REVIEW OF THE MINERALOGICAL SYSTEMATICS OF JASPER AND RELATED ROCKS[1]

A JÁSPIS ÉS A VELE ROKON KOVAKŐZETEK ÁSVÁNYTANI OSZTÁLYOZÁSA

RUSLAN I. KOSTOV

University of Mining and Geology "St. Ivan Rilski", Sofia 1700, Bulgaria

E-mail: rikostov@yahoo.com

Abstract

A review of the genetic classifications of jasper based on mineralogical data outlines three main types of jasper and related rocks: 1 – jaspers; 2 – jasperoids; 3 – jasper-like rocks. True jasper has a quartz composition and is of metamorphic or metasomatic origin. Related in different colour and density to jasper other rocks of sedimentary or igneous origin can be found usually having a dominantly chalcedony-quartz and feldspar-quartz composition (jasperoids and jasper-like rocks). Main mineral impurities which cause the colour of the described rocks are listed.

Kivonat

A jáspis és a rokon kőzetek genetikai osztályozásával az ásványtani adatok szerint három fő kategóriát különíthetünk el: 1 – jáspis; 2 – jasperoid; 3 – jáspis-szerű kőzetek. A valódi jáspis ásványtanilag kvarckristályokból áll és metamorf vagy metaszomatikus eredetű. Hasonló, változatos színű és sűrűségű kőzetek a jasperoidok és jáspisszerű közetek melyek lehetnek üledékes és magmás eredetűek is, és ásványos összetételük uralkodóan kalcedon és kvarc, vagy földpát és kvarc. A tanulmány foglalkozik a fenti kőzetekben kis mennyiségben előforduló ásványokkal és színező anyagokkal is.

KEYWORDS: JASPER, JASPEROID, JASPER-LIKE ROCK

KULCSSZAVAK: JÁSPIS, JASPEROID, JÁSPIS-SZERŰ KŐZET

Jasper is a widely used term for SiO_2 bearing rocks of predominantly metasomatic or metamorphic origin. They have a variety of different colours and texture, which together with their technical properties, such as density, ability for polish and decorative impact makes them an important raw material for jewellery industry. This mineral aggregate has been used since prehistoric times and in antiquity for beads, ring insets and has been widely applied in glyptic art. Heliotrope, for example, is dark green jasper with small red spots.

The name *jasper* is from the Greek – *ϊασπις* and Latin – *iaspis* (probably related to the Assyrian *eshpu*, Persian *yashon* or *yasp,* or Hebrew *yashpheh*, meaning "spotty" or "flame-like"). According to Fersman (1962), in the Middle Ages in the Central Asian region the term jasper was used for nephrite.

In the classical study "Gemstones" (Smith, 1940) jasper is recognized as "impure opaque quartz, heavily impregnated with impurities, and according to their nature coloured red, yellow, or brown; in ribbon-jasper the colours run in stripes and in Egyptian-jasper in zones".

The wide variety of genetic environments, in which jasper is formed, in some cases has lead to their interpretation as sedimentary or volcanogenic products, and even as a dense variety of quartz (i.e. of hydrothermal genesis). In this respect, a review of the ideas on the origin of jasper, genetic classifications with reference to their mineralogical composition is considered as necessary. There are also classifications based on a decorative, formation and geological-economic principles. In several cases complex classifications are used.

---

[1] *This is an English translation with additions of: Kostov, R. I. 2006. Review of the mineralogical systematics of jasper and related rocks. – *Geology and Mineral Resources, 13*, 9, 8-12 (in Bulgarian with an English abstract).

HU ISSN 1786-271X; urn: nbn: hu-4106

According to Fersman (1962) jasper is an aggregate of quartz particles, cemented by quartz or chalcedony and containing an average of about 20% clay mineral impurities. Besides, because of the similarity to other jasper-like rocks (of volcanic or sedimentary origin) jaspers can hardly be distinguished and he assumes, that the term should refer not only to the mineral composition of the rock, but also its technical properties. Fersman (1962) introduces two types of classification for jaspers – a genetic classification including 5 main groups and a practical classification based on texture and colour properties, with 6 main groups.

