lower Cretaceous radiolarian chert from Sümeg-Mogyorósdomb, Hungary.

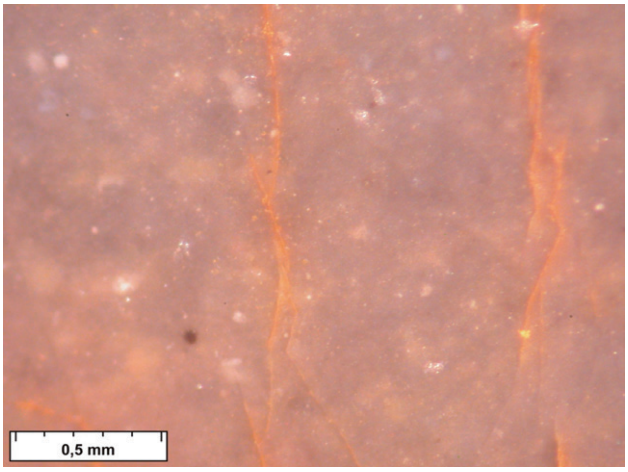


Photo 153. Radiolarian chert from Sümeg in water immersion under the stereomicroscope.

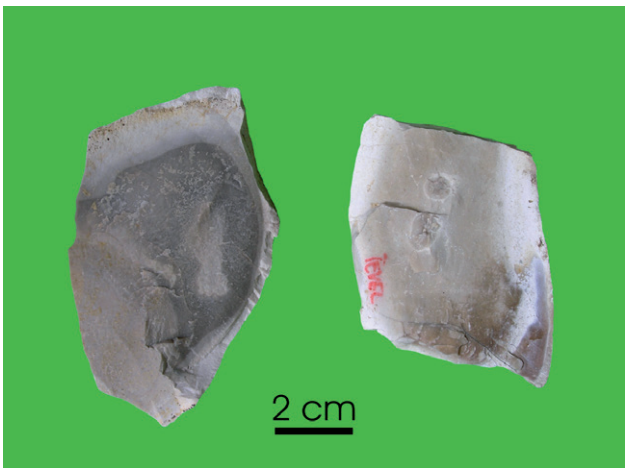


Photo 154. Upper Cretaceous flint from Nagytevel, Tevel-hegy, Hungary.

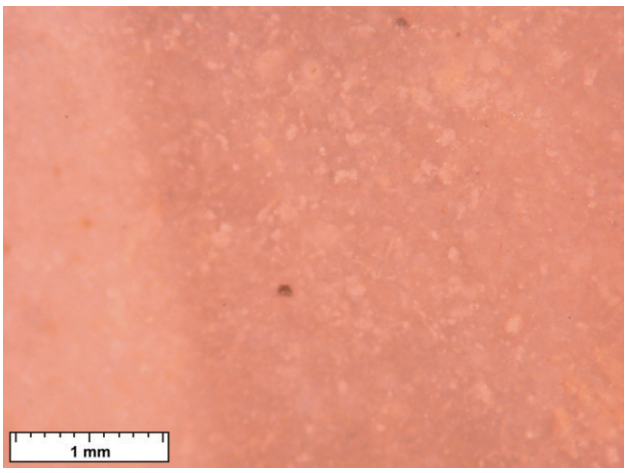


Photo 155. Flint from Nagytevel in water immersion under the stereomicroscope.

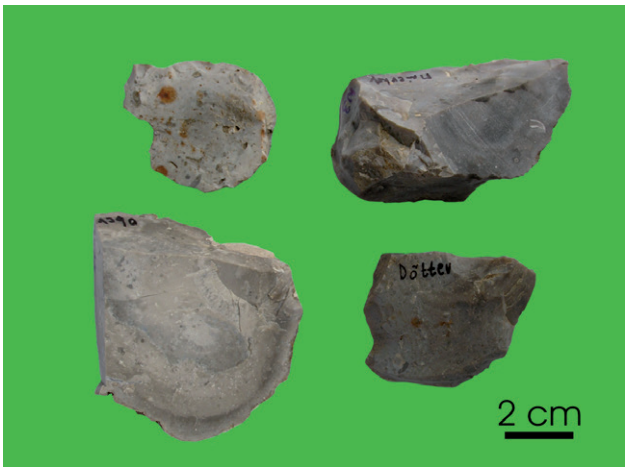


Photo 156. Silicites (cherts) of the Ortenburg Jurassic from Dötter, Obermühle and Maierhof, Bavaria.

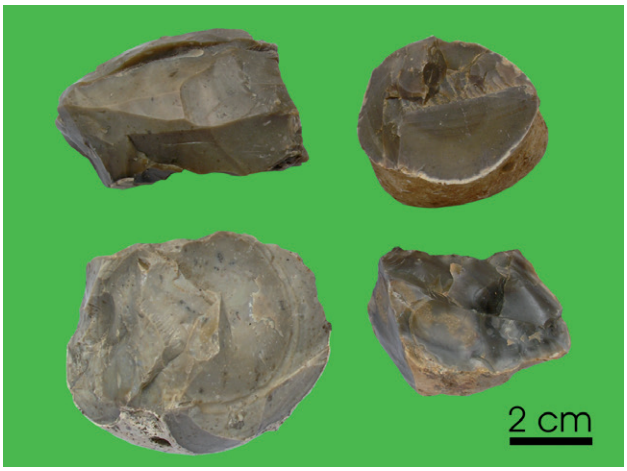


Photo 157. Silicites of the Ortenburg Jurassic from Flintsbach, Bavaria.

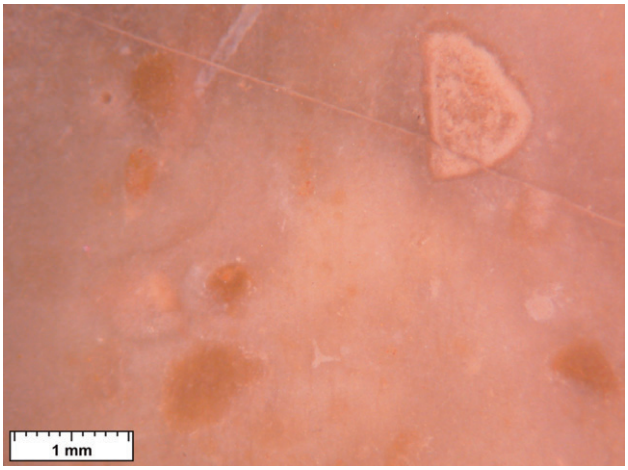


Photo 158. Jurassic silicite (chert) from Flintsbach in water immersion under the stereomicroscope.

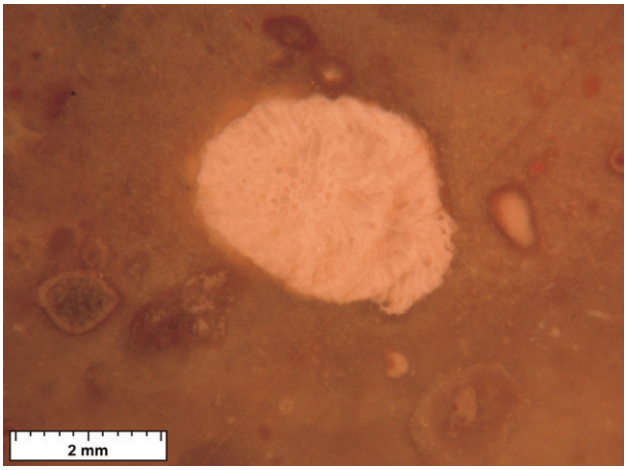


Photo 159. Silicite from Flintsbach in water immersion under the stereomicroscope. Big whitish fragment probably of moss-animal in the centre of the picture.

Photo 160. Jurassic tabular chert ("plattensilex" in German) from Baiersdorf, Bavaria.

Photo 161. Jurassic tabular chert from Baiersdorf in water immersion under the stereomicroscope.

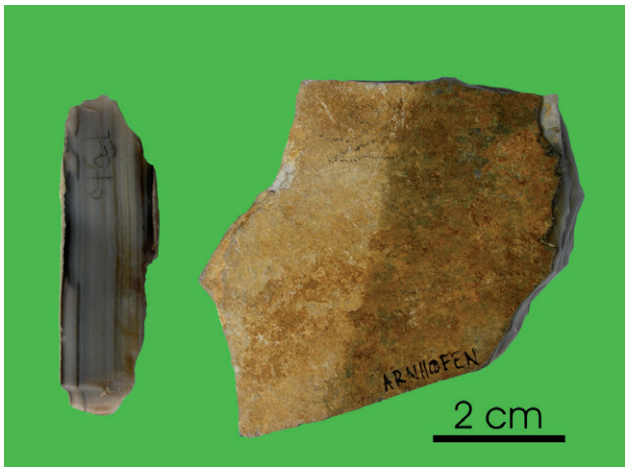


Photo 162. Jurassic tabular chert from Arnhofen, Bavaria.

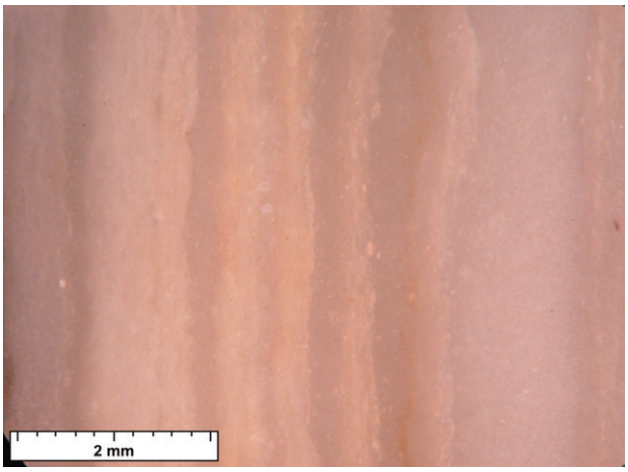


Photo 163. Jurassic tabular chert from Arnhofen in water immersion under the stereomicroscope.

Photo 164. Upper Palaeolithic artefacts made of variable coloured quartz. Brno-Žebětín (upper left), Moravany near Brno (lower left), Rozdrojovice near Brno (the both right).

Photo 165. Semiprecious quartz varieties used for chipped artefacts in the Czech Republic: citrine (Sklené), rock crystal (Žulová), rose quartz (Dolní Bory) and smoky quartz (Sklené).

Photo 166. Citrine and rock crystal from the surroundings of Sklené and Rousměrov near Žďár nad Sázavou.

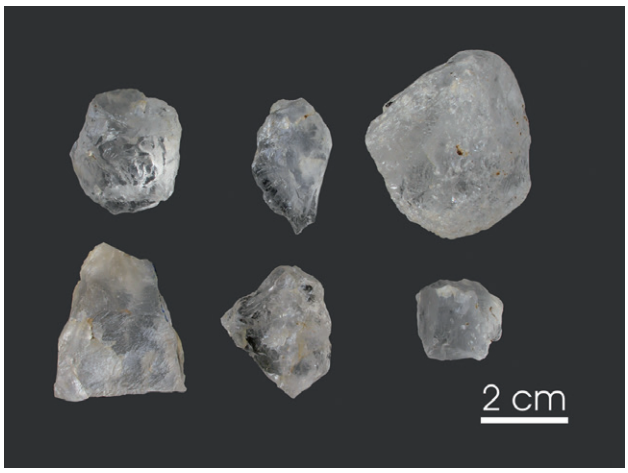


Photo 167. Rock crystal, citrine and smoky quartz from the surroundings of Brtnice SSE of Jihlava.

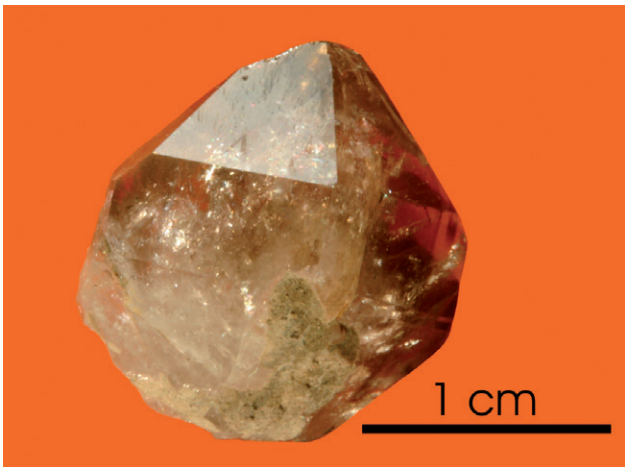


Photo 168. Smoky quartz from a feature of the Plátěnice culture (Hallstatt period of the urnfield cultures) at Klimkovice, SW of Ostrava (by the courtesy of T. Krasnokutská).

Photo 169. Rock crystal from Andělské Domky near Žulová, Czech Silesia.

Photo 170. Rock crystal from Devonian metaquartzites at Jegłowa in Polish Silesia.

Photo 171. Rock crystal artefacts from the hillfort of Baden culture at Hlinsko near Lipník nad Bečvou, central Moravia (by the courtesy of L. Šebela).

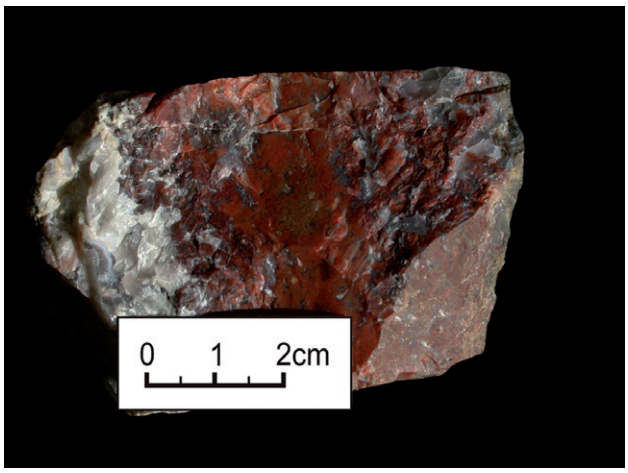


Photo 172. Jasper from melaphyre of the Kozákov Hill, northern Bohemia.

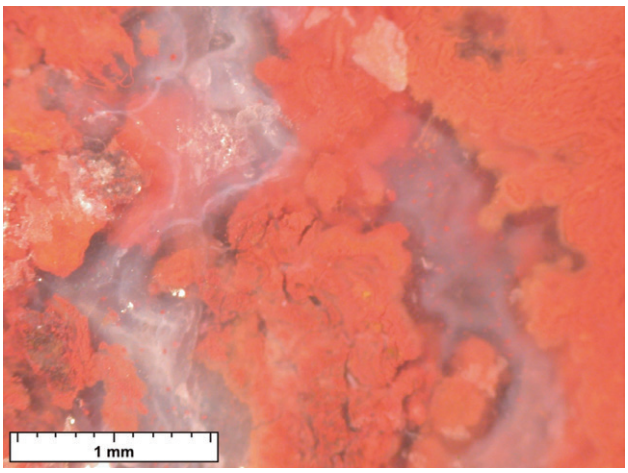


Photo 173. Kozákov jasper in water immersion under the stereomicroscope.

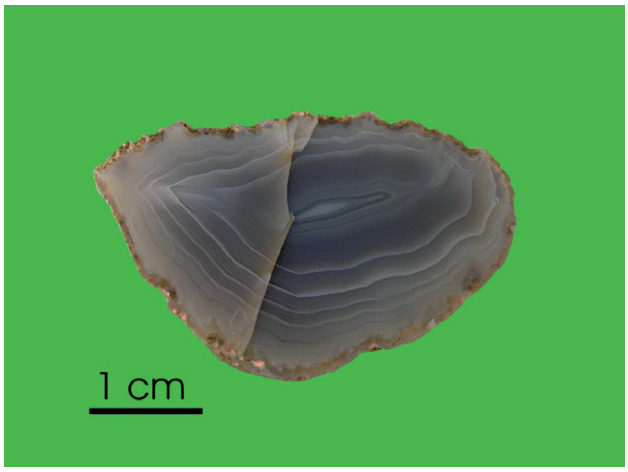


Photo 174. Agate from a melaphyre cavity at Frýdštejn, northern Bohemia.

Photo 175. Chalcedony from sandy gravels of the Olešnický (Kalenský) brook at Vestřev, south of Hostinné.

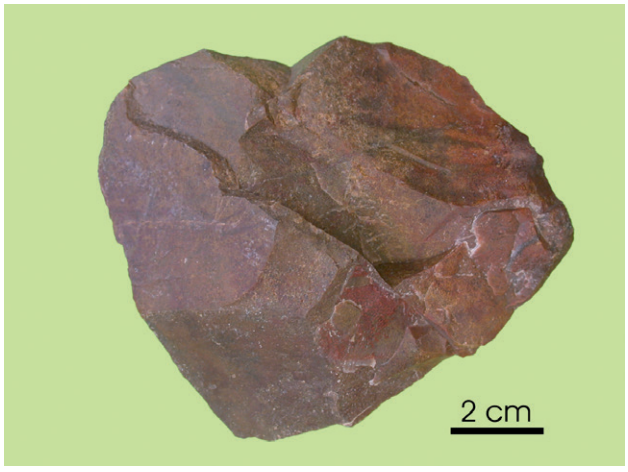


Photo 176. Jasper from the range between Raszków and Kamieniec in the Intra-Sudetic Basin, Poland.

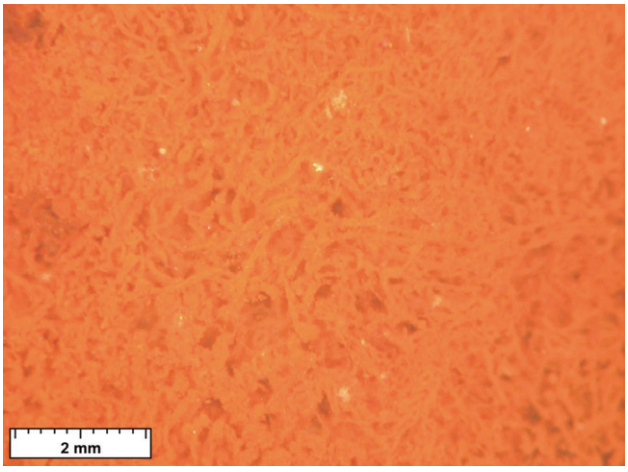


Photo 177. Jasper from Raszków in water immersion under the stereomicroscope.

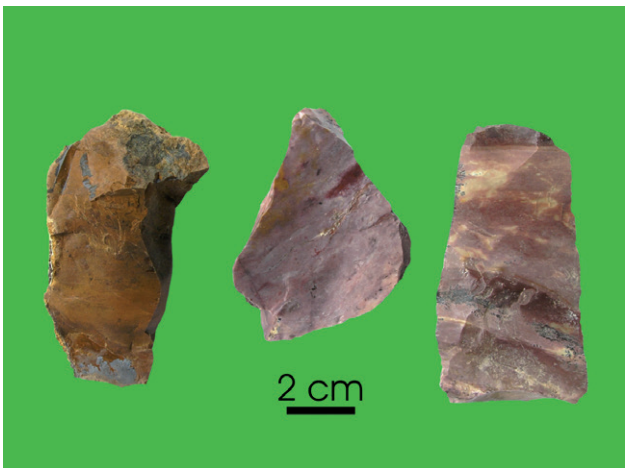


Photo 178. Opals from Dargov in eastern Slovakia.

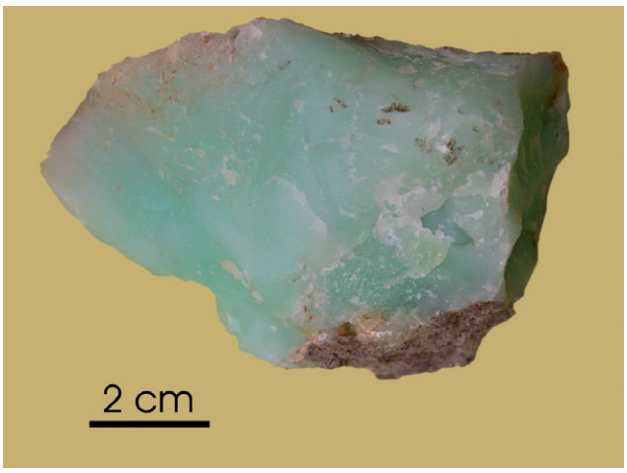


Photo 179. Chrysoprase from Szklary (Polish Silesia).

