31st International Symposium on Archaeometry

Budapest, 27 April - 1 May 1998

An International Conference on the Application of Scientific Methods and Advanced Technology in the study of Archaeological Finds and other fields of Arts and Antiquities

Program and Abstracts

Program

26th of April, Sunday

Registration in HNM 12:00 - 22:00
Guided tour:
Hungarian Coronation Insignia 18:30 -19.00
Reception in HNM 19:00 - 22:00
Greetings by István Gedai, chief director of the Hungarian National Museum and Csanád Bálint, Director of the Archaeological Institute of the Hungarian Academy of Sciences

27th of April, Monday

Registration in HAS 8:00 - 18:00
Opening session 9:00 - 10:00
Greetings by the representatives of the Hungarian Academy of Sciences and the Ministry of Culture and Education,

Opening address by Michael Tite, Chairman of the Standing Committee of Archaeometry Symposia and János Borszéki, Chairman of the Working Group of Archaeometry and Industrial Archaeology of the Hungarian Academy of Sciences

Session 1. Biomaterials 1-3
Moderators: Michael Tite, László Bartosiewicz

10.00-10.20 Dudd, S. N. - Evershed, R.P., The use of stable carbon isotopes in the identification of dairy products in archaeological ceramics (78)
10.20-10.40 Stacey, R.J. - Heron, C.P. - Craig, O. E. et al., Lipids in ancient ceramics: patterns and processes (239)
10.40-11.00 Vargas-Sanders, R. - Salazar, C. Z., A study of migration in Mexican Prehispanic populations by DNA analysis (268)

Coffee break

Session 1. Biomaterials 4-8
Moderators: Günther A. Wagner, János Csapó

11.20-11.40 Evershed, R.P. - Simpson, I.A. - van Bergen, P.F. et al., Multi-molecular biomarker techniques to identify early agricultural practices in the Orkney Islands, Scotland.Evershed-Simpson (88)
11.40-12.00 Child, A.M. - Minnikin, D. E. - Ahmed, Ali M.S., Biomarkers for ancient tubercolosis (42)
12.00-12.20 Burton, J. H. - Price, D. T. - Middleton, W.D., Correlation of barium and strontium during trophic-level biopurification and its osteoarchaeological implications (35)
12.20-12.40 Young, S. M. - Van der Merwe, N. J., Evaluation of ancient diet: Dietary tracing by stable isotpe analysis of consumer tissues (263)
12.40-13.00 Tykot, Robert H.,The Origins and Dispersal of Maize Agriculture: A Review and Critical Assesment of the Isotopic Evidence (260)

Lunch

Session 1. Biomaterials 9-10
Session 4.a Provenance metals 1-4
Moderators: R. P. Evershed, Zsófia Medzihradszky

14.10-14.30 Burger, J. - Grosskopf, B. - Hummel, S. et al., DNA techniques in archaeometry - News and progresses (34)
14.30-14.50 Price, D. T., Strontium Isotopes and the Bell-Beaker Period: evidences of residential mobility (205)
14.50-15.10 Gegus, E., Archievement in spectroscopic investigation of archaelogical metal objects in Hungary (102)
15.10-15.30 Gondonneau, A. - Roux, C. - Guerra, M.F. et al., The Muslim conquest and the routes of gold. A new approach (108)
15.30-15.50 Dillmann, P. - Fluzin, P. - Chevallier, P., Application of synchrotron microdiffraction coupled with X-ray fluorescence microprobe to the determination of the iron making processes by identification of inclusion in archaeological artefacts (73)
15.50-16.10 Adriaens, A. - Earl, B. - Özbal, H. - Yener, K.A., Tin bronze metallurgy in transformation: analytical investigation of crucible fragments from Tell Judaidah, Amuq /Turkey/, Dating to circa 3000-2900 BC (1)

Coffee break

Session 2. Dating 1-5
Moderators: Ay Melek Özer, Ede Hertelendi

16:30-16.50 Gläser, R., The process of neolithization of SE-Europe according to 14 C-dates (105)
16.50-17.10 Bassiakos, Y. - Doumas, C., ESR spectroscopy of calcitic encrustations on archaeological finds, serving as authenticity test (14)
17.10-17.30 Zhilin, M. G., C-14 dating of the Mesolithic of East European forest zone /A critical review/ (287)
17.30-17.50 Korac, M. - Ognjanovic, Z. - Dugandzic, F. An approach to dating based on the expert system technology (151)
17.50-18.10 Zacharias, N. - Michael, C.T. - Dimotikali, D. et al., A modified TL technique (Foil technique) for dating calcite shells from an Upper Pleistocene Marine (285)

28th of April, Tuesday

8:00 8:40 **Installation of posters** for PS 1
Sessions Biomaterials, Dating, Provenance