The genetic classification includes: 1 – contact-alteration radiolarite mud in metamorphic rocks, often interlayered with green tuffs and diabases (ribbon-like jaspers); 2 – metamorphic schists, limestones, marls and other sedimentary rocks undergone replacement by quartz (layered to jasper breccia); 3 – jaspers, related to quartzites and hornfelses; 4 – felsitic porphyry and silicified porphyry rocks (often with a spherulitic composition); 5 – compact coloured varieties of quartz or chalcedony in the agates.

The practical (based on texture; colour) classification includes the following groups: 1 – massive (dense) jaspers with different uniform colour, in some cases with spots and inclusions; 2 – banded (ribbon-like, wavy) jaspers; 3 – porphyritic (with inclusions of feldspars, quartz, augite or amphibole); 4 – variously coloured (uniform with veins from another colour; grains of different colour with uniform in colour cement; with wavy, curly colours); 5 – jasper breccias and conglomerates; 6 – spheroidal ("kopeek"-like) and colomorph (agate) jaspers (coin-like; layer or vein agate; concentric-zonal).

A more detailed textural classification on the base of the Ural jaspers was made by Igumnov (1960), including 11 texture varieties (Semenov, 1979; Arinstein et al., 1986; Putolova et al., 1989): massive, banded (with stripes), brecciated, concentric, colomorphic, concretional, incrusted, cataclastic, curly (with folds), breccia-like, fluidal.

According to Frondel (1962) jasper is a dense opaque quartz rock with a high content (up and above 20%) of mainly iron impurities. Fine grained structure is characteristic especially among the metamorphic varieties. According to the genesis, jaspers are described as big bodies of metamorphic or sedimentary origin. Gradual transition from jaspers towards the varieties of chalcedony or on the contrary is also mentioned.

A non-uniform explanation of the origin of jaspers is observed among other researchers, too. Petrovskii (1969) describes jaspers as primary sedimentary silica rocks undergone intensive influence of effusive, dominantly underwater igneous activity in geosyncline regions (e.g., jasper formation in volcanogenic-flint association after N. S. Shatskii – 1954). According to him, SiO_2 is introduced to the sedimentary basin as a component of gas emanation in the postvolcanic stage accompanied by intensive fumarole activity. Jaspers are characterized with a quartz composition with a novaculite structure (c. Folk & Weaver, 1952) and differ from jasperoids, which are of chalcedony-quartz composition and have a replacement structure (Petrov et al. 1981). Jaspers are reviewed as sedimentary rocks (among the silicites – silica rocks) with a chalcedony and quartz-chalcedony composition in a textbook on sedimentology (Sultanov, 2005).

For comparison a short review has to be made of sedimentary silica formation. The flint rocks (silicites) are with a source of SiO_2 from the earth, igneous activity and water basins. The SiO_2 can be in an amorphous state or crystallized as quartz and other phases. Recrystallization takes part depending on depth (geothermal gradient) and time. Based on mineral composition several main types of sedimentary silica rocks are distinguished (Pettijohn, 1981; Vassoevich et al., 1983):

1. Opal-cristobalite rocks:

a. abiomorphic (with an aggregate-globular structure with 50-85% SiO_2 containing most often impurities of montmorilonite, glauconite, pyrite and zeolites) – represented by tripoli (density 0.7-1.2 g/cm^3); opoka (a bit harder; density 1-1.6 g/cm^3); porcelanite (recrystallized opoka); geyserite (colomorphic; silica-gel).

b. biomorphic (organogenic) – represented by diatomite (fine porous rock with dimensions of the particles 0.01-0.2 mm; it may contain up to 30-70 mln. fossil remains in 1 cm^3 (density up to 0.2-1 g/cm^3, contains up to 80-95% SiO_2); silicoflagelite (density 0.9-1.2 g/cm^3); radiolarite; spongolite (density 1-1.5 g/cm^3).