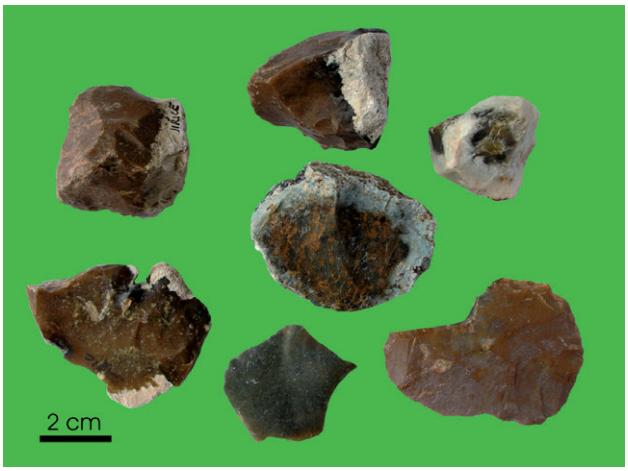


Photo 180. Siliceous weathering products of serpentinite, Jevišovice, western Moravia.

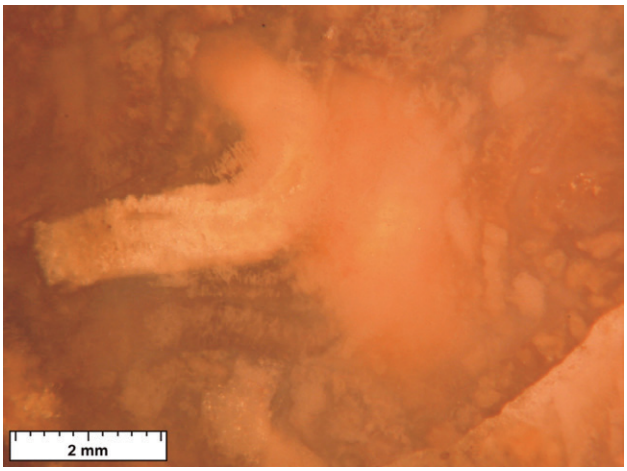


Photo 181. Siliceous weathering product of serpentinite from Jevišovice in water immersion under the stereomicroscope.

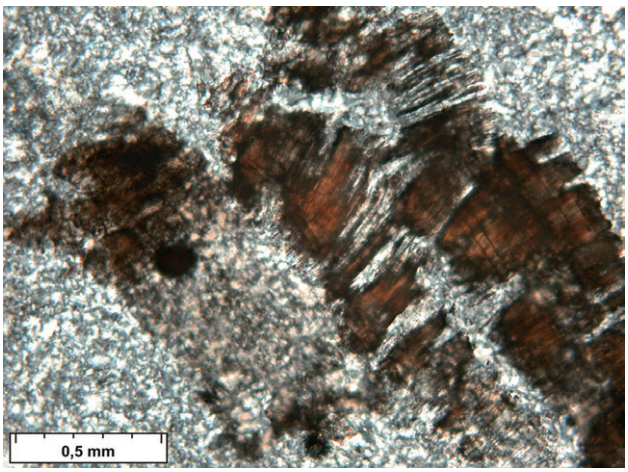


Photo 182. Weathering product of serpentinite from Jevišovice in thin section, plane-polarized light.

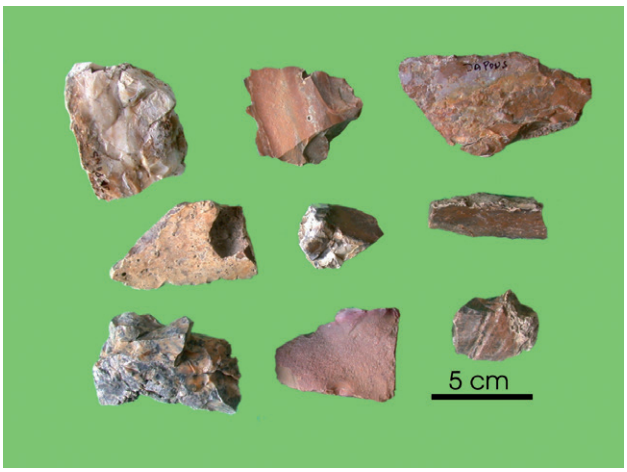


Photo 183. Siliceous weathering products of serpentinite, Japons, Lower Austria.

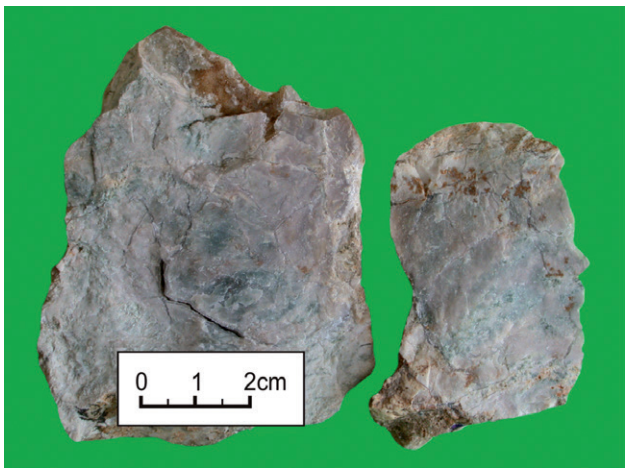


Photo 184. Siliceous weathering products of serpentinite, Holubov near Křemže, southern Bohemia.

Photo 185. Siliceous weathering products, Mlaka near Písek, southern Bohemia.

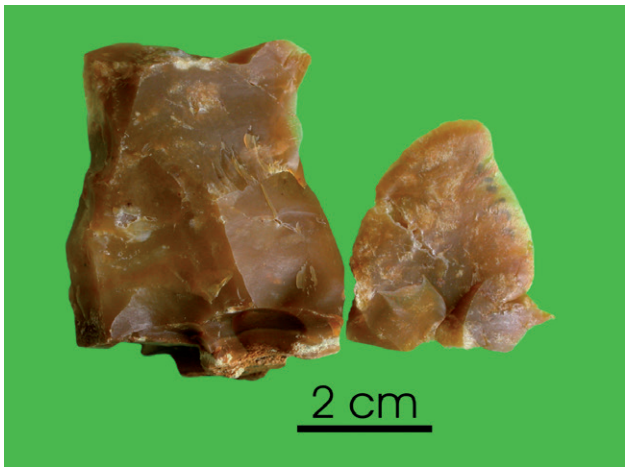


Photo 186. Siliceous weathering product – brown opal, Písecká Smoleč, southern Bohemia.

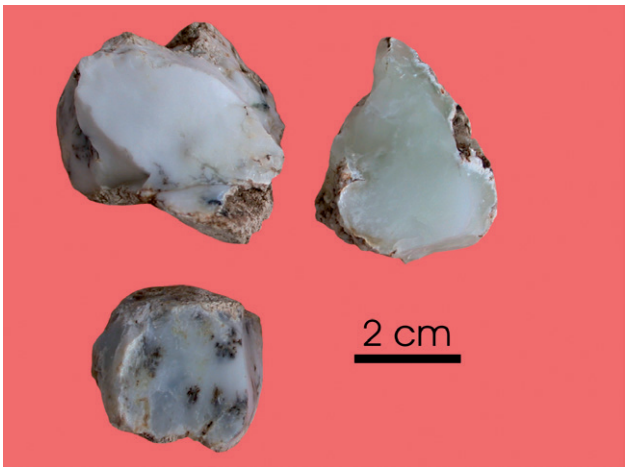


Photo 187. Siliceous weathering product of serpentinite – milky white opal, Bohouškovice near Křemže, southern Bohemia.

Photo 188. Natural obsidian raw material, Viničky and Malá Bara, SE Slovakia.

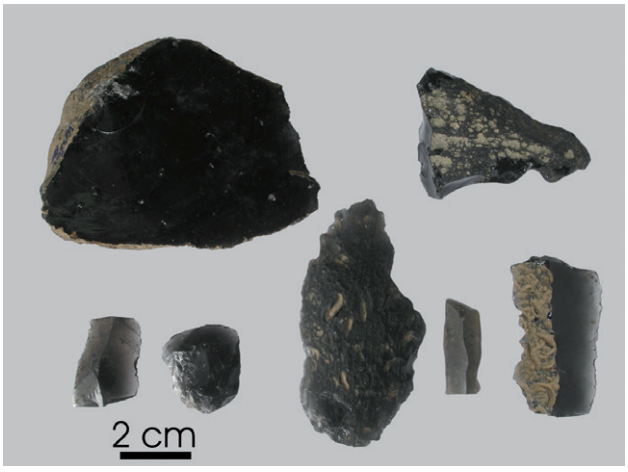


Photo 189. Obsidian artefacts from the surroundings of Cejkov and Kašov, SE Slovakia.

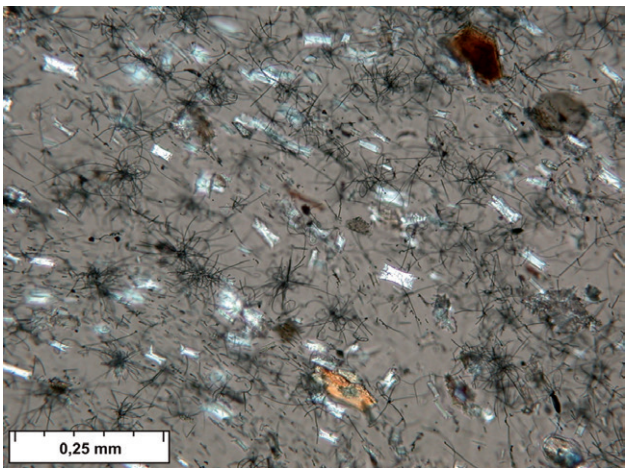


Photo 190. Obsidian in thin section, crossed polars. Malá Bara, SE Slovakia.

Photo 191. Perlite, Lehôtka pod Brehmi, central Slovakia.

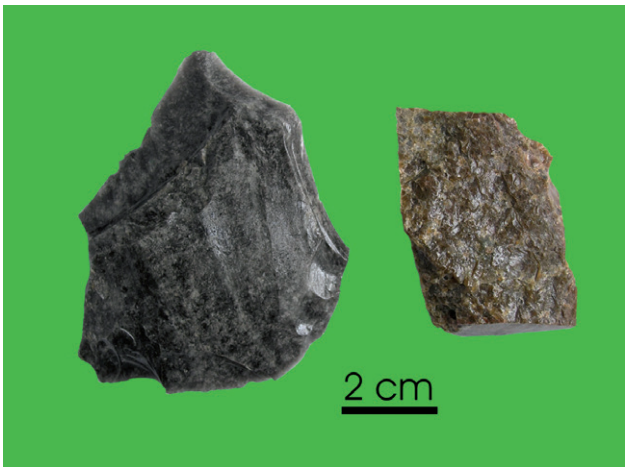


Photo 192. Saxon pitchstone. Left specimen – collection of the Institute of Geological Sciences, Masaryk University in Brno, without more precise location; right specimen – Garsebach west of Meissen.

Photo 193. Characteristic appearance of moldavites from southern Bohemia: Ločenice – four peripheral pieces; Blanice near Vodňany – upper central piece; Lhenice – moldavite artefact, lower central piece.

Photo 194. Characteristic appearance of moldavites from SW Moravia: Dukovany – two pieces in the upper left corner; Skryje – piece in the lower left corner and lower central one; Senorady – upper central piece; Mohelno-Boleniska – artefact, upper right corner; Skryje – artefact, lower right corner.

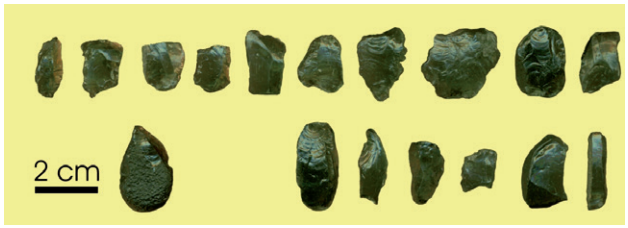


Photo 195. Moldavite artefacts from the surroundings of Lipí near České Budějovice, southern Bohemia; isolated piece in the lower left corner – artefact from Mohelno-Boleniska, SW Moravia.

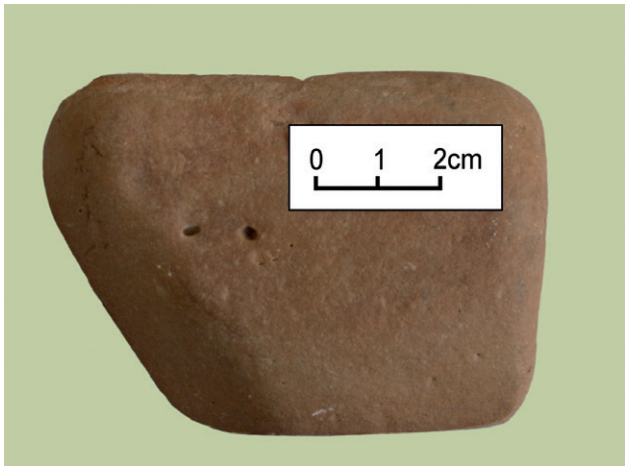


Photo 196. Ventifact of the Ordovician quartzite with couples of holes (trace-fossils). Terrace fluvial gravels of the Vltava River in Prague.

Photo 197. Písečný Hill near Bečov – source of the Bečov quartzite, NW Bohemia.

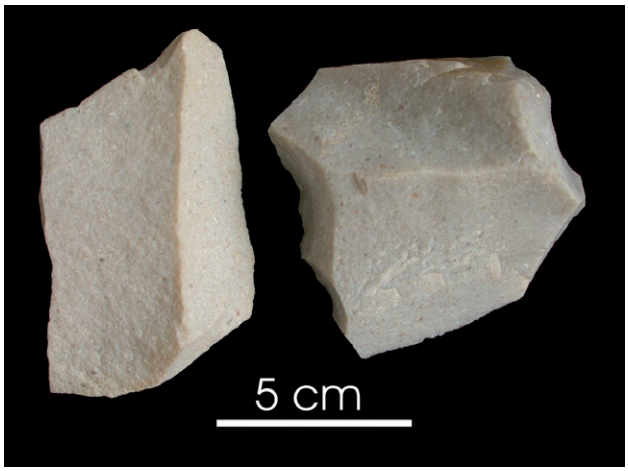


Photo 198. Bečov quartzite.

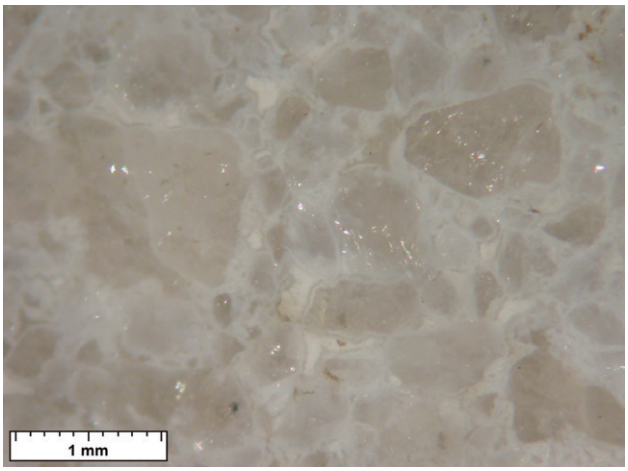


Photo 199. Bečov quartzite in water immersion under the stereomicroscope.

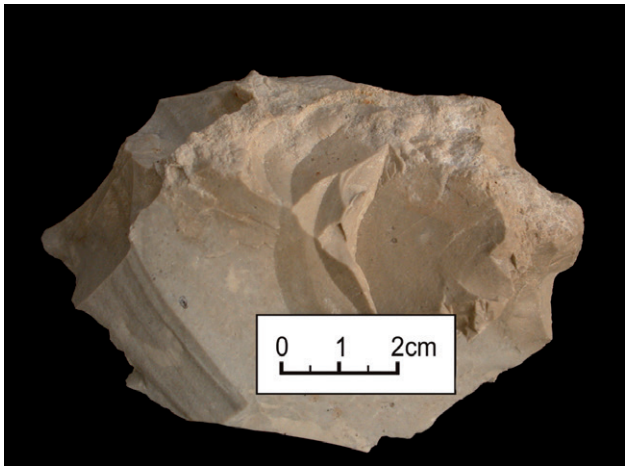


Photo 200. Tušimice quartzite, NW Bohemia.

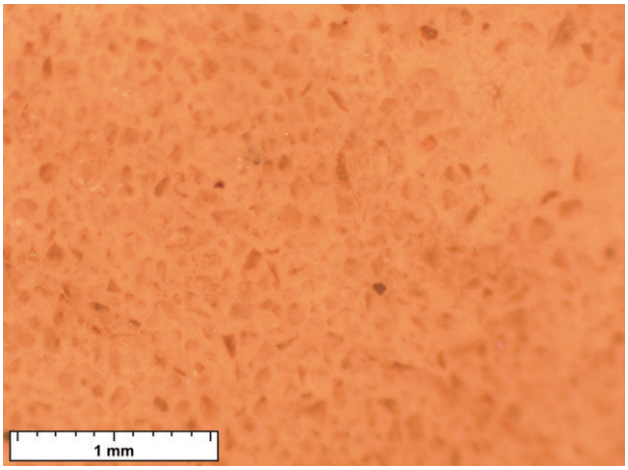


Photo 201. Tušimice quartzite in water immersion under the stereomicroscope.

Photo 202. Skršín quartzite, NW Bohemia.

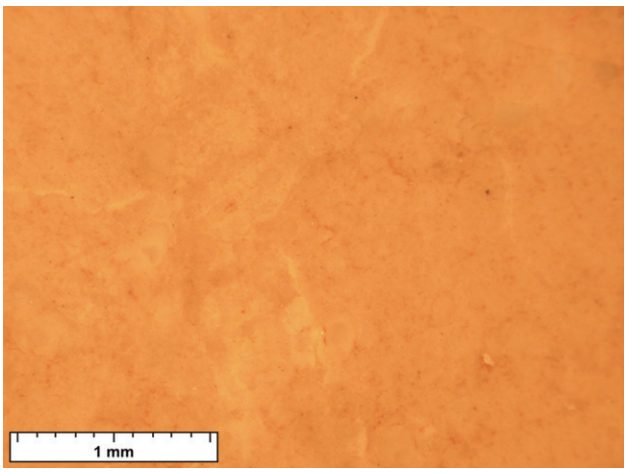


Photo 203. Skršín quartzite in water immersion under the stereomicroscope.

Photo 204. Kamenná Voda quartzite, NW Bohemia.

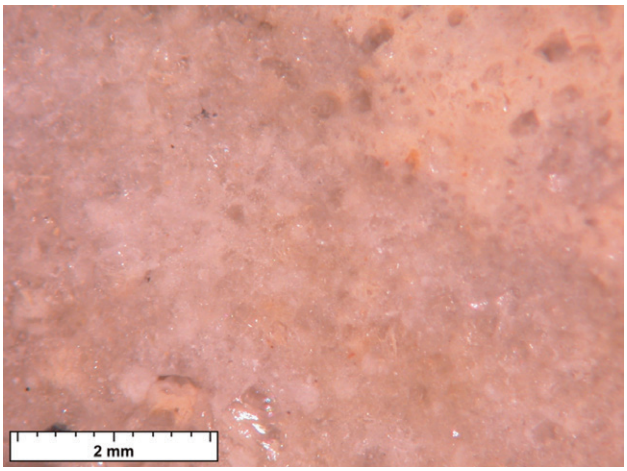


Photo 205. Kamenná Voda quartzite in water immersion under the stereomicroscope.

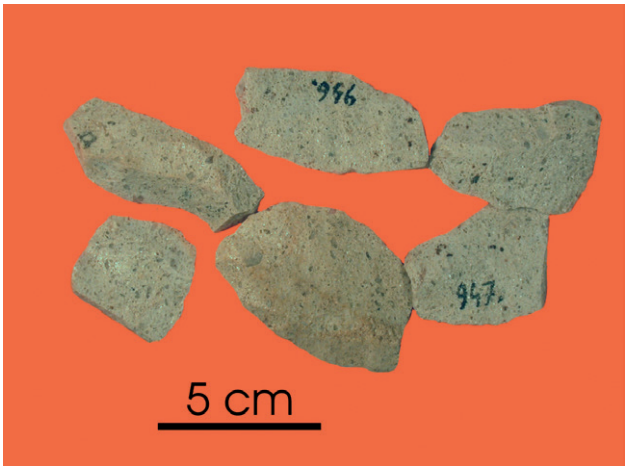


Photo 206. Artefacts made of the Lipnice quartzite, pre-Neolithic settlement at Putim-Ražice, southern Bohemia.