Session 4a. Provenance metals 5-10
Moderators: Ernst Pernicka, Márta Járó

8.40-9.00 Ryndina, Natalia., On casting mould of the Northern-East Balkan Eneolithic (219)
9.00-9.20 Eniosova, N., Casting moulds from the Upper Dnieper Region /10th-11th centuries A.D./ (84)
9.20-9.40 Liversage, D. - Pernicka, E., An industry in crisis? Changes in bronze composition near the end of the Hungarian Bronze Age (163)
9.40-10.00 Özbal, H. - Adriaens, M. A. - Earl, B., Minor metallic components associated with Anatolian copper and bronze artifacts: indications of the utilization of polymetallic ores (187)
10.00-10.20 Gillis, C. - Stos-Gale, Z. - Gale, N.., Metal sources at Asine in the Greek Argolid:a diachronic analysis of metal sources using LIA (103)
10.20-10.40 Prohászka, M., Technical aspects on Greek mirrors from Southern Italy (206)

Coffee break

Session 3 Field archaeology 1-3
Moderators Alain Tabbagh, Péter Márton

11.00-11.20 Garrison, E. - Serman, N. - Schneider, K.) (Archaeological prospection using GPR and Cryogenic Soil Probes (98)
11.20-11.40 Barba, L. - Ortiz, A., Geophysical studies of archaeological structures under the pavement at Mexico city (11)
11.40-12.00 Hesse, A. - Andrieux, P. - Atya, M. et al., Archaeological and geophysical survey for the Heptastadium in Alexandria: a new hypothesis (120)

Posters 1. 12:00 13:00
Sessions Biomaterials, Dating, Provenance

Lunch

Session 4a. Provenance metals 11-14
Session 4b. Provenance pottery 1-2
Moderators: Suzanne Young, László Költő

14.10-14.30 Klein, S. - Brey, G.- von Kaenel, H-M. et al., Chemical characterization of roman brass and copper coins from Rome /Tiber/, Italy (148)
14.30-14.50 Wang, Q. - Merkel, J., Study of black layer on ancient Chinese bronzes (294)
14.50-15.10 Eremin, K., Non-destructive analysis of copper alloy artefacts from Pagan Norse graves in Scotland (86)
15.10-15.30 Tóth, A. - Járó, M., Alternate methods of EPMA characterisation of gilt silver metal threads (254)
15.30-15.50 Gunneweg, J. - Balla, M., Instrumental Neutron Activation Analysis and Eastern Terra Sigillata-II. Pottery Revisited (113)
15.50-16.10 Hayashida, F. - Glascock, M. - Neff, H et al., Technology and organization of Inka pottery production: neutron activation analysis and Mössbauer spectroscopy studies (292)

Coffee break

Session 3. Field archaeology 4-8
Moderators: Ron Farquhar, Miklós Pattantyús

16.30-16.50 Scurtu, F., The geophysical image of a part of the Respublica Municipii Septimi Porolissensium in Dacia (231)
16.50-17.10 Sarris, A. - Maragou, L. - Gkiourou, A. et al., The Island of Amorgos: Micro-scale & Macro-scale Remote Sensing (223)
17.10-17.30 Schiegl, S., Diagenetic processes in fossil wood ash deposits in Kebara and Hayonim Caves (Israel) (226)
17.30-17.50 Kadereit, A. - Lang, A. - Wagner, G.A., Colluvial sediments near archaeological sites as a key to the past landscape evolution under human impact - a geoarchaeological case study from the Kraichgau Hills in Southern Germany (142)
17.50-18.10 Puszta S., Magnetic Prospecting in the Proximity of the Town (Problems of data collection and processing) (208)

Organ Concert

19.30-20:00 In Matthias Church

29th of April, Wednesday

Theme Session: Experimental archaeology and its impact on scientific archaeology
Moderators: Peter Reynolds, Elisabeth Jerem
9.00-9.20 Beck, C.W. - Stout, E.C. - Lee, K., Ancient pine tar technology: correlations between manufacturing methods and composition (18)
9.20-9.40 Eccleston, M. - Ottaway, B.S. - Scordara, M. et al.) (Metallographic examination of Sand Cast Copper and Bronze (80)
9.40-10.00 Poroszlai, I. - Jerem, E., Experimental results from the Százhalombatta Archaeological Park (204)
10.00-10.20 Iovino, M. R., Processing fishes with obsidian tools: a description of the experimental microwear (132)
10.20-10.40 Wolf, S., Technical investigation of bricks from St. Urban (13th century Cistercian monastery, Lucerne, Switzerland): first results of a firing experiment (283)

Coffee break

Poster Discussion 1.
12:00 13:00 Sessions Biomaterials, Dating, Provenance
Discussion moderators: M. Tite, G. Wagner, P. Meyers, E. Gegus

Lunch

Conference excursion
14:30 19:00 Excursion to Aquincum, the Roman capital
Guided tour
Posters related to Pannonia
Choyke, Alice, Archaeometry at the Aquincum Museum (43)
Gladiators combat

30th of April, Thursday

8:00 8:40 **Installation of posters** for PS 2
Sessions Field Archaeology,Experimental Archaeology, Provenance