2. Quartz (chalcedony-quartz) rocks (=*jasperoids, but not jaspers or jasper-like rocks* – comment by the author).

a. abiomorphic – represented by phtanite (lydite) (black compact rocks with clay minerals, organics and pyrite, containing up to 95% SiO_2); phtanitoid (bluish and greenish better crystallized rocks, often Mn-bearing); jaspers (hard, red, green and yellow rocks with uniform or banded texture, containing up to 97% SiO_2, which can include also impurities of iron and manganese oxides and hydrooxides); novaculite ("Arkansas Stone"), which is milky white in colour, with conchoidal fracture, and contains up to 99% SiO_2.

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

Table 1.: Mineral phases other than quartz and chalcedony, causing different types of colouration in jaspers (after Yakovleva & Putolova, 1971)

1. táblázat: Egyéb ásványfázisok a kvarcon és a kalcedonon kívül, amelyek a jáspis és vele rokon kőzetek különböző színeit okozzák (Yakovleva & Putolova, 1971 nyomán)

Colour	Mineral
Gray	albite, K-feldspar, sericite
Black	magnetite, Mn-oxides
Red, pink	hematite, garnet
Brown	goethite, hematite
Yellow	goethite
Green	chlorite (penine), pumpellyite, epidote, actinolite, clinozoisite, celadonite
Blue, violet	magnetite, glaucophane-riebeckite, hematite

b. biomorphic (organogenic) – represented by radiolarite or spongolite jasper-like rocks and phtanites.

3. Postsedimentary silicites – diagenetic and catagenetic flints (concretions, lenses, layers) distributed in clay-bearing rocks with a dominantly cristobalite composition, and in limestones –with a dominantly quartz (chalcedony) composition; marshalite; silcretes.

The mentioned three types of silica rocks of sedimentary origin have to be differentiated from the typical (true) jaspers, despite the fact that in some cases they look similar and have the same physical properties ("sedimentary jaspers" after Frondel, 1962). The term jaspilite (jaspilyte) has to be added for interlayered jaspers (quartz) with hematite and magnetite in the metamorphosed Precambrian iron formations (iron quartzites). In the *Dictionary of Petrology* jasperoid "is a dense grey chert-like siliceous rock which consists of chalcedonic or cryptocrystalline quartz and which has formed through the silicification of limestone" and jaspilite – interbedded jasper and hematite with at least 25% iron (Tomkeieff, 1983).

The most important mineral impurities, which are the cause for the colouration in jaspers and related rocks, are listed in **Table 1.** According to the frequency of distribution, the SiO_2 varieties are followed by feldspars (up to 70-90%), garnets (up to 20-30%), epidote and pumpellyite (up to 20%), chlorites (up to 10%) hydromicas and amphiboles, and among the most important impurities responsible for colouration – hematite, magnetite and goethite (Barsanov & Yakovleva, 1978).

A common definition of jasper can be found in the *Petrographical Dictionary* (Petrov et al. 1981): a massive dense hard opaque material, with conchoidal fracture, frequently banded or spotted siliceous rock, composed of chalcedony and micrognanular quartz with impurities of Al- and Ca-phases, coloured in yellow, redbrown and green colours with fine dispersed iron and manganese oxides. The genesis of the rock is related to metasomatic processes.

Barsanov & Yakovleva (1978), in reviewing the studies on jaspers, distinguish three main genetic cases of jasper formation: 1 – metasomatism during volcanic exhalations and diagenesis of basic volcanic and volcanic-sedimentary materials at near-surface and medium metamorphic facieses; 2 – hydrothermal SiO_2-autometasomatism of volcanogenic rocks; 3 – contact metamorphic rocks of a hornfels type and postvolcanic metasomatism of the tuffogenic covers.