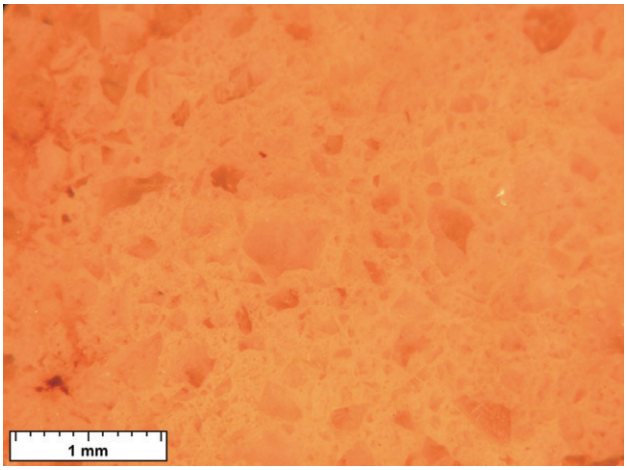


Photo 207. Lipnice quartzite in water immersion under the stereomicroscope.

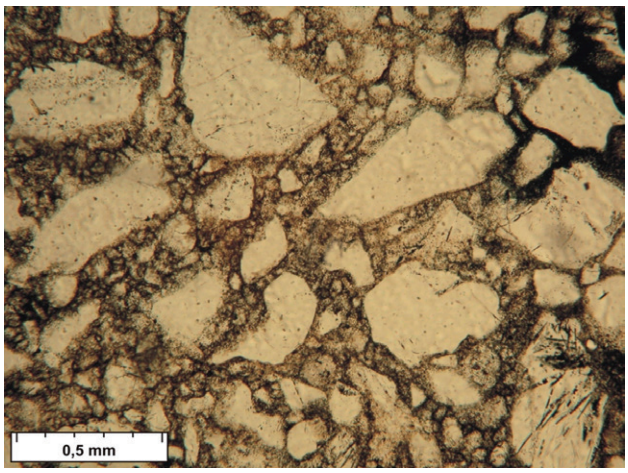


Photo 208. Lipnice quartzite in thin section, plane-polarized light.

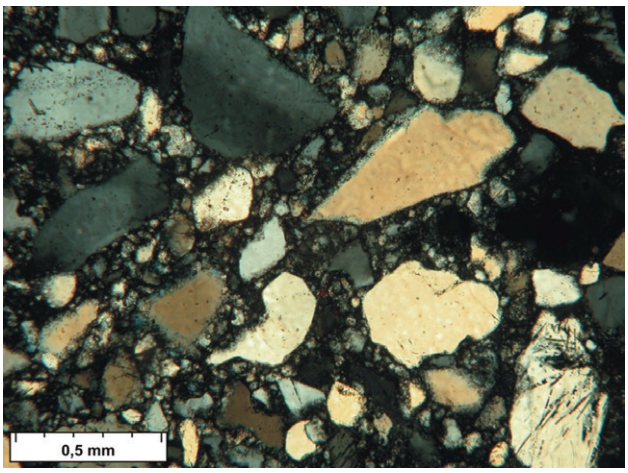


Photo 209. Lipnice quartzite in thin section, crossed polars.

Photo 210. Quartzite of the silcrete type (so called sluňák), Hlinsko near Lipník nad Bečvou, central Moravia.

Photo 211. Quartzite of the silcrete type (so called sluňák) with a relic of probably Jurassic colonial coral (determination by Š. Hladilová). Brno-Líšeň, plateau above the post-office Brno 28.

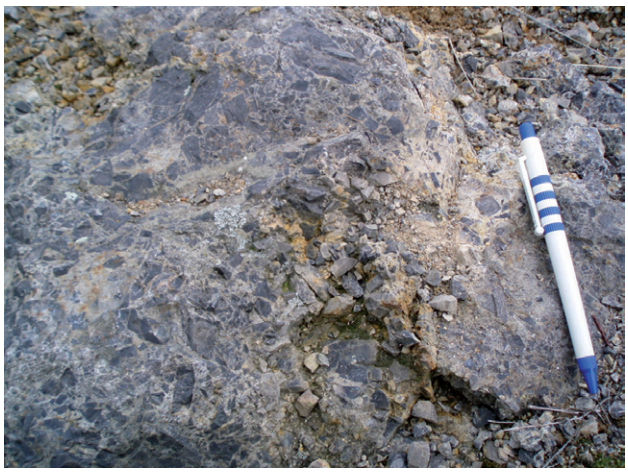


Photo 212. Chert breccia built of chert fragment from the Hády- Říčka limestone. The uppermost floor in the Lesní lom quarry, Brno-Líšeň.

Photo 213. Chert breccia with a silicified Jurassic(?) solitary coral. A boulder at the road from the street Velká Klajdovka to the Lesní lom quarry, Brno-Líšeň.

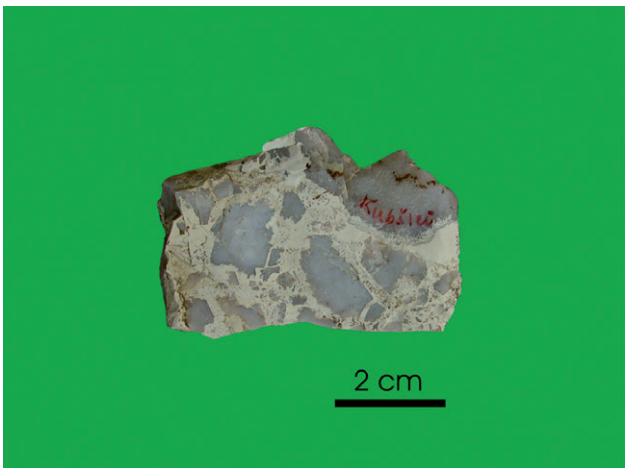


Photo 214. A blade made of chert breccia, settlement of the Únětice culture at Kubšice near the natural source in the Krumlovský les Highland.

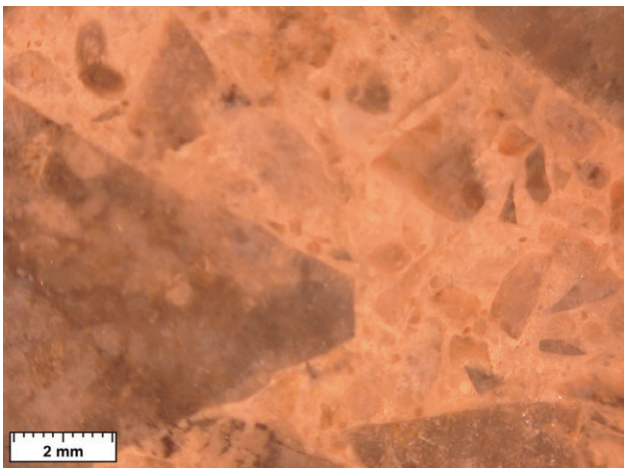


Photo 215. Chert breccia in water immersion under the stereomicroscope. Brno-Líšeň, Zikova street.

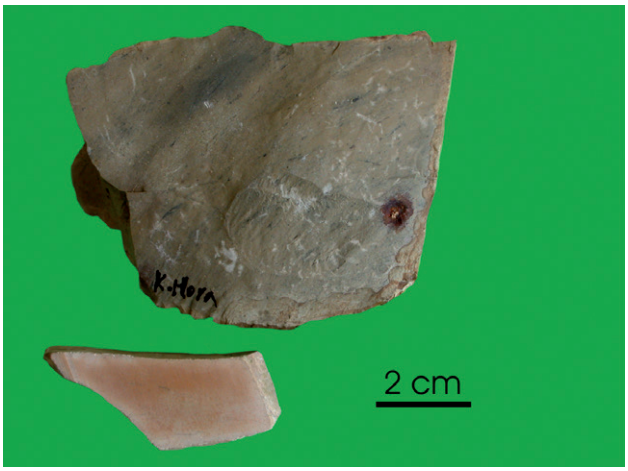


Photo 216. Massive porcellanite and a cross section of porcellanite artefact. Kunětická hora Hill near Pardubice, eastern Bohemia.

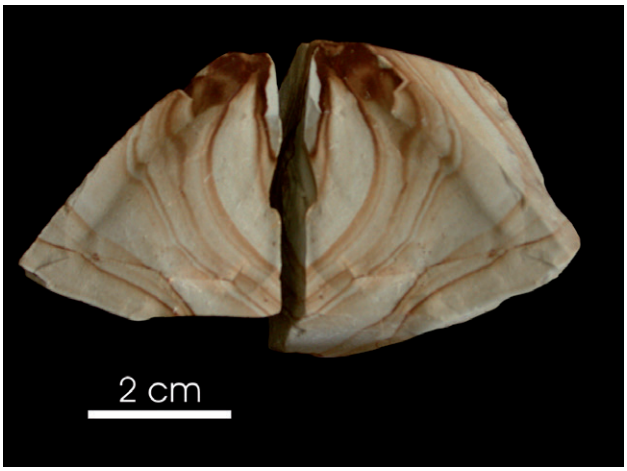


Photo 217. Porcellanite with bands of iron compounds, Kunětická hora Hill near Pardubice.

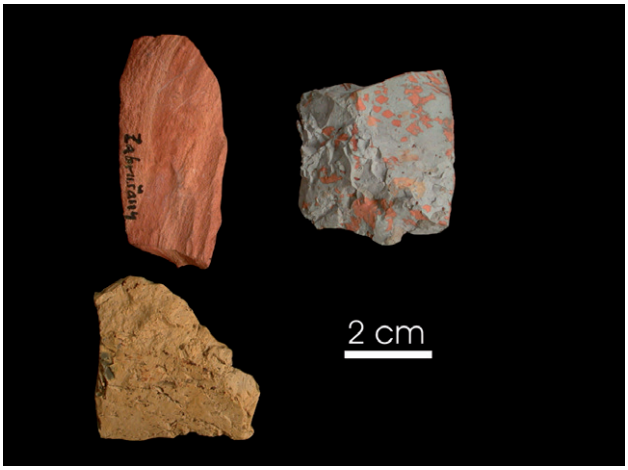


Photo 218. Porcellanite varieties from Zabrušany near Duchcov, NW Bohemia.

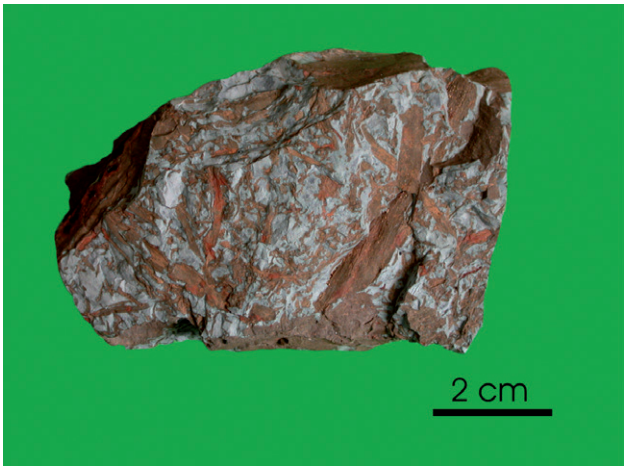


Photo 219. Porcellanite from Zabrušany containing burnt fragments of wood.

Photo 220. Porcellanites from the Bučník Hill near Komňa, SE Moravia.

Photo 221. Abandoned quarry for porcellanites at Medlovice near Uherské Hradiště, SE Moravia.

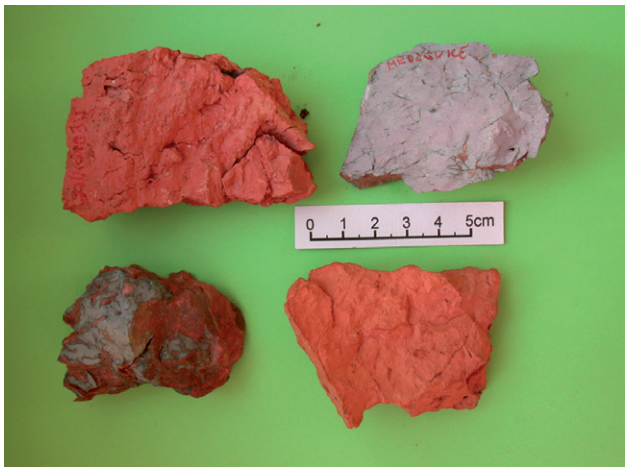


Photo 222. Varieties of porcellanite from Medlovice.

Photo 223. Green porcellanites originated at contacts of teschenite rocks in the Janovice – Žilina area and spotted bluish chalcedony from a cavity filling in the volcanic rock on the Hončova hůrka Hill near Nový Jičín, NE Moravia.

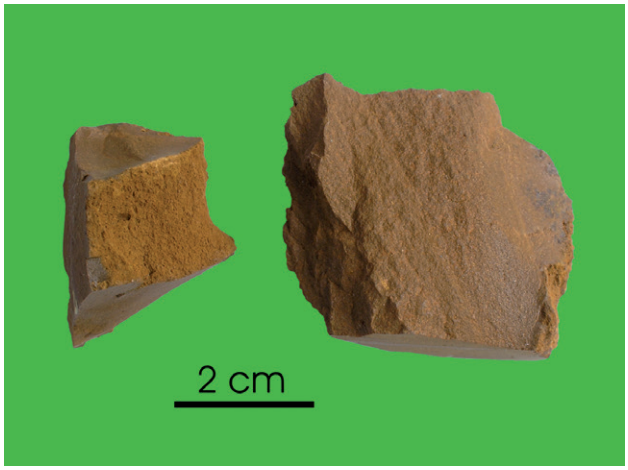


Photo 224. Porcellanite from the Góra Św. Anny Hill, south of Opole, Poland.

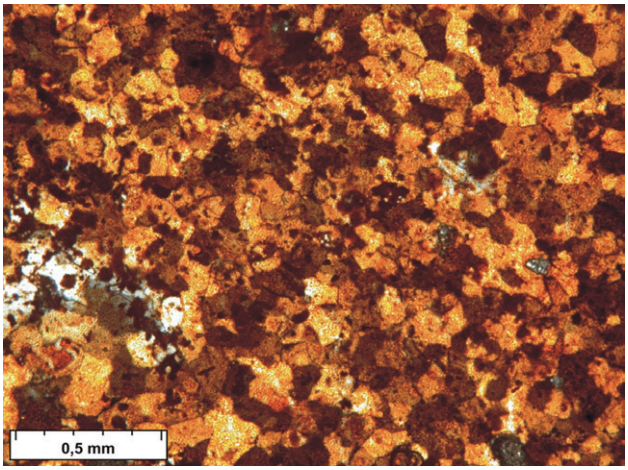


Photo 225. Porcellanite from the Góra Św. Anny Hill in thin section, crossed polars.

Photo 226. Cretaceous silicified corals from Příbor-Klokočov, NE Moravia.

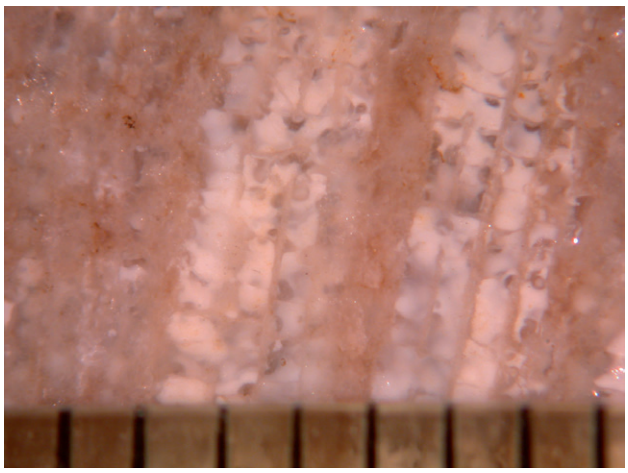


Photo 227. Silicified coral from Příbor-Klokočov in water immersion under the stereomicroscope.

Photo 228. Varieties of révaite including a piece arranged as modern jewellery. Ostrožská Nová Ves, SE Moravia.

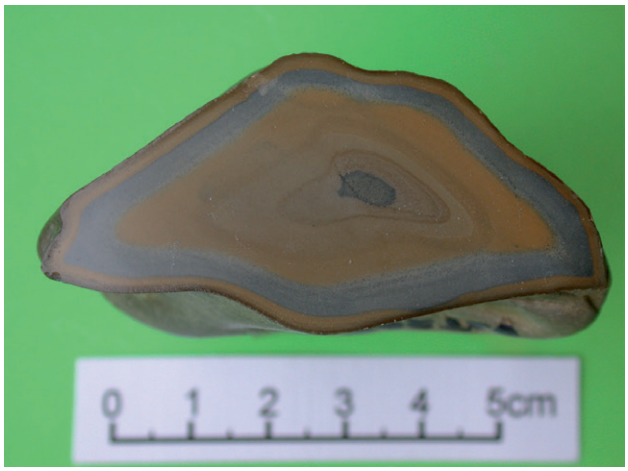


Photo 229. Conspicuous zonal structure of révaite after its polishing. Ostrožská Nová Ves.

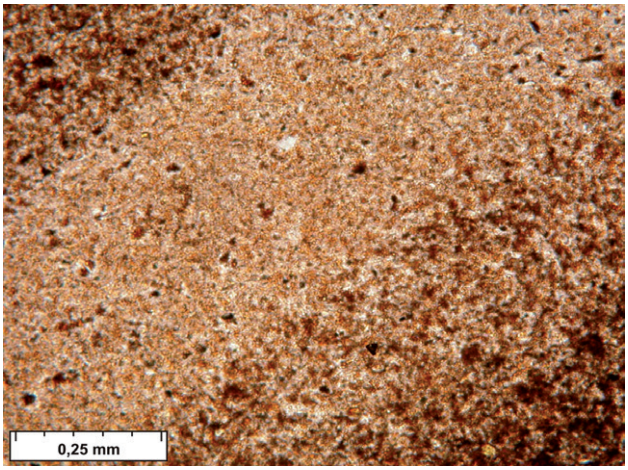


Photo 230. Révaite in thin section, plane-polarized light.

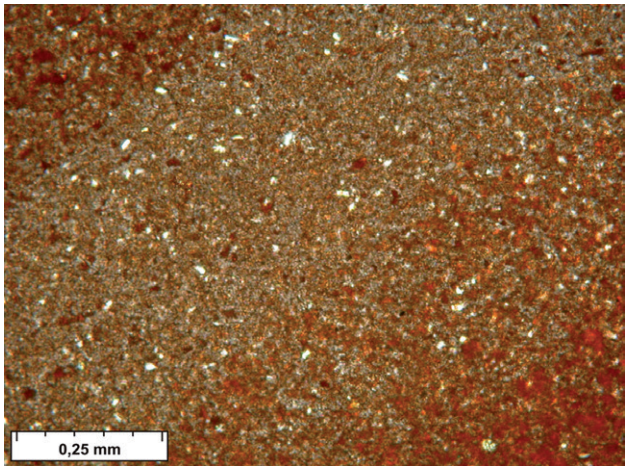


Photo 231. Révaite in thin section, crossed polars.

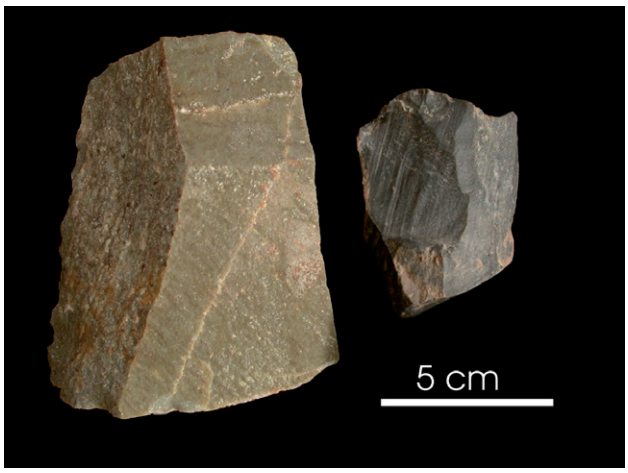


Photo 232. Comparison of acid subvolcanic rock from the natural source at Lásenice (left specimen) with a pre-Neolithic artefact from Putim-Ražice, southern Bohemia.

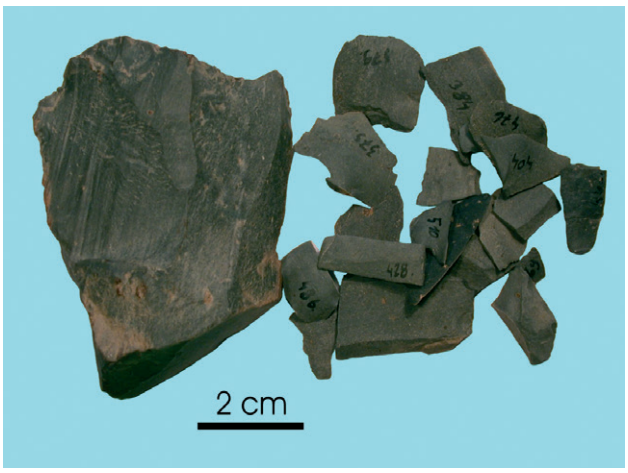


Photo 233. Artefacts made of acid subvolcanics from the Late Palaeolithic and Mesolithic settlement at Putim-Ražice.

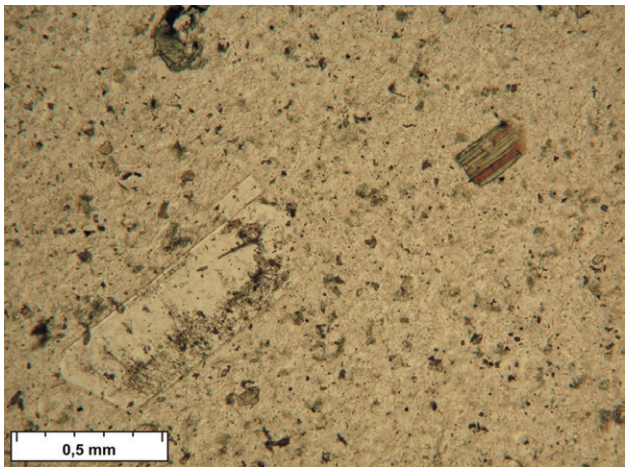


Photo 234. Artefact made of acid subvolcanite with phenocrysts of feldspar and biotite in thin section. Plane-polarized light.

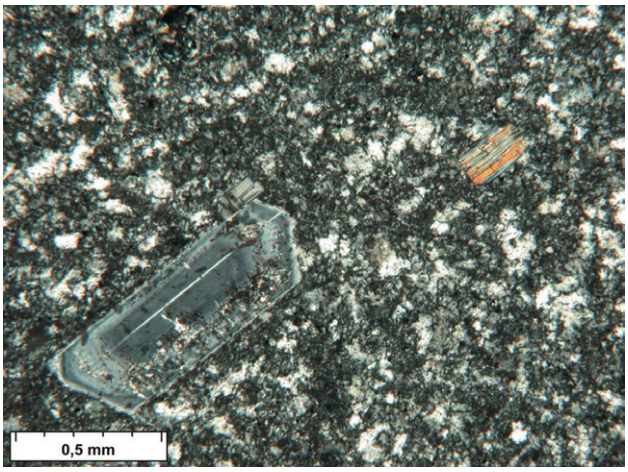


Photo 235. The same picture, crossed polars.

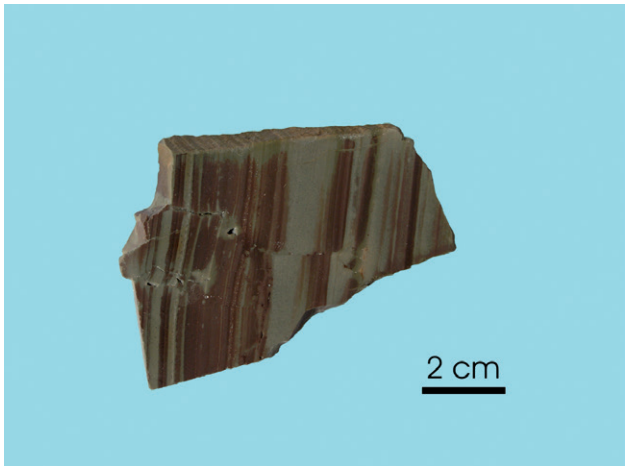


Photo 236. Silicified banded tuff from Gnandstein, Saxony.

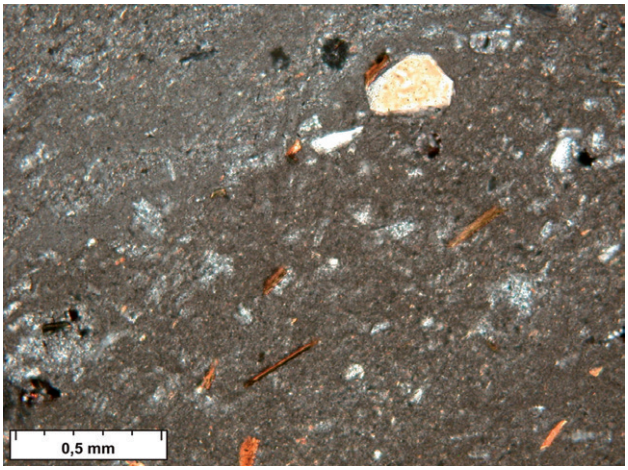


Photo 237. Silicified banded tuff from Gnandstein in thin section, crossed polars.

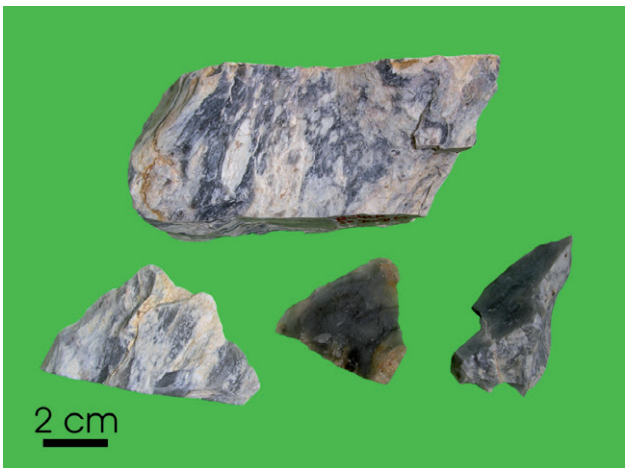


Photo 238. Felsitic metarhyolite ("kvarcporphyr") from the Bükk Mts., Hungary.

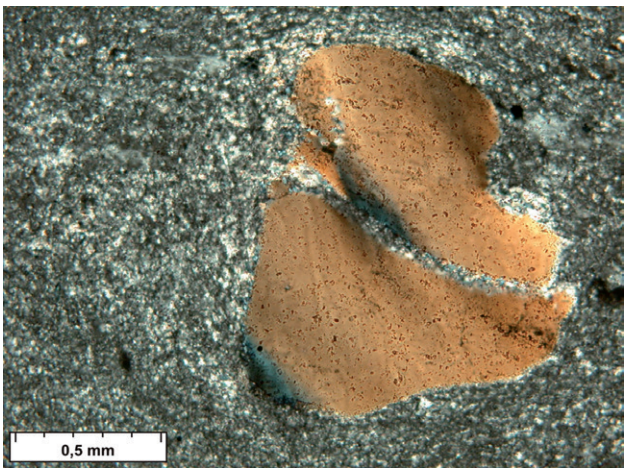


Photo 239. Felsitic metarhyolite from the Bükk Mts. in thin section, crossed polars.

Photo 240. Silicified woods of the Permian age from the Krkonoše Piedmont Basin.

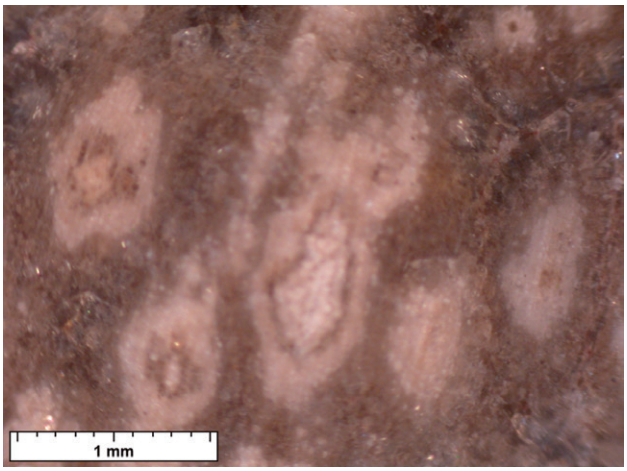


Photo 241. Silicified wood of the Permian age in water immersion under the stereomicroscope. Surroundings of Pecka (northern Bohemia).

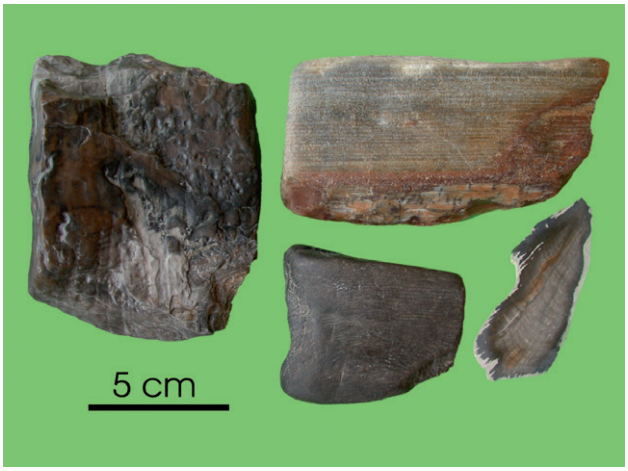


Photo 242. Silicified woods of the Tertiary age, Žabčice and Břeclav-Poštorná in southern Moravia.

Photo 243. Silicified woods from the Maleník Block. The upper specimen comes from the uppermost part of the quarry Podhůra at Hlinsko, the lower piece has been located only "the Hranice area" and it was probably a part of priest Přikryl's collection (samples provided by J. Pavelčík).

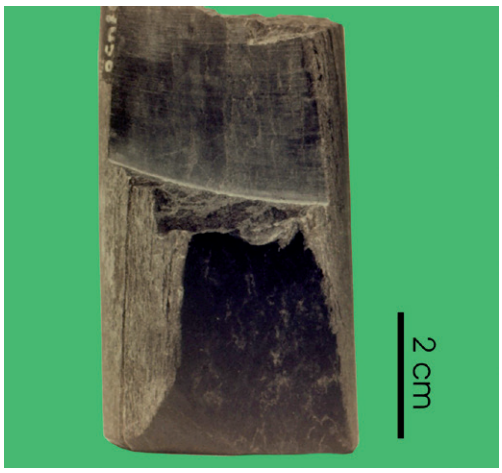


Photo 244. Difference in appearance of the patinated surface and polished section of a Neolithic shoe-last celt, Lengyel culture – Moravian Painted Ware, Těšetice near Znojmo.

Photo 245. Pebbles of thermally metamorphosed metabasites (together with big granite boulders) in the Kamenice River, Velké Hamry in the Jizerské hory Mts.

Photo 246. Elongated pieces of the thermally metamorphosed metabasite have suitable shapes for preparation of long shoe-last celts. Velké Hamry I.

Photo 247. Semifinished axes made of metabasite from the mining area Velké Hamry I (two marginal pieces), raw material from the Kamenice River (4 specimens in the centre).

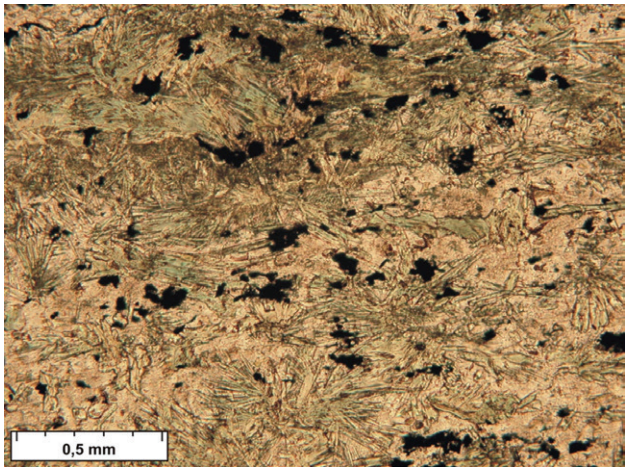


Photo 248. Metabasite of semifinished artefact in thin section, plane-polarized light. Velké Hamry I.

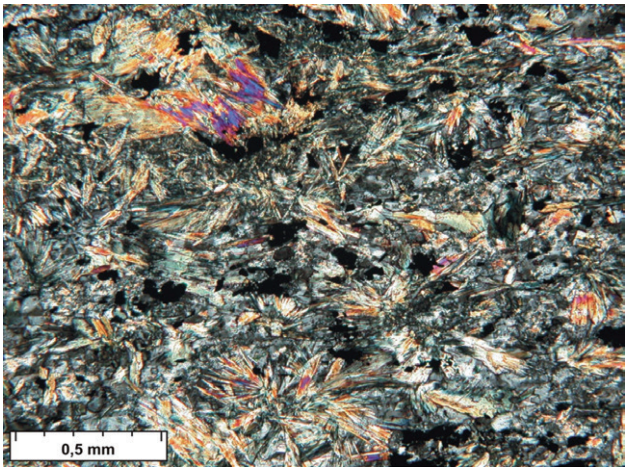


Photo 249. The same thin section, crossed polars.

Photo 250. Prehistoric mining field for thermally metamorphosed metabasite at Velké Hamry I., Jizerské hory Mts.

Photo 251. Raw material and semifinished artefacts from the prehistoric mining area at Jistebsko, Jizerské hory Mts.

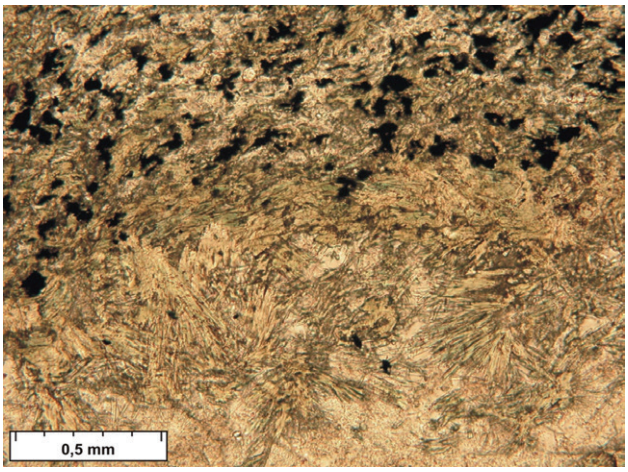


Photo 252. Metabasite from Jistebsko in thin section, plane-polarized light.

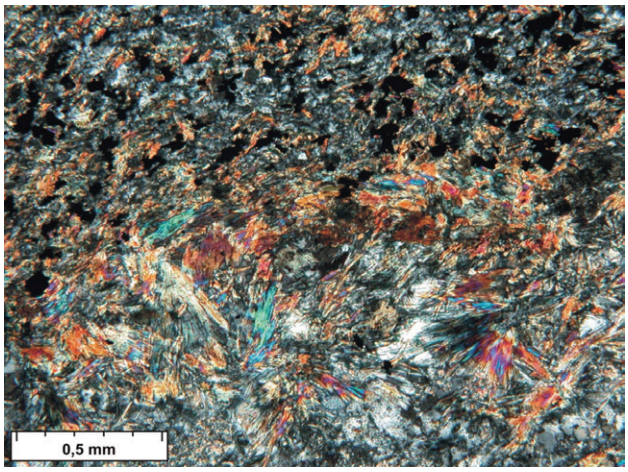


Photo 253. The same thin section, crossed polars.

Photo 254. Semifinished axes from a hoard found at the village of Lípa, district of Hradec Králové, eastern Bohemia. Metabasite of Jizerské hory. Deposited in the Museum of Hradec Králové.

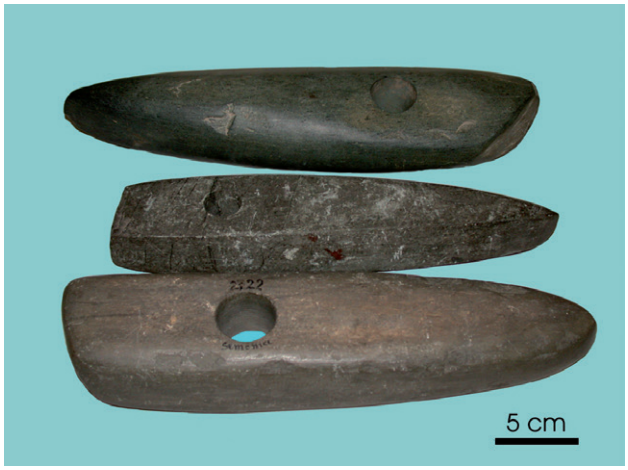


Photo 255. Big polished tools made of the Jizerské hory metabasite and found in eastern Bohemia. Finding places (from above): Hradec Králové-Bezhrad, Lípa (district of Hradec Králové), Senoradice (district of Náchod).

Photo 256. Semifinished tools from a Neolithic workshop at Hněvčeves, eastern Bohemia. Metabasite of Jizerské hory. Deposited in the Museum of Hradec Králové.

Photo 257. Shoe-last celts from the Linear Pottery settlement at Mohelnice, northern Moravia. Metabasite of Jizerské hory.

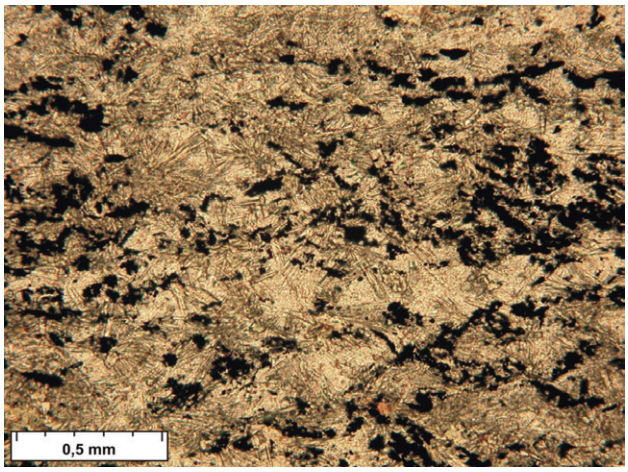


Photo 258. Shoe-last celt from Vedrovice in thin section, plane-polarized light. Linear Pottery culture.

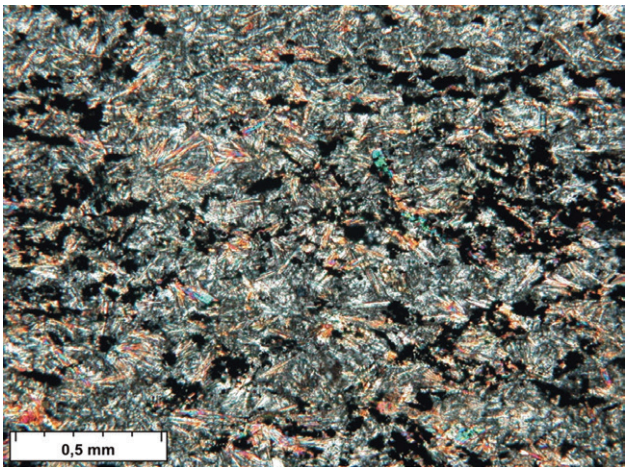


Photo 259. The same thin section, crossed polars.

Photo 260. The Želešice metabasite. Left piece – fresh metabasite from a quarry in the Bobrava River valley at Želešice; central piece – patinated metabasite from a field above the quarry; right piece – patinated metabasite from a garden east of the quarry.

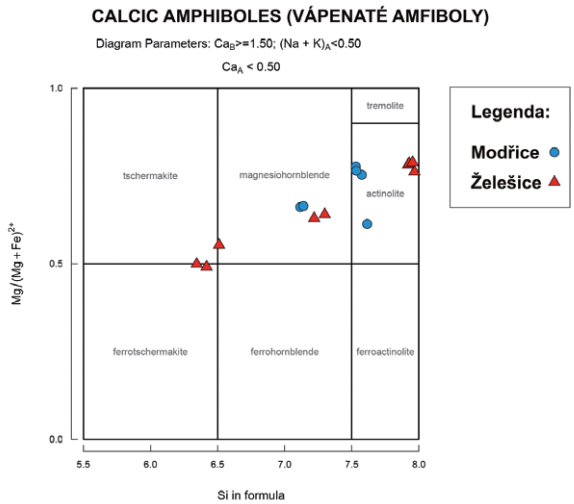


Photo 261. Microprobe analyses of amphiboles from the Želešice metabasite plotted in the diagram after Leake et al. (1997). Red triangles – samples from the quarry at Želešice; blue circles – boulder of the raw material found at Modřice-Sádky (i.e. about 3 km to the east of the source) in the feature No. 1542 of the Linear Pottery culture. Rescue excavation of M. Přichystal in 2004 at Modřice-Sádky.