According to Kievlenko (1980) jaspers are the result of metamorphic processes in low temperature metamorphic facieses, and different jaspers are described, as products of greenschist facies metamorphism or of metasomatic replacement and contact metamorphism. In the genetic and genetic-practical classification of jasper formations, Kievlenko & Senkevich (1983) distinguish 4 types: 1 – true jaspers (metamorphosed volcanogenic-sedimentary and hydrothermal-metasomatic formations) of dominantly quartz composition; 2 – jasper-like quartzites and hornfelses, which differ from jaspers with a higher degree of recrystallization of the main mass and by a lot of impurities; 3 – jasperoids (postvolcanic formations of dominantly chalcedony composition); 4 – jasper-like intrusive and effusive rocks with a feldspar-quartz composition. The same classification is accepted in another work about jaspers, where varieties are described with respect to their mineral composition, texture and structural peculiarities (Putolova et al., 1989).

Tomkeieff (1983) uses the description of jasper given by Pettijohn (1975) for rocks of sedimentary origin: "a dense cryptocrystalline, opaque or slightly translucent variety of chert which is usually red in colour, but may be yellow, brown, green or black".

In the definition of Arinstein et al. (1986) jaspers are rocks with SiO_2 composition, high hardness and decorative significance. In the group of "jasper rocks" three cases are listed: 1 – jaspers (dominantly quartz and chalcedony-quartz in composition), represented by altered (metamorphosed) massive microgranular rocks with a beautiful colour – they can be easily polished; 2 – jasperoids (with a dominantly chalcedony and quartz-chalcedony composition), which are considered as volcangenic-sedimentary rocks undergone strong alteration, poorly altered effusive containing SiO_2 and chert rocks originating from the impact of solutions on the contact of serpentinites and volcanogenic formations; 3 – jasper-like rocks (with a significant feldspar and quartz-feldspar composition) – sedimentary and sedimentary-volcanogenic abiomorphic and biomorphic rocks built by SiO_2 and remains of silica organisms, for example lydites (with a dominant chalcedony composition), phtanites (of dominantly quartz composition and with clay and graphite impurities) and tuffites.

Jasper rocks are separated in four groups in a monograph, related to decorative gemmological materials (Putolova et al., 1989): 1 – true jaspers, described as volcanogenic-sedimentary metamorphic and hydrothermal-metasomatic products of dominantly quartz composition; 2 – jasper-like quartzites and hornfelses with a higher degree of recrystallization; 3 – jasperoids represented by postvolcanic SiO_2 formations of dominantly chalcedony composition; 4 – jasper-like intrusive and effusive rocks, of dominantly feldspar-quartz composition. In most gemmological monographs genetic classification of jaspers is not reviewed. For example, O'Donoghue (2006) explains jasper as "the archetypal collectable beach pebble", which "consists of massive, fine-grained quartz, fairly dense, containing significant amounts of other materials, particularly iron oxides".

Jaspers in Bulgaria have been described in two regions – Srednogorie, related to Upper Cretaceous volcanism, and Eastern Rhodopes, linked to Paleogene volcanism, and in both cases the metasomatic replacement of the host carbonate rocks and organic remains is pointed out (Atanasov & Jordanov, 1986). They are considered as hydrothermal formations as they are related to the agates and are recognized not as true jaspers, but as *jasperoids*. In their mineral composition are included chalcedony, quartzine, quartz, lusatite, opal, hematite, goethite, celadonite, magnetite, pyrite, pyrolusite, calcite, siderite and zeolite. The same authors point out to other genetic manifestations of jasper in iron deposits (Kremikovtsi), in Permian breccia-conglomerates and in quartzites from the Paleozoic diabase-phillitoid complex. Secondary deposits of jasper are described in the same regions among the conglomerates of the Paleogene and Pliocene, as well as in the contemporary alluvial and deluvial sediments. In the Eastern Rhodopes good quality heliotrope is also described. Chalcedony composition is suggested for the jaspers (*jasperoids* – comment by the author) from the region of village of Chukovo in the Eastern Rhodopes, and jasper breccia is described at the village of Gaberovo (Iliev, 1996).