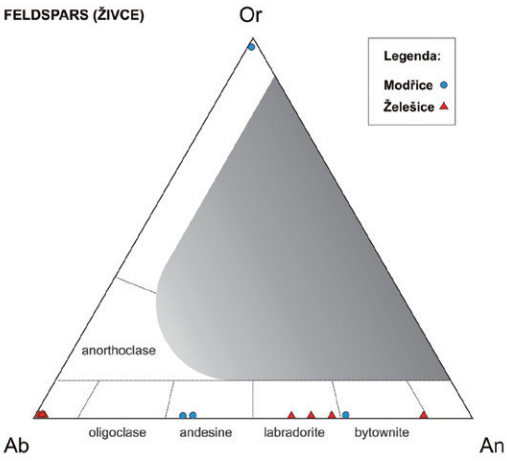


Photo 262. Microprobe analyses of feldspars from the Želešice metabasite plotted in the triangular diagramme Ab (albite) – An (anortite) – Or (ortoclase). Analysed the same samples as in the previous Photo 261.

Photo 263. Roughouts made of the Želešice metabasite and found at the workshop of the Moravian Painted Ware (Lengyel culture) at Brno-Holásky, 7 km to the east of the natural source.

Photo 264. A stele produced from the Želešice metabasite and originally erected at a grave of the Horákov culture at Modřice, south of Brno. Nowadays it is exhibited near the building of the Institute for Archaeological Heritage Preservation in Brno, Kaloudova street.

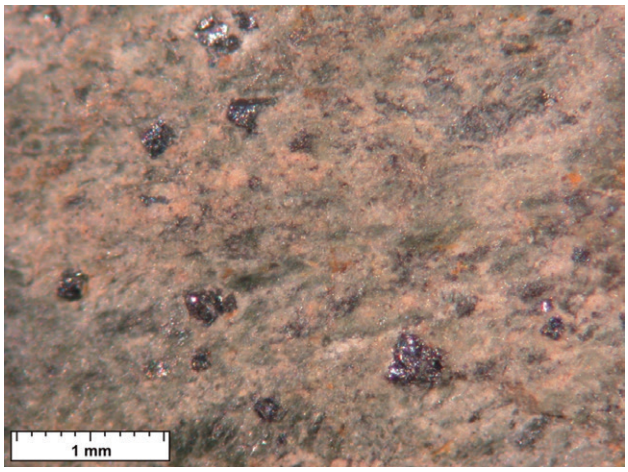


Photo 265. Euhedral crystals of magnetite in the Želešice metabasite under the stereomicroscope. A roughout from the settlement with the Moravian Painted Ware (Lengyel culture) in Brno-Bystrc.

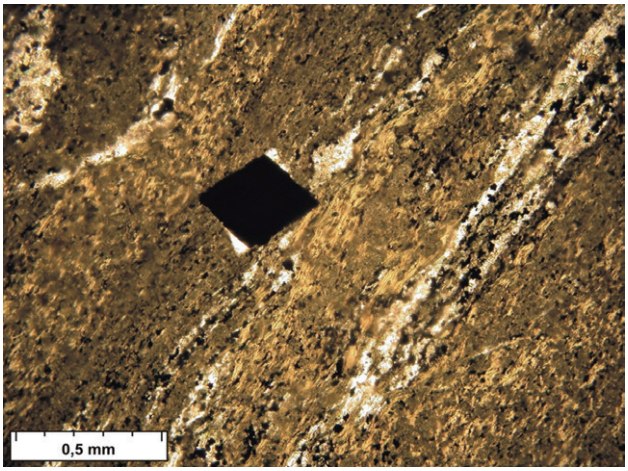


Photo 266. The Želešice metabasite in thin section, plane-polarized light.

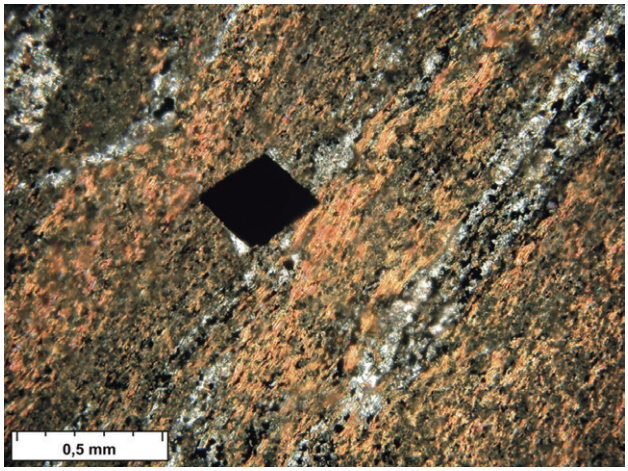


Photo 267. The same thin section, crossed polars.

Photo 268. Polished tools made of the Felsöcsatár greenschist, Hungary (specimens provided by the courtesy of G. Szakmány, Budapest).

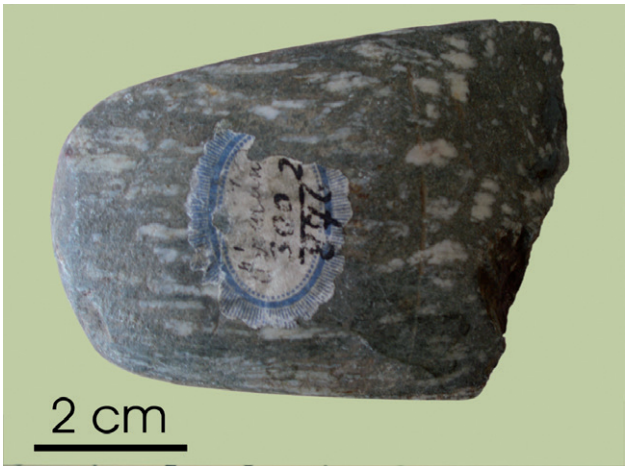


Photo 269. A detailed view on an axe made of the Felsöcsatár greenschist.

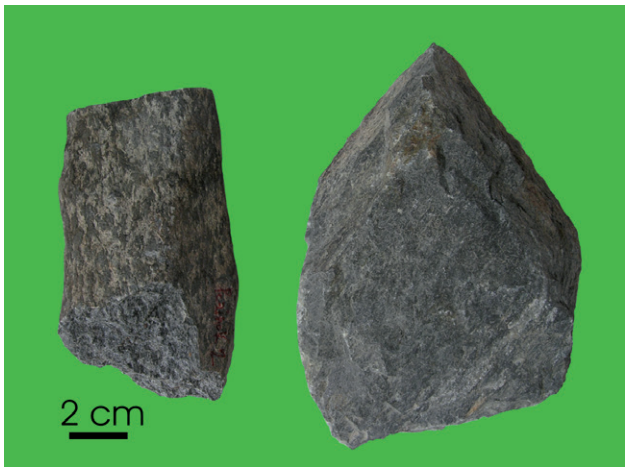


Photo 270. Metabasite of the Pezinok – Pernek Group, Malé Karpaty Mts., Slovakia.

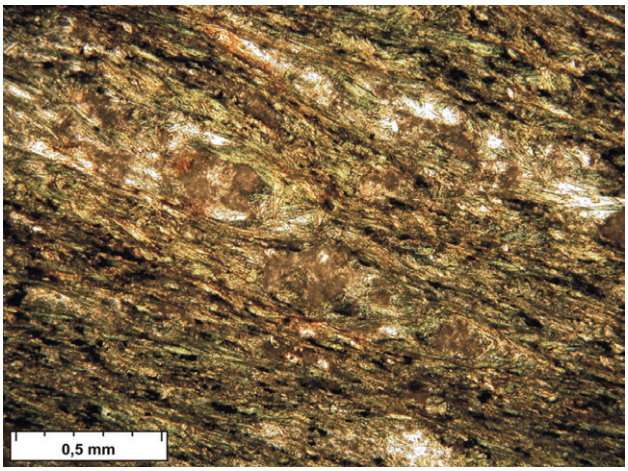


Photo 271. Metabasite from the Malé Karpaty Mts. in thin section, crossed polars.

Photo 272. Adapted amphibolite pebble, settlement of the Linear Pottery culture at Vedrovice, southern Moravia. Provenance from gravels of the Jihlava River.

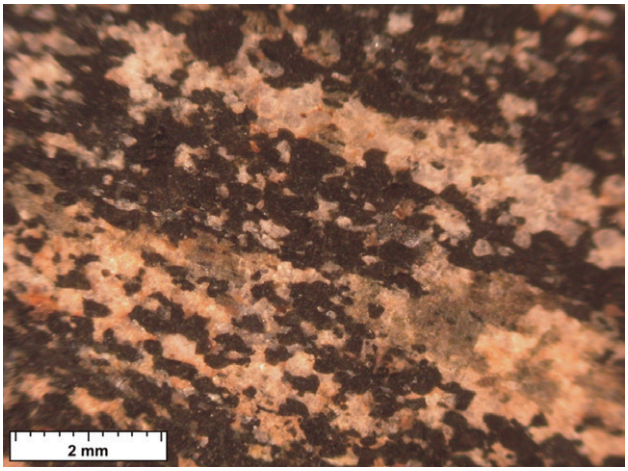


Photo 273. Amphibolite from the photo 272 in water immersion under the stereomicroscope.

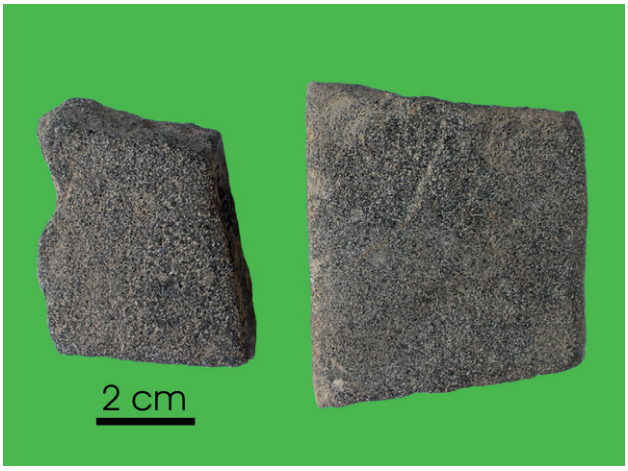


Photo 274. Fine-grained Moldanubian amphibolites from the surroundings of Horn, Lower Austria.

Photo 275. Amphibolite pebble from gravels of the Váh River, Pruské north of Dubnice nad Váhom, Slovakia.

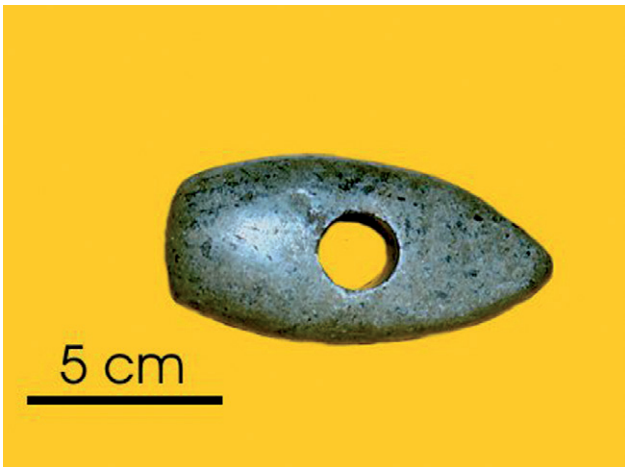


Photo 276. Patinated serpentinite battle-axe, Corded Ware culture, Slížany (district of Kroměříž), grave no. 7. Archaeological characterization of the axe-hammer can be found in the monograph of Šebela (1999, 144).

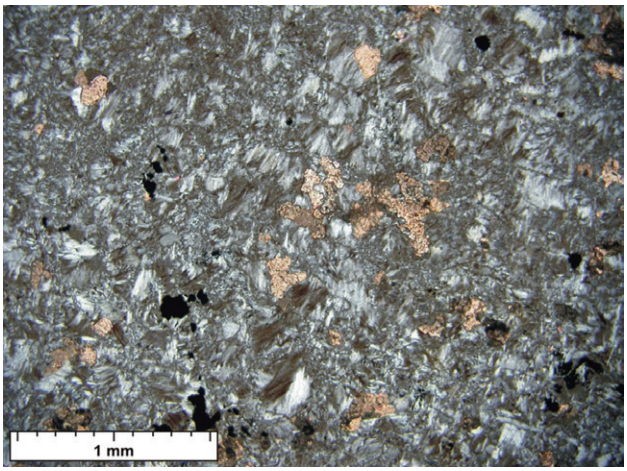


Photo 277. Serpentinite of battle-axe from Zdětín (district of Prostějov) in thin section, crossed polars. Corded Ware culture. Archaeological characterization of the axe-hammer can be found in the monograph of Šebela (1999, 172).

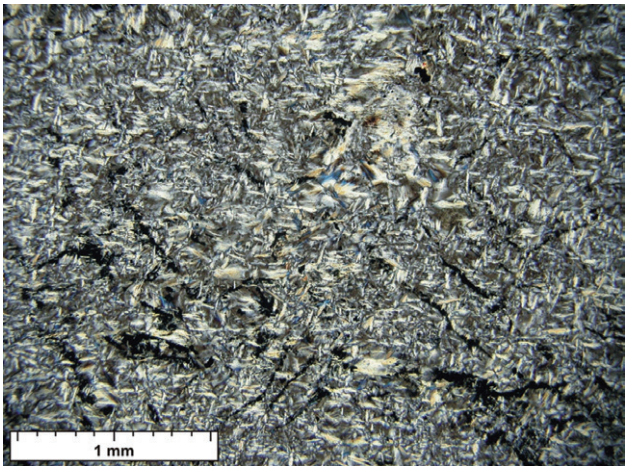


Photo 278. Serpentinite of battle-axe from Ježkovice (district of Vyškov) in thin section, crossed polars. Corded Ware culture. Archaeological characterization of the axe-hammer can be found in the monograph of Šebela (1999, 69).

Photo 279. Jańska Góra Hill, a mining site of serpentinite in prehistory. About 10 km east of the famous Ślęża Mt., Polish Silesia.

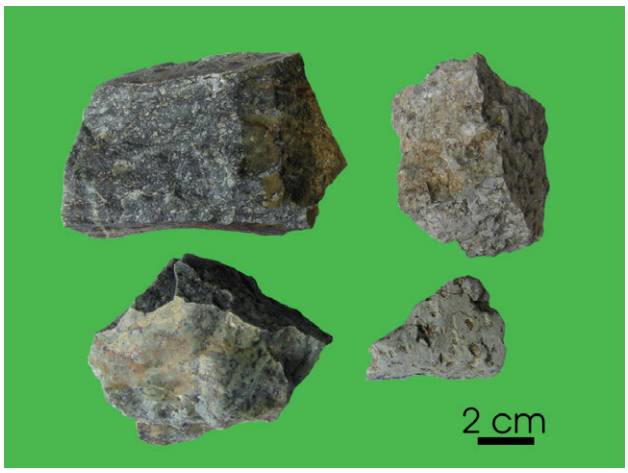


Photo 280. Varieties of serpentinite from the Jańska Góra Hill and from the surroundings of Jordanów in Polish Silesia.

Photo 281. Serpentinite exposure at the entry of active quarry 2 km north of Bernstein. Burgenland, Austria.

Photo 282. Prevalent serpentinite and so called "precious" serpentinite (upper right specimen) from Bernstein.

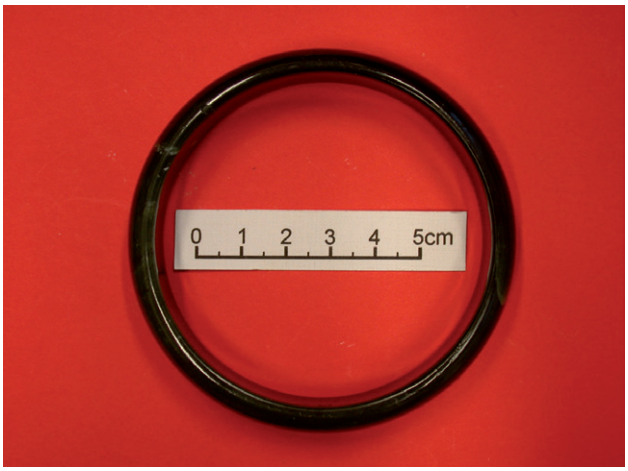


Photo 283. Modern bracelet made of "precious" serpentinite from Bernstein.

Photo 284. A view from the western margin of Genova (NW Italy) towards the Beigua massif, a source of jadeitite.

Photo 285. Pebbles of ultrabasic rocks released with jadeitite pebbles from Oligocene conglomerates at the municipality of Palo, Beigua massif, NW Italy.

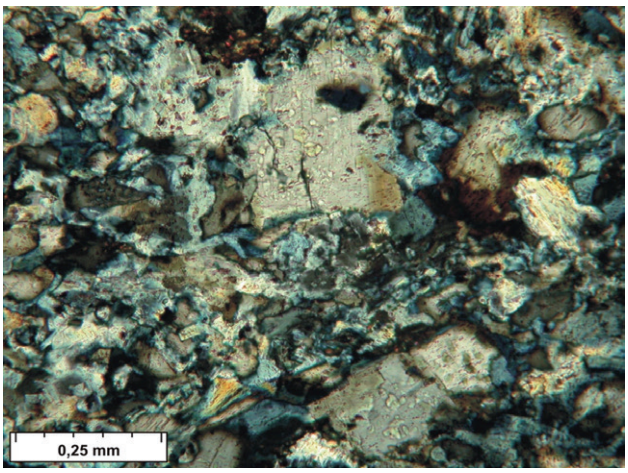


Photo 286. Jadeitite axe from Kamegg in Lower Austria in thin section, crossed polars. Lengyel culture – Moravian-Austrian group, Stage Ia Ia-b.

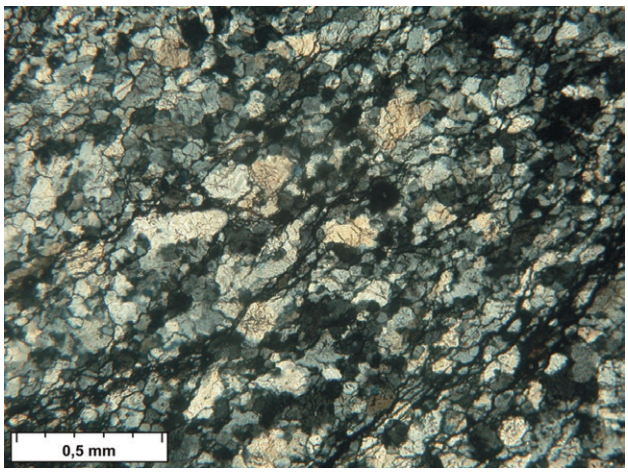


Photo 287. Jadeitite axe from Brno-Žebětín in thin section, crossed polars. Lengyel culture – Moravian Painted Ware, Stage Ib.

Photo 288. Abandoned quarry for nephrite at Jordanów in Polish Silesia.

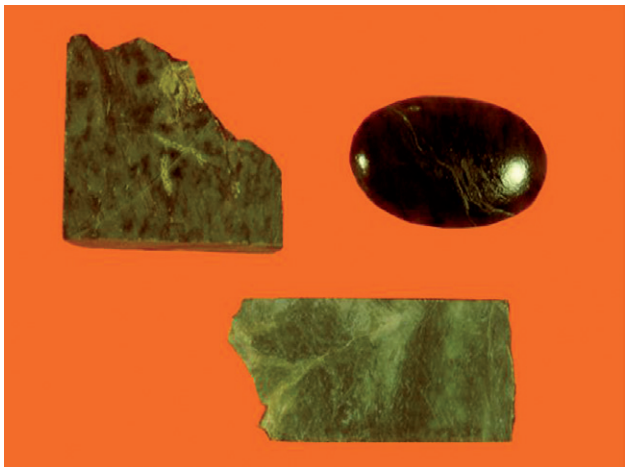


Photo 289. Varieties of nephrite from Jordanów.

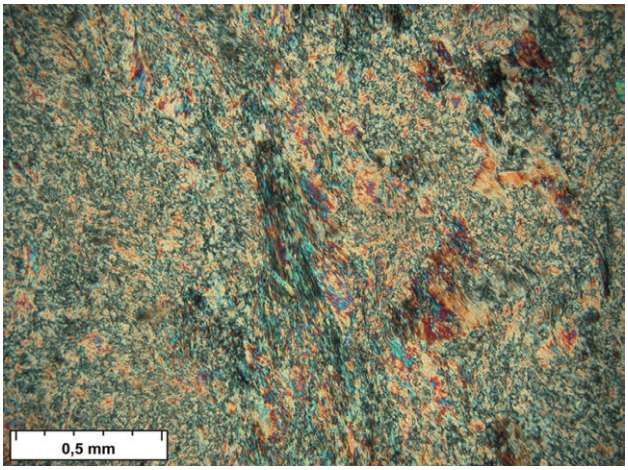


Photo 290. Nephrite from Jordanów in thin section, crossed polars.

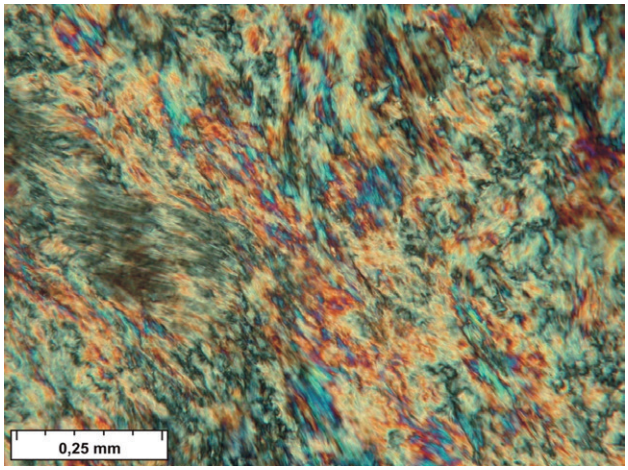


Photo 291. Nephrite from Jordanów in thin section, crossed polars, at high magnification.

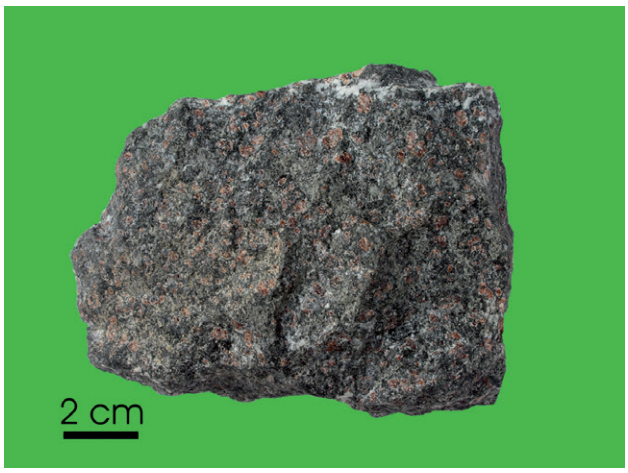


Photo 292. Moldanubian eclogite, Kostníky-Police, western Moravia.

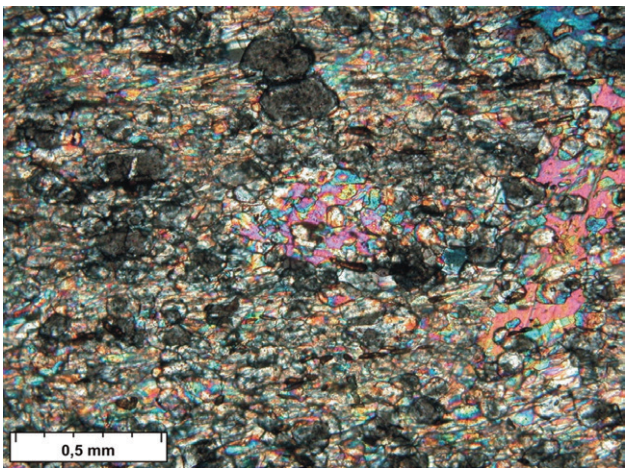


Photo 293. Eclogite axe from Plaveč near Znojmo in thin section, crossed polars. Lengyel culture – Moravian Painted Ware.

Photo 294. Marble from the Bílý kámen Hill near Sázava (right specimen). Alpian marble from Viruna in Kärnten (Austria) for comparison (left specimen)

Photo 295. Moldanubian marble, Zblovice, western Moravia.

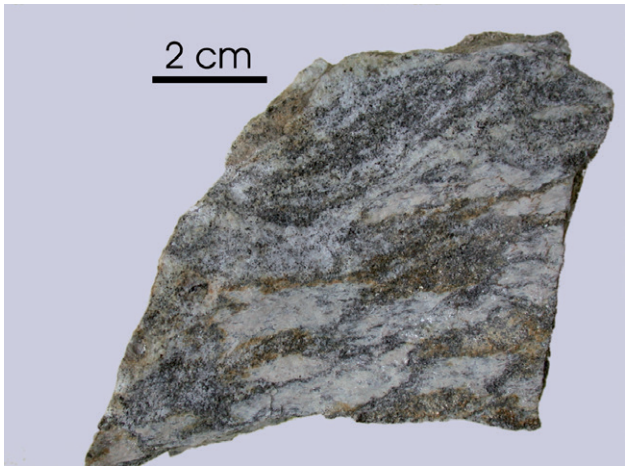


Photo 296. Moldanubian biotite-sillimanite gneiss, Dívčí kámen, southern Bohemia.

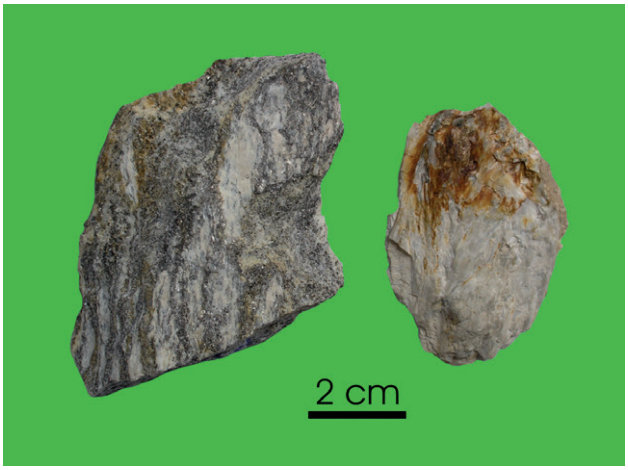


Photo 297. Moldanubian biotite-sillimanite gneiss, Dívčí kámen, and a quartz-sillimanite lense from gneiss at Kněžice near Brtnice, western Moravia.

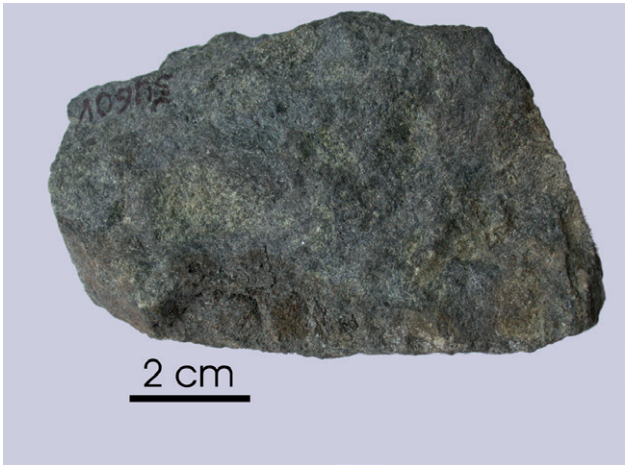


Photo 298. Blueschist, Meliata Group, Šugov in SE Slovakia.

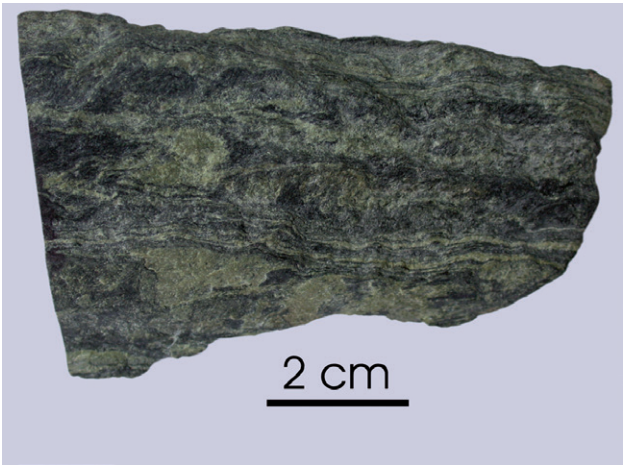


Photo 299. Blueschist, Rýchory Crystalline Unit, Sněžný Stream, northern Bohemia.

Photo 300. Conical waste after shafthole perforation in axe hammers made of amphibole diorite. Lengyel culture – Moravian Painted Ware, Brno-Žebětín.

Photo 301. Stone flakes after preparation of roughouts in amphibole diorite. A workshop pit of the Lengyel culture – Moravian Painted Ware in Brno-Bystrc.

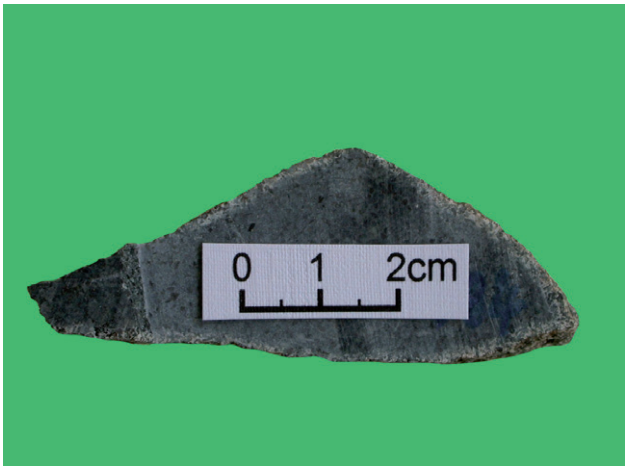


Photo 302. Cross section of a diorite flake with a few mm thick patina. Lengyel culture – Moravian Painted Ware, Brno-Žebětín.

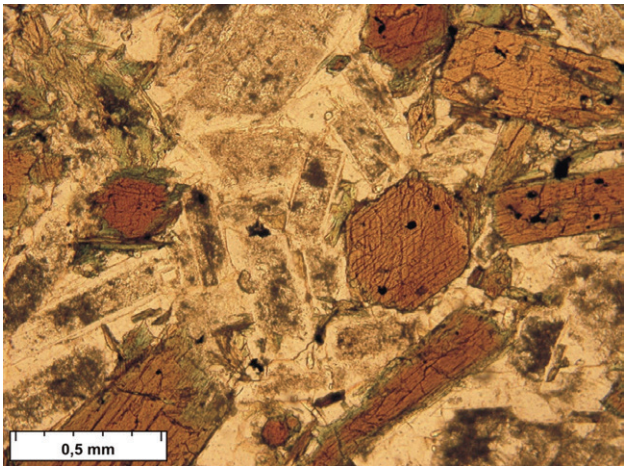


Photo 303. Amphibole diorite in thin section, plane-polarized light. Brno-Starý Lískovec.

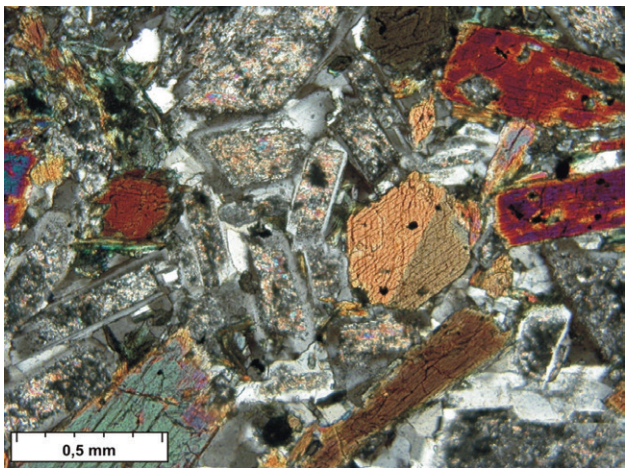


Photo 304. The same thin section as in the photo 303, crossed polars.

Photo 305. Part of an axe made of porphyritic microdiorite. Lengyel culture – Moravian Painted Ware, Brno-Žebětín.

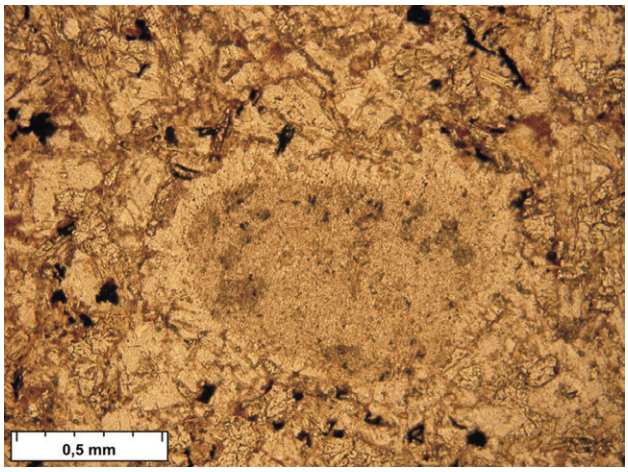


Photo 306. Porphyritic microdiorite in thin section, plane-polarized light. Lengyel culture – Moravian Painted Ware. Lesůňky near Jaroměřice nad Rokytnou, western Moravia.

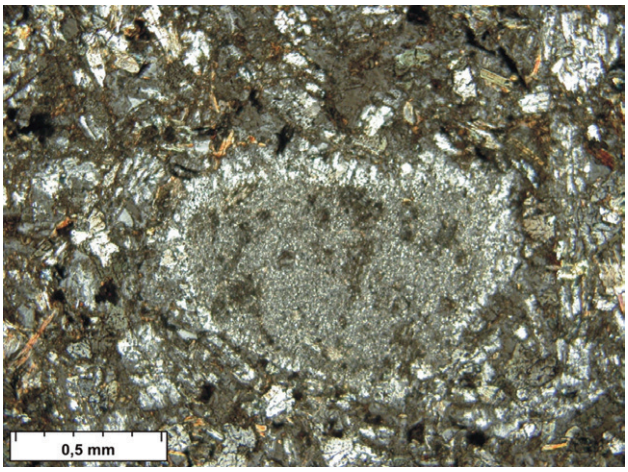


Photo 307. The same thin section, crossed polars.

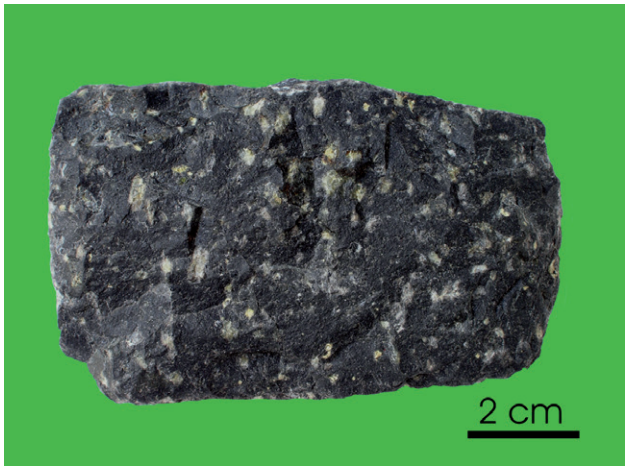


Photo 308. Andesite, natural source at Levice, central Slovakia.

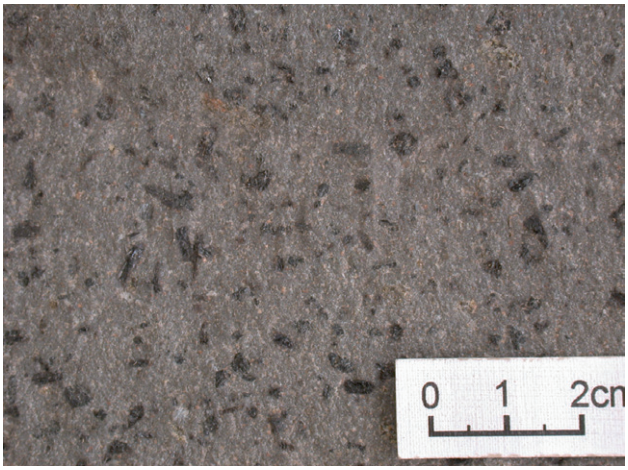


Photo 309. Trachyandesite, natural source at Nezdenice, Uherský Brod area, SE Moravia.

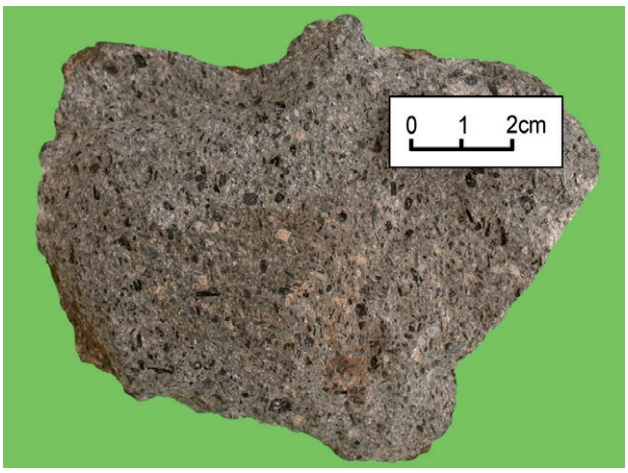


Photo 310. Andesite, natural source on the Vżar Mt., Pieniny Mts., southern Poland.

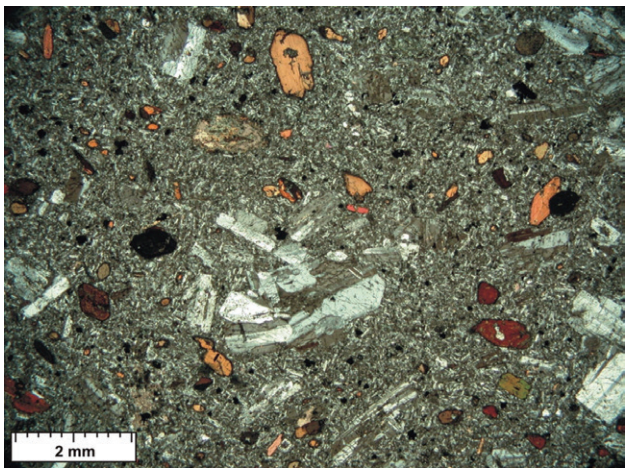


Photo 311. Trachyandesite in thin section, crossed polars. Natural source on the Bučník Hill, Uherský Brod area, SE Moravia.

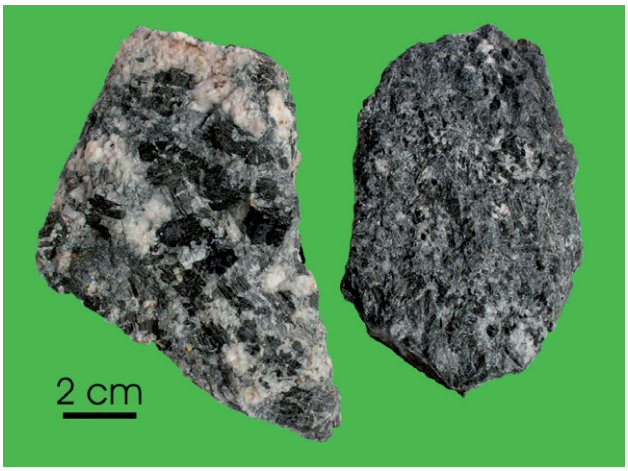


Photo 312. Metagabbro, natural source on the Ślęża Mt., Polish Silesia.

Photo 313. Gabbro, natural source in the Moldanubicum. Between the villages of Wultschau and Reinprechts, west of Weitra, Lower Austria.