Probably the most broad and complete definition of true jasper is: "rocks or mineral formations, which are to be considered mainly among the metasomatic products, as a result of metasomatism (or autometasomatism) and recrystallization of the primary sedimentary-volcanic, effusive or intrusive rocks during the processes of diagenesis, regional, contact-metasomatic and postvolcanic hydrothermal metamorphism" (Barsanov & Yakovleva, 1978).

In conclusion, in contemporary mineralogical and gemmological literature, the following system with three groups has been introduced for jaspers and related rocks according to their mineral composition: true jaspers, jasperoids and jasper-like rocks (Kostov, 2003). The term jasper is suggested to be used only in the case with the first group with the corresponding genetic class (metamorphic or metasomatic) of deposits.

The macroscopic identification of "jaspers" is difficult according to the suggested classification. For their precise determination microscopic, X-ray, and in certain cases additional chemical and spectroscopic methods of study are recommended.

References

ARINSTEIN, M., MEL'NIKOV, E., SHAKINKO I. (1986): *Colour Stones of the Urals.* Sverdlovsk, 355 p. [in Russian] [Аринштейн, М., Е. Мельников, И. Шакинко. 1986. *Цветные камни Урала.* Свердловск, Средне-Уральское книжное изд., 355 с.]

ATANASOV, V. A. & JORDANOV J. A. (1986): Jasper deposits in Bulgaria. – In: *Morphology and Phase Equilibria of Minerals.* Materials of the XIII Meeting of the IMA, Varna, 19-25 September 1982. BAS, Sofia, 379-386. [in Russian] [Атанасов, В. А., Й. А. Йорданов. 1986. Месторождения яшм в Болгарии. – В: *Морфология и фазовые равновесия минералов. Материалы XIII конгресса ММА, Варна, 19-25 сентября 1982.* С., Изд. БАН, 379-386.]

BARSANOV, G. P. & YAKOVLEVA M. E. (1978): *Mineralogy of Jaspers from the USSR (Ural, Altai).* Nauka, Moscow, 88 p. [in Russian]

[Барсанов, Г. П., М. Е. Яковлева. 1978. *Минералогия яшмы СССР (Урал, Алтай).* М., Наука, 88 с.]

FERSMAN, A. E. (1962): Gem and colour stones of Russia. – In: *Selected Works. Volume VII.* AS USSR, Moscow, 209-242. [in Russian] [Ферсман, А. Е. 1962. Драгоценные и цветные камни России. – В: *Избранные труды. Том VII.* М., Изд. АН СССР, 209-242.]

FOLK, R. L. & WEAVER, CH. E. (1952): A study of the texture and composition of chert. – *Amer. J. Sci., **250***, 7.

FRONDEL, C. (1962): *The System of Mineralogy. Vol. III. Silica Minerals.* Seventh Ed., John Wiley & Sons Inc., New York – London, 334 p.

IGUMNOV, A. N. (1960): On the texture peculiarities of the multicoloured jasper from the Southern Ural. – *Trudi Gorno-Geol. Inst. UF AN SSSR, 35, Mineral. Sbornik, 4*. [in Russian] [Игумнов, А. Н. 1960. О текстурных особенностях пестроцветной яшмы Южного Урала. – *Труды Горно-геол. инст. УФ АН СССР, 35, Минерал. сборник, 4*.] 143-155.

ILIEV, R. (1996): Study on the decorative chalcedonies and jaspers from some deposits in the Eastern Rhodopes. – *Ann. Sofia Univ., Fac. Geol. Geogr., 1, Geol., 89*, 191-201. [in Bulgarian] [Илиев, Р. 1996. Изследвания върху декоративни халцедони и ясписи от някои находища в Източните Родопи. – *Год. СУ, ГГФ, Кн. 1 – Геол., 89*, 191-201.]