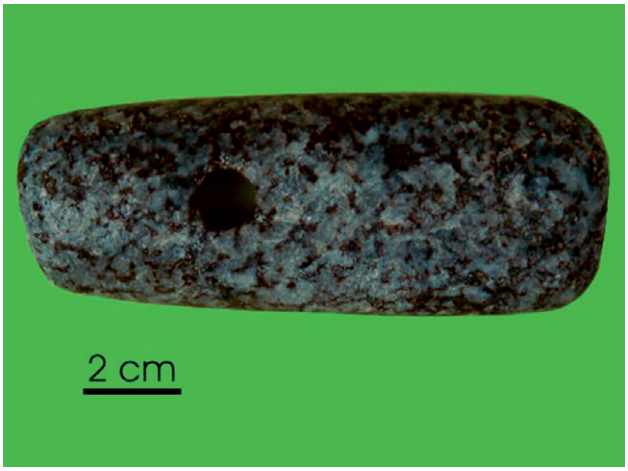


Photo 314. Stone hoe made of gabbro, burial ground of the Linear Pottery culture, grave 2/85, Vedrovice-Za dvorem, southern Moravia.

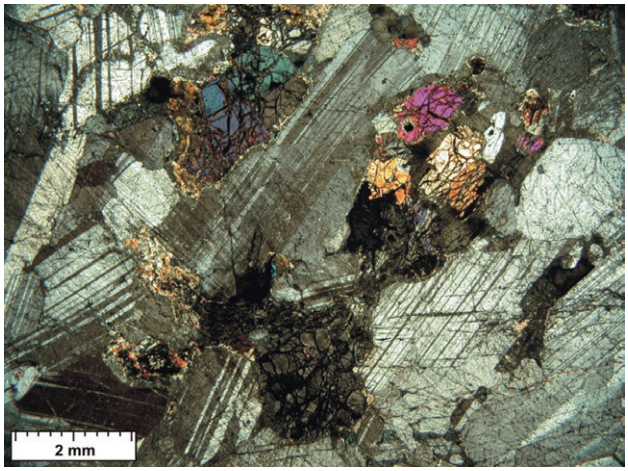


Photo 315. Gabbro hoe from Vedrovice in thin section, crossed polars.

Photo 316. Shoe-last celt made of olivine basalt, Lengyel culture – Moravian Painted Ware, No. L 6314, Těšetice near Znojmo, southern Moravia.

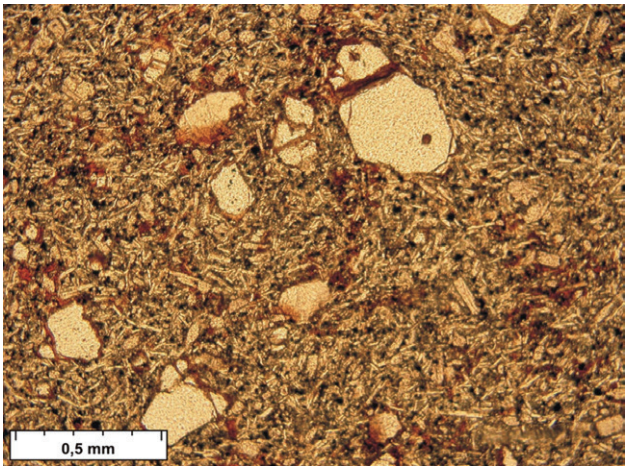


Photo 317. Olivine basalt in thin section, plane-polarized light. Battleaxe of the Corded Ware culture, No. 006589 from the Prostějov museum, central Moravia.

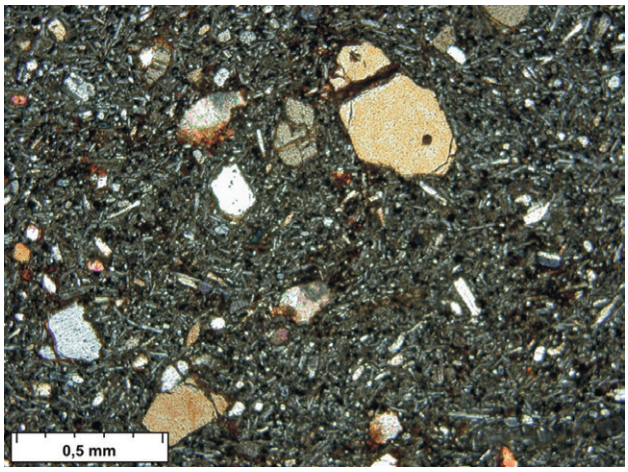


Photo 318. The same thin section, crossed polars.

Photo 319. Mallet prepared from olivine basalt. Found by the author in the mining area for the Jizerské hory metabasite, Velké Hamry I.

Photo 320. Conspicuous difference between fresh rock (black) and patinated surface of basaltic rock. Natural outcrop on the Štemplovecká hůrka Hill west of Opava, Czech Silesia.

Photo 321. Exposure of dolerite basalt with columnar jointing at Starý Hrozenkov, Uherský Brod area, SE Moravia.

Photo 322. Pebble of Permian basaltic andesite (melaphyre), gravels of the Váh River, Pruské north of Dubnica nad Váhom, western Slovakia.

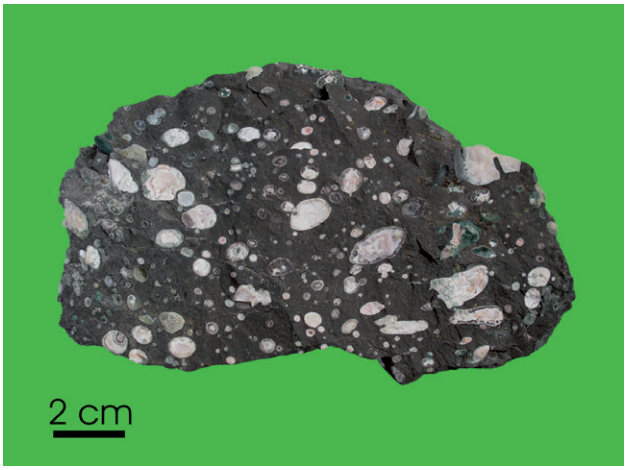


Photo 323. Permian basaltic andesite (melaphyre), active quarry at Frýdštejn, northern Bohemia.

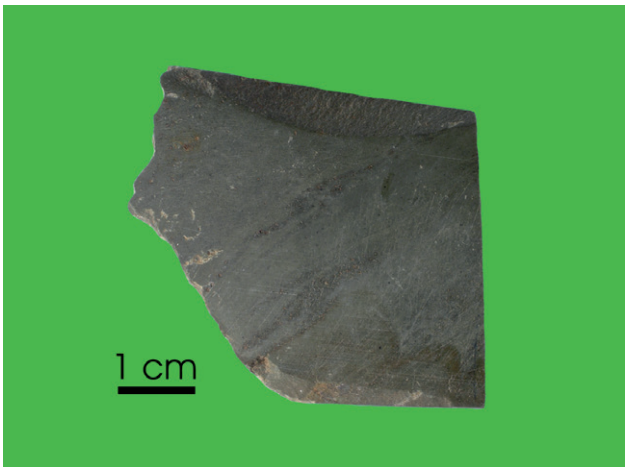


Photo 324. Part of an axe made of spilite crystal tuff, Řivnáč culture. Hostivice-Palouky, west of Prague (the sample provided by J. Zavřel from Prague).

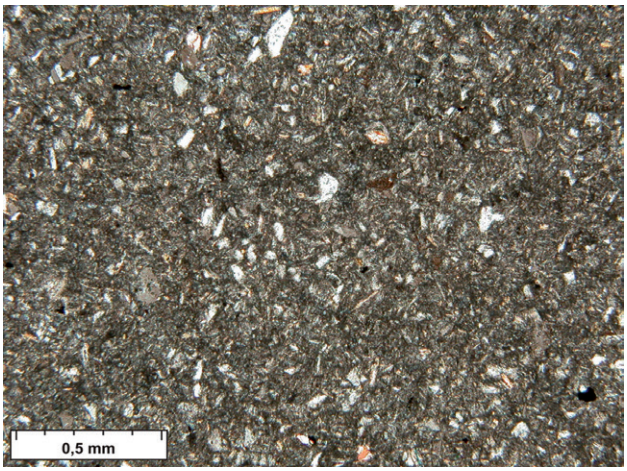


Photo 325. Spilite crystal tuff of the artefact from Hostivice-Palouky in thin section, crossed polars.

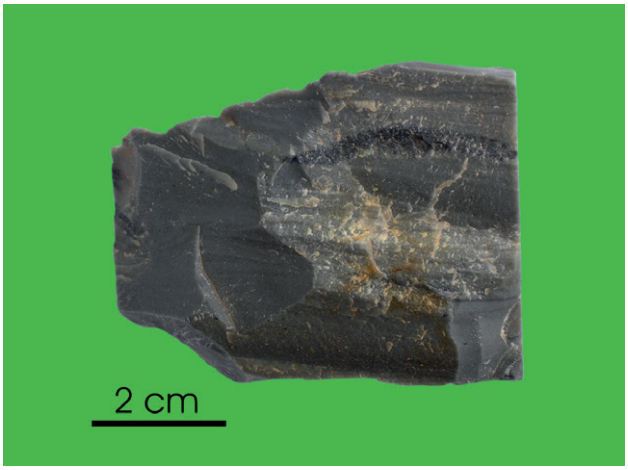


Photo 326. Tuffaceous siltstone from the potential mining place at Vrané nad Vltavou, south of Prague (the sample provided by J. Zavřel from Prague).

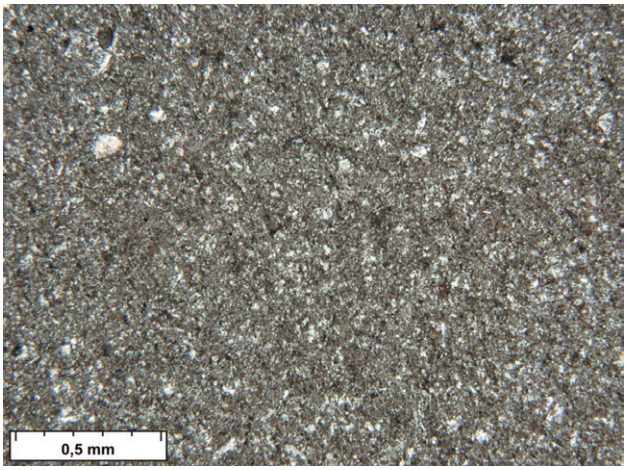


Photo 327. Tuffaceous siltstone from Vrané nad Vltavou in thin section, crossed polars.

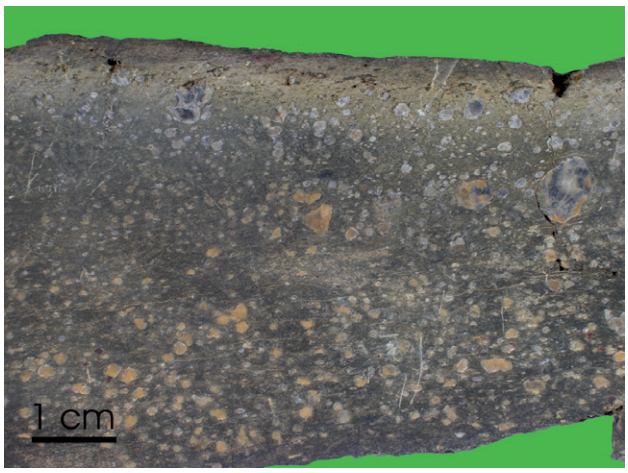
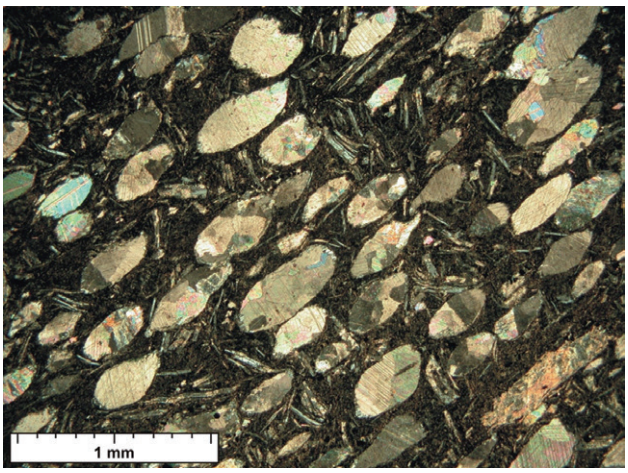


Photo 328. Amygdaloidal spilite (a part of lava pillow) of the Devonian age, exposure at Šternberk, district of Olomouc.



Phot 329. Amygdaloidal spilite in thin section, crossed polars. Abandoned quarry at Moravský Beroun, northern Moravia.

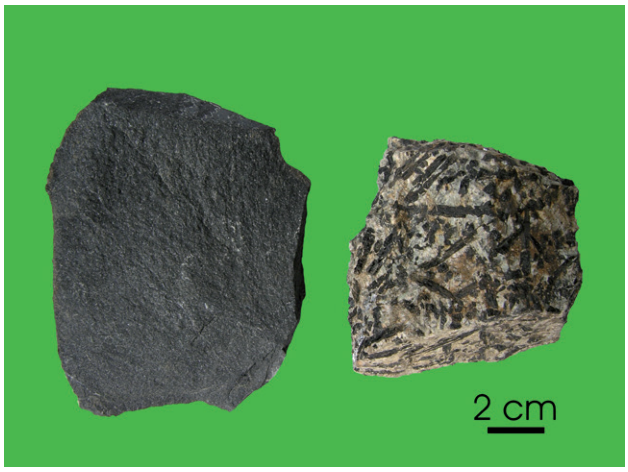


Photo 330. Picrite (left specimen) from the Petřkovická hora Hill 8 km SE of Nový Jičín and teschenite (right specimen) from the Čerťák water reservoir, 3.5 km south of Nový Jičín, northern Moravia.

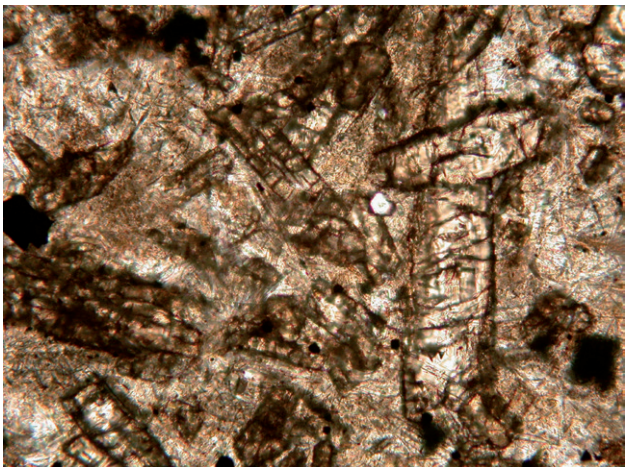


Photo 331. Thin section of teschenite battleaxe, plane-polarized light. Funnel Beaker culture, Vávrovice near Opava, Czech Silesia (archaeological excavation by P. Stabrava).

Photo 332. Axe hammer made of Culmian siltstone. Funnel Beaker culture, Holasovice near Opava, Czech Silesia (for more details see Janák & Přichystal 2007).

Photo 333. Part of an axe hammer made of Culmian siltstone from Opava-Palhanec, Czech Silesia. Probably the Funnel Beaker culture (for more details see Janák & Přichystal 2008).

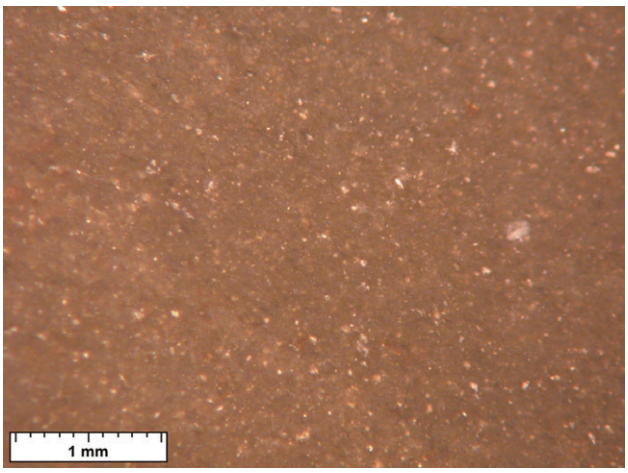


Photo 334. Culmian siltstone of the axe hammer fragment from Opava-Palhanec in water immersion under the stereomicroscope.

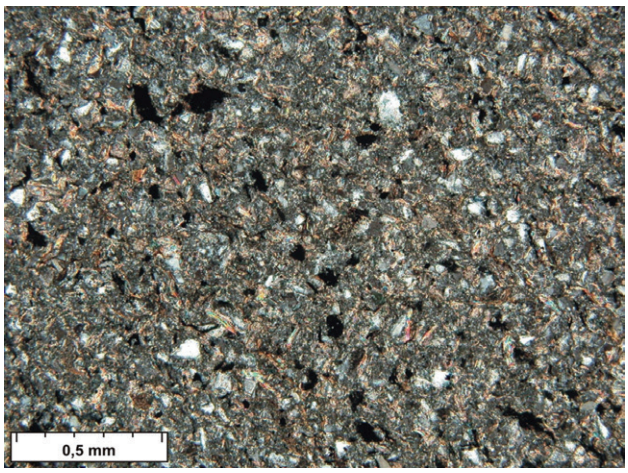


Photo 335. Culmian siltstone of the axe hammer fragment from Opava-Palhanec in thin section, crossed polars.

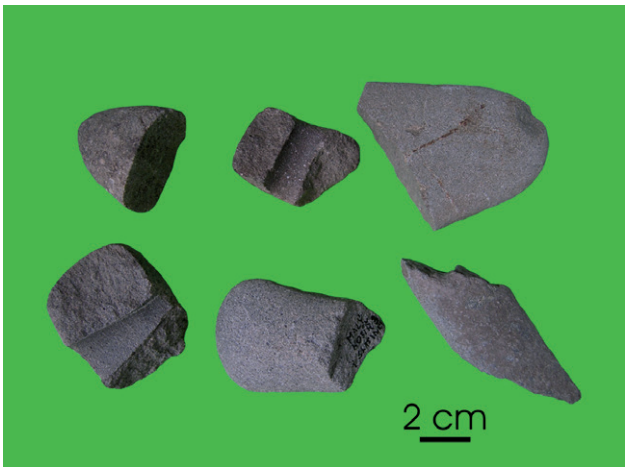


Photo 336. Polished tools made of Culmian greywackes. Eastern slope of the Velký Kosíř Hill near Prostějov, central Moravia.

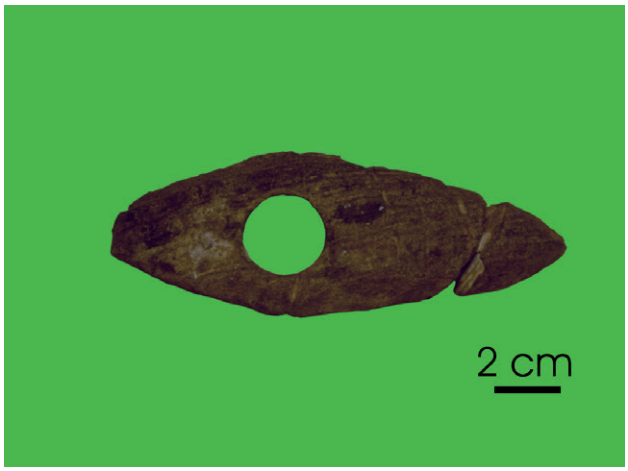


Photo 337. Battleaxe made of flysch sandstone with a weathered out calcite veinlet. Corded Ware culture, Kyjov-Netčice II, grave I, southern Moravia.

Photo 338. Stone mining tools from Špania Dolina-Piesky, a prehistoric exploitation site of copper ores north of Banská Bystrica, central Slovakia. The tools are prevalently made of imported rocks, especially andesites, rarely a big pebble of quartzite (lower left specimen), partly of local Permian sandstones.

Photo 339. Březina shale from archaeological features found at Mokrá-Horákov, east of Brno. Lengyel culture – Moravian Painted Ware.

Photo 340. Oolithic limestone of the Jurassic age from the Stránská skála Hill in Brno.

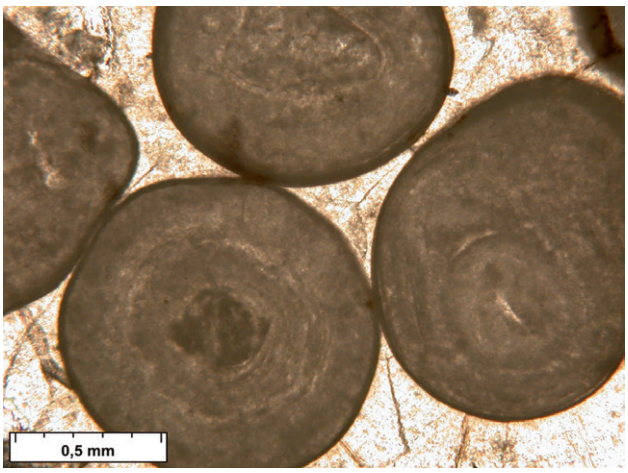


Photo 341. Oolithic limestone from the Stránská skála Hill in thin section, plane-polarized light.

Photo 342. Wristguards of the Bell Beaker culture in Moravia. They are made of fine-grained sedimentary rocks.

Photo 343. Whetstones prepared from Culmian siltstones and shales. The Velký Kosíř Hill near Prostějov, central Moravia.

Photo 344. Neolithic whetstone (left specimen) made of fine-grained Permian arcose from the Boskovice Furrow, Lengyel culture – Moravian Painted Ware, Brno-Žebětín. Medieval whetstone (right specimen), Permian siltstone from the Boskovice Furrow, Ketkovice-Panorama.

Photo 345. Whetstone made of the Cretaceous sandstone, Late Roman Period, Kostelec na Hané, central Moravia. Photo by D. Vachůtová.

Photo 346. Traces after grinding(?) of stone tools on a boulder of thermally metamorphosed phyllite. Velké Hamry I, Jizerské hory Mts., prehistoric mines for the Jizerské hory metabasite.

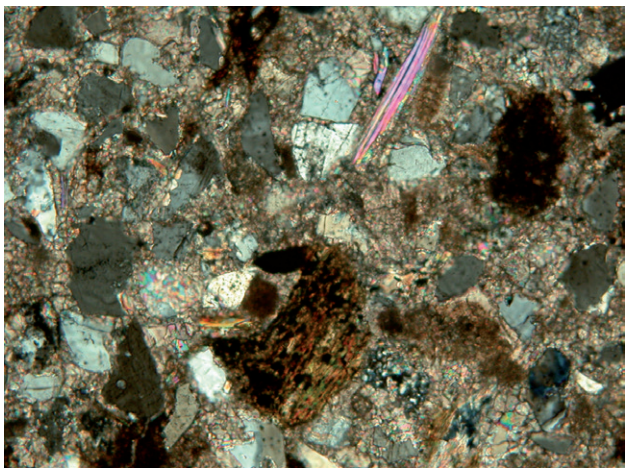


Photo 347. Thin section of sandstone with calcite matrix, whetstone No. 7681/88 from early medieval settlement at Pavlov, southern Moravia (cooperation with D. Jelínková).

Photo 348. Rotary quern made of garnet mica schist, Roman Period, Kelčice, southern Moravia (cooperation with T. Zeman).

Photo 349. Part of mica schist rotary quern, early medieval centre Pohansko near Břeclav, southern Moravia.

Photo 350. Traces after quarrying of rotary querns on a mica schist outcrop, Altenhof near Gars am Kamp, Lower Austria.

Photo 351. Roughout of a millstone on a mica schist outcrop, Altenhof near Gars am Kamp, Lower Austria.

Photo 352. Tourmaline mica schist from Altenhof near Gars am Kamp, Lower Austria.

Photo 353. Tourmaline mica schist from Čučice near Oslavany, SW Moravia.

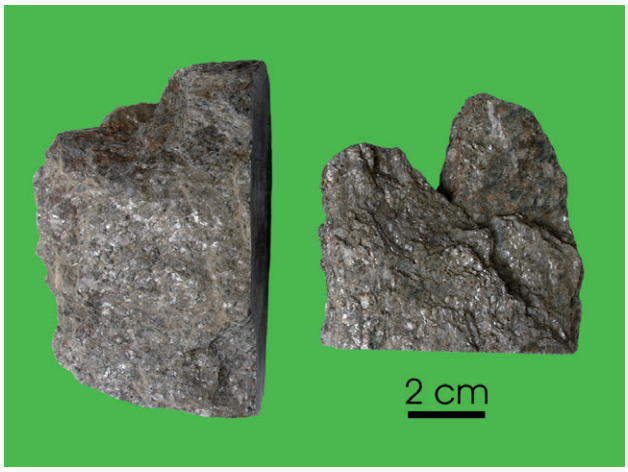


Photo 354. Part of a mica schist rotary quern from the hillfort Chotěbuz-Podobora near Český Těšín, Czech Silesia. Early Middle Ages (cooperation with P. Kouřil).

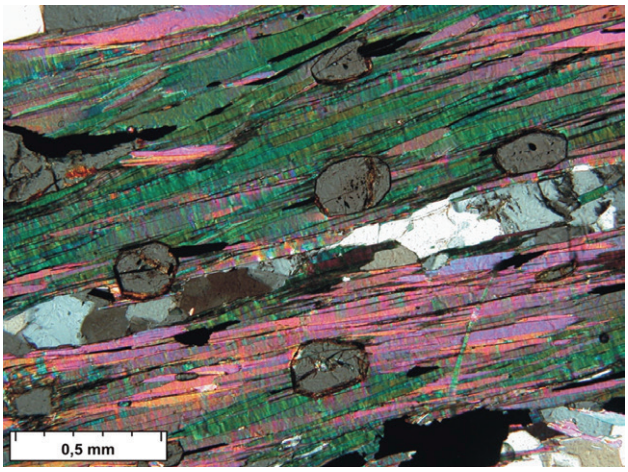


Photo 355. Garnet mica schist used for a rotary quern in thin section. Early medieval settlement at Pavlov, southern Moravia (cooperation with D. Jelínková).

Photo 356. Neolithic saddle querns made of Culmian conglomerate and greywacke, Velký Kosíř Hill near Prostějov, central Moravia.

Photo 357. Eneolithic saddle quern made of Culmian conglomerate to greywacke, view on the lower and upper side. Funnel Beaker culture, Stránská skála Hill in Brno.

Photo 358. Eneolithic saddle quern made of fine-grained Culmian conglomerate. Václavský vrch Hill in Olomouc (cooperation with R. Zatloukal).

Photo 359. Detailed view on the conglomerate saddle quern from Olomouc.

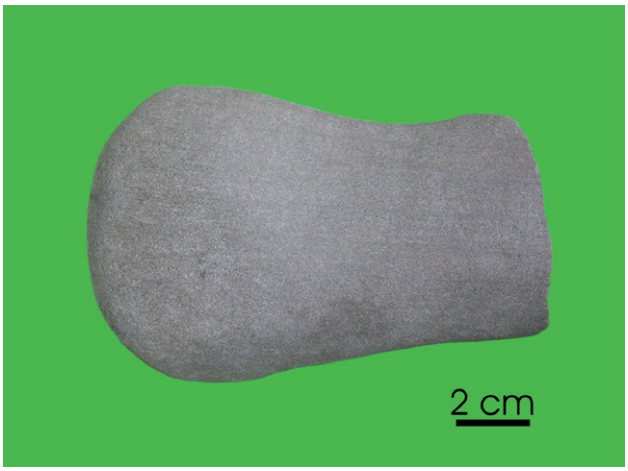


Photo 360. Sandstone pebble used as a crusher of human bones after cremation. Grave of the Lusatian phase of the Urnfield culture, Třebčín near Olomouc, central Moravia.

Photo 361. A part of granite millstone on the Ślęża Mt. foothill, Polish Silesia.

Photo 362. Variscan biotite granite from the Ślęża Mt., Polish Silesia.

Photo 363. Granite statue "Monch", nowadays situated at the western margin of Sobótka town.

Photo 364. Part of rhyolite rotary quern from Pohansko near Břeclav, Early Middle Ages (cooperation with J. Macháček).

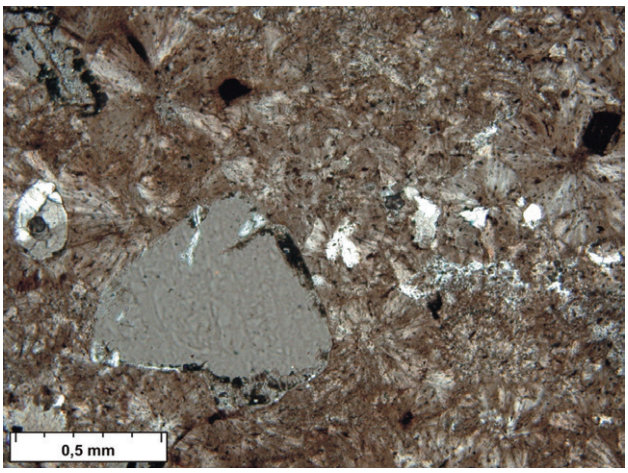


Photo 365. Rhyolite of rotary quern in thin section. Roman Period, Zlechov near Uherské Hradiště, southern Moravia (cooperation with T. Zeman).

Photo 366. Exposure of the Permian rhyolite ignimbrite in a quarry of the Kubo company near Malé Žernoseky, NW Bohemia.

Photo 367. Permian rhyolite ignimbrite from the quarry near Malé Žernoseky.

Photo 368. "Stone sea" of Miocene rhyolite, Vyhne near Banská Štiavnica, central Slovakia.

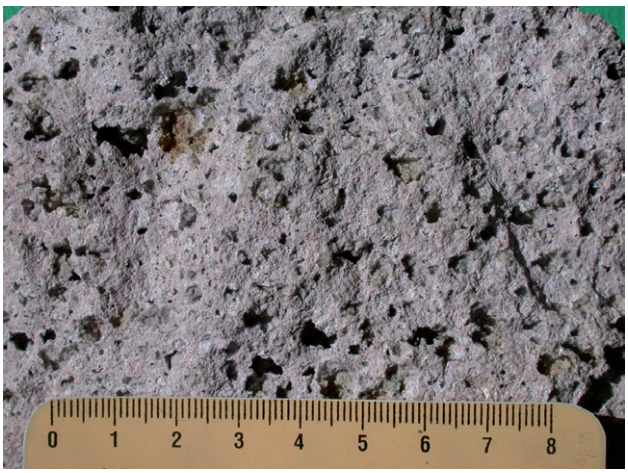


Photo 369. A detailed view on the Miocene rhyolite from Vyhne, central Slovakia.

Photo 370. Medieval rhyolite millstone from Hliník nad Hronom, central Slovakia.

Photo 371. Trachybasalt (tephritic fonolite) from the Kunětická hora Hill near Pardubice.

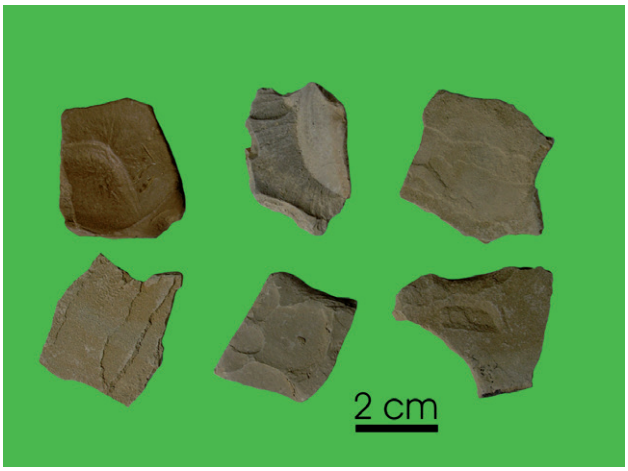


Photo 372. Silty shale from Uherské Hradiště-Sady.

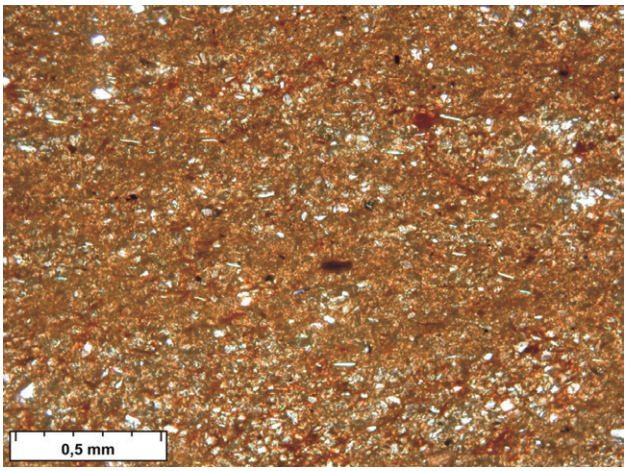


Photo 373. Silty shale from Uherské Hradiště-Sady in thin section, crossed polars.

Photo 374. Talc schist from Prachatice, western Bohemia.

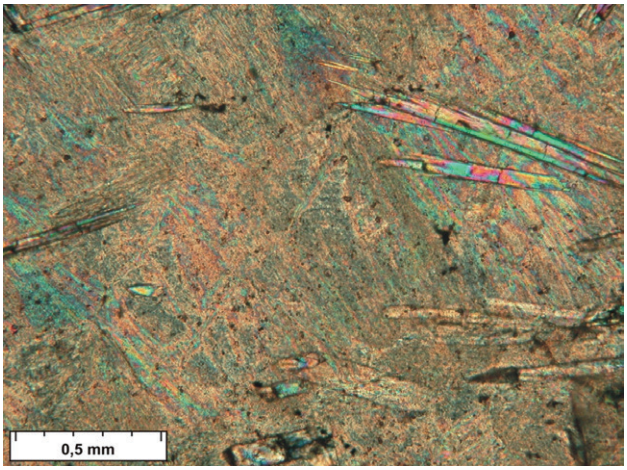


Photo 375. Talc schist from Prachatice in thin section, crossed polars.

Photo 376. Museum in Hallstatt (Austria) with the exposition on prehistoric mining of salt. Waterfall of the Mühlbach stream running from Salzberg in the background.

Photo 377. View on the Hallstatt Lake from the upper station of funicular at the eastern margin of the Salzberg valley.

Photo 378. Wooden holders of metal mining tools found in the Hallstatt prehistoric salt mines. Museum in Hallstatt.

Photo 379. Salt in the Hallstatt mines has a conspicuous red or black colour due to content of iron oxides or organic matter.

Photo 380. Pseudoartefacts formed by the Krumlovský les chert are very similar to prehistoric chipped tools. Lower Badenian gravels in Brno-Líšeň, Jedovnická street.

Photo 381. Pseudoartefact of the Krumlovský les chert lying in situ in a gravel layer. Exposure in Ottnangian sediments, eastern margin of the Vedrovice village, Krumlovský les area.

Photo 382. Natural chips of quartzites (so called sluňák type) on the rich localities offer also pieces having appearance of human or animal heads. Žerotice west of Plumlov, Drahany Highland, central Moravia.

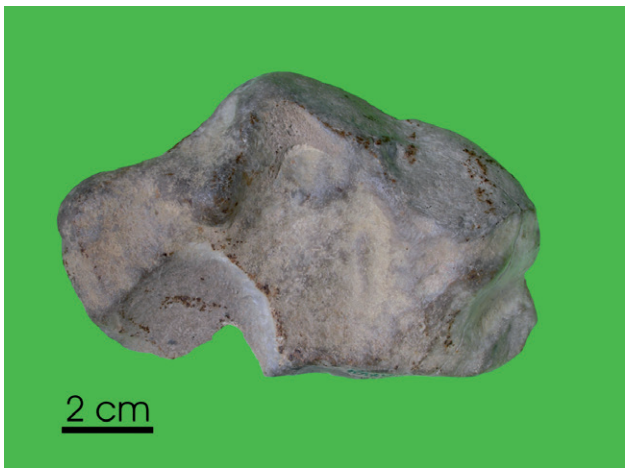


Photo 383. Natural chert fragment resembling a sculpture of mammoth. Němčičky near Dolní Kounice, southern Moravia.

Photo 384. Limestone pebble bored by a mollusc resembling battleaxe (Rab Island, Chroatia) and a limestone fragment naturally shaped as an axe from the Hády Hill in Brno (upper specimen).

Photo 385. Devonian limestone from the Hranice cement works (central Moravia) bored by Miocene molluscs.

Photo 386. Naturally bored pebbles of Triassic limestone from the southern margin of the Tiesňavy valley in the Malá Fatra Mts. in Slovakia (big grey specimens), from the seashore on the Crete Island (small white pebbles) and from the Poneloya beach, Pacific seashore in Nicaragua (brownish flat pebbles).

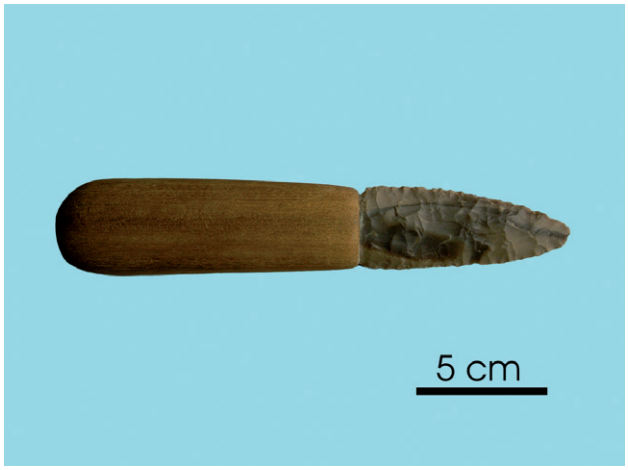


Photo 387. Recently prepared dagger from the Krzemionki banded silicite by W. Migal from Warszaw.

All photos in the Picture supplement are made by L. Plchová or A. Přichystal (excluding No. 168, 171 and 345 where the source is mentioned).

Antonín Přichystal

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ABOUT THE AUTHOR

Prof. RNDr. Antonín Přichystal, DSc.

After school-leaving examination at the Secondary Chemical School in Přerov he studied geology at the Faculty of Science, University of J. E. Purkyně in Brno. He graduated in 1974 and than obtained a one-year study stay at the Department of Mineralogy and Petrology to submit the thesis for the title RNDr. (1975). Postgraduate study at the Department of Petrology, Charles University in Prague (supervisor prof. F. Fediuk) successfully finished in 1986 (CSc. as equivalent of PhD. at that time). In 1985 he graduated from the Summer School on Volcanology and Geothermal Energy at the University of Saint-Denis, Réunion (oversee department of France in the Indian Ocean). As is longer stays abroad concerned, A. Přichystal spent a month at the Geological Survey of Finland (1983) or had lectures at the University of Cairo in Egypt (1993). He qualified as a university lecturer at the Faculty of Science, Masaryk University in Brno (1990) and later as a university professor of geology (1998). In 2011 he obtained the title "Doctor of Historical Sciences (DSc.)" at the Czech Academy of Sciences in Prague.

The author worked in 1975–1987 at the Czech Geological Survey (Branch Brno), since 1987 he has been an employer of the Faculty of Science, Masaryk University in Brno. He did also geological mapping of a granite pluton and its mantle at locality of Modoto in Mongolia (1981) or he carried out geological investigation of the Moldanubian Pluton for the Geological Survey of Austria (1991–1994). In the years 2000–2008 he participated in a project of the Czech Geological Survey concerning prediction of geological hazards in Central American countries, especially in Nicaragua. At the Faculty of Science, Masaryk University, he was a head of the Department of Geology and Paleontology (1990-1997) and a few times also a head of the Section Earth Sciences.

During his studies at the University of J. E. Purkyně he completed some lectures at Department of Archaeology and since that time he has cooperated with archaeologists in the determination of lithic raw materials used for prehistoric and medieval artefacts. He took part in the 1st, 3rd and 4th Petroarchaeological Seminars (Brno 1975, Plovdiv 1984, Wrocław 2007) or in the VIIth and VIIIth International Flint Symposia (Warszawa 1994, Bochum 1999). He had possibility to study stone raw materials used in prehistoric times not only in Central Europe but also in Egypt, Syria, Turkey and Nicaragua.

The total number of published papers is about 350. From the most important it can be mentioned a Czech volume Geology of Moravia and Silesia (Přichystal, Obstová & Suk, eds. 1983) or a Czech book The Mystery of Býčí skála Cave (Přichystal & Náplava 1985), a chapter on lithic raw materials in The Palaeolithic of Moravia and Silesia (Svoboda et al. 1994, 2002) and other chapters in books published in Slovakia, Germany, the U.S.A., Austria or Poland. Together with J. Kopacz and L. Šebela he has written a book Lithic chipped industry of the Bell Beaker culture in Moravia and its East-Central European context (Kraków 2009) or he drew attention to the Jurassic oolithic limestone from the Stránská skála Hill in Brno as the probable raw material of the Willendorf Venus (with A. Binsteiner et al., Wien 2008).

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