KIEVLENKO, E. YA. (1980): *Prospecting and Evaluation of Deposits of Gem and Decorative Stones*. Nedra, Moscow, 263 p. [in Russian] [Киевленко, Е. Я. 1980. *Поиски и оценка месторождений драгоценных и поделочных камней*. М., Недра, 166 с.]

KIEVLENKO, E. YA. & SENKEVICH N. N. (1983): *Geology of Deposits of Decorative Stones*. Nedra, Moscow, 263 p. [in Russian] [Киевленко, Е. Я., Н. Н. Сенкевич. 1983. *Геология месторождений поделочных камней*. 2-е изд., М., Недра, 263 с.]

KOSTOV, R. I. (2003): *Precious Minerals: Testing, Distribution, Cutting, History and Application (Gemmology).* Pensoft, Sofia-Moscow, X, 453 p. [in Bulgarian] [Костов, Р. И. 2003. *Скъпоценни минерали: определяне, разпространение, обработка, история и приложение (Гемология).* С.-М., Pensoft, X, 453 с.]

O'DONOGHUE, M. (2006): *Gems.* Sixth Ed., Butterworth-Heinemann, Amsterdam-Boston-Heidelberg-London, 863 p., 63 Pl.

PETROV V. P., BOGATIKOV O. A., PETROV R. P. (1981): *Petrographical Dictionary*. Nedra, Moscow, 496 p. [in Russian] [*Петрографический словарь.* 1981. М., Недра, 496 с.]

PETROVSKII, A. D. (1969): Mineralogical and genetic peculiarities of jaspers. – *Soviet Geology*, 7, 71-78. [in Russian] [Петровский, А. Д. 1969. Минералогические и генетические особенности яшм. – *Советская геология*, 7, 71-78.]

PETTIJOHN, F. J. (1981): *Sedimentary Rocks*. Nedra, Moscow, 751 p. [in Russian, transl. from English, 1975] [Петиджон, Ф. Дж. 1981. *Осадочные породы*. М., Недра, 751 с.]

PUTOLOVA, L. S., MENCHINSKAYA, T. I. BARANOVA, T. L., VDOVENKO, A. P. (1989): Decorative Varieties of Coloured Stone in the USSR. Nedra, Moscow, 272 p. [in Russian] [Путолова, Л. С., Т. И. Менчинская, Т. Л. Баранова, А. П. Вдовенко. 1989. Декоративные разновидности цветного камня СССР. М., Недра, 272 с.]

SEMENOV, V. B. (1979): *Jasper*. Sverdlovsk, 355 p. [in Russian] [Семенов, В. Б. 1979. *Яшма.* Свердловск, Средне-Уральское книжное изд., 355 с.]

SMITH, G. F. H. (1940): *Gemstones.* Methuen & Co., London, 443 p.

SULTANOV, A. (2005): *Sedimentology.* Sofia, 26 p. [in Bulgarian] [Султанов, А. 2005. *Седиментология*. С., 276 с.]

TOMKEIEFF, S. I. (1983): *Dictionary of Petrology.* John Wiley & Sons, Chichister-London-Brisbane-Toronto-Singarore, 680 p.

VASSOEVICH N. B., LIBROVICH V. L., LOGVINENKO N. B., MARCHENKO V. I. eds. (1983): Notebook on Lithology. 1983. Nedra, Moscow, 509 p. [in Russian] [*Справочник по литологии.* 1983. М., Недра, 509 с.]

YAKOVLEVA, M. E., PUTOLOVA L. S. (1971): On the mineralogical composition of some jaspers and the cause of their colour. – *New Data on Minerals from the USSR, 20,* 172-179. [in Russian] [Яковлева, М. Е., Л. С. Путолова. 1971. О минералогическом составе некоторых яшм и причина их окраски. – *Новые данные о минералах СССР, 20,* 172-179.]

HU ISSN 1786-271X; urn: nbn: hu-4106