Session 1. Biomaterials 11
Session 4a. Provenance metals 15-17
Session 4b. Provenance pottery 3-4
Moderators: Mark Pollard, Márta Balla
8.40-9.00 Weser, Ulrich, Antique Metalloenzymes (277)
9.00-9.20 Clayton, R. - Gale, N. H. - Stos-Gale, Z. A., Isotope fingerprinting of ancient tin (47)
9.20-9.40 Rehren, Th. - Bartelheim, N. - Niederschlag, E., Prehistoric tin metallurgy in the Bohemian/Saxon Erzgebirge (213)
9.40-10.00 Stos-Gale, Z. A. - Gale, N. H. The characterization, by lead isotopes and trace elements, of the ore deposits of Cyprus & Sardinia and its bearing of the possibility of the lead isotope provenancing of copper alloys (66)
10.00-10.20 Faber, E. W. - Kilikoglou, V. - Kiriatzi, E. et al., Pottery production and exchange in Eleusis, Greece, during the Middle Helladic Period (91)

10.20-10.40	Quinn, P. S. - Day, P. M. - Hine, N. M.., Ceramic micropalaeontology: Potentials and limitations of Micro- and Nanno-fossil Analysis in Archaeological Ceramics (210)

Coffee break

Session 4b. Provenance pottery 5-7
Moderators: Hans Mommsen, Andrea Vaday

11.00-11.20 Sauer, R. - Gassner, V. - Haiden, H., Identification and characterisation of local pottery production sites in Southern Italy by a combination of thin-section and heavy mineral analysis (225)
11.20-11.40 Uzgil, E. - Saglamer, G. - Tekin, A. et al., A multidisciplinary study on ancient Iznik ceramics (261)
11.40-12.00 Wang, Ch. - Chen, X. - Liang, Zh., The Earliest Carbon Fibre was discovered in Chinese Black pottery (273)

Posters 2. 12:00 13:00
Sessions Field Archaeology,Experimental Archaeology, Provenance

Lunch

Session 4c Provenance stones 1-5
Moderators: Yannis Maniatis, Viola Dobosi

14.00-14.20 D'Amico, C. - Bernabo B. M. - Felice, G. et al., Polished stone between Neolithic and Bronze Age in Northern Italy (61)
14.20-14.40 Malyk-Selivanova, N. - Ashley, G. M. - Gal, R. et al., Geological - geochemical sourcing of prehistoric chert artifacts, northwestern Alaska (167)
14.40-15.00 Wisseman, S. - Sarin, P. - Ousterhout, R. et al., Fresco pigments from Byzantine Cappadocia, part II. (281)
15.00-15.20 Bellot-Gurlet, L. - Dorighel, O. - Poupeau, G. et al.,Characterization of Colombian and Ecuadorian obsidian sources and Prehispanic obsidian trading (19)
15.20-15.40 Shackley, S., Precision versus accuracy in the XRF analysis of archeological obsidian: some lessons in archeometry and archeology (235)

Coffee break

Session 4b Provenance pottery 8-10
Moderators: Sarah Wisseman, György Szakmány

16.00-16.20 Palaguta, I., Some results of study of Cucuteni-Tripolye decoration technics (189)
16.20-16.40 Mao, Y. - Mellon Fellow, A.,Technical investigation of Ptolemaic Period Faience in the Walters Art Gallery (170)
16.40-17.00 Tite, M.S. - Mason, R.B., The technology and development of 12th century AD Islamic polychrome ceramics (252)

1st of May, Friday

Session 4b Provenance pottery 11-16
Moderators: Gar Harbottle, Paula Zsidi

8.40-9.00 Appoloni, C.R. - Espinoza-Quinones, F.R. - Aragao, P. H. et al. EDXRF study of Tupiguarani archaeological ceramics from the north of Paraná state in Brasil (6)
9.00-9.20 Garcia-Heras, M. - Fernandez-Ruiz, R., New developments in the analysis of archaelogical ceramics by total reflection X-ray fluorescence /TXRF/ (97)
9.20-9.40 Mirti, P. - Sagui, L., Scientific examination of 7th century glass fragments from Rome (177)
9.40-10.00 Gratuze, B. - Uzonyi, I. - Elekes, Z. et al. A study of Hungarian medieval glass composition (110)
10.00-10.20 Eggert, G. - Hillebrecht, H., The enigma of the emerald green - Medieval Lead Glass Vessels a la Heraclius (81)
10.20-10.40 McCray, W. P., Strangers in a strange land? - Renaissance Glassmaking in Amsterdam (173)

Coffee break

Session 4c. Provenance stones 6-10
Moderators: Ivelin Kuleff, Tamás Weiszburg

11.00-11.20 Maniatis, Y. - Polykreti, K., Provenance of white marble with EPR spectroscopy: further developments (168)
11.20-11.40 Hovorka, D. - Illásová, L., Peculiar rock-types used by the Neolithic man of southern foothills of the Western Carpathians (127)
11.40-12.00 Wehling, B., The identification of pigments in medieval manuscripts by Raman-microscopy (276)
12.00-12.20 Ciliberto, E. - Spoto, G., X-Ray photoelectron spectroscopy studies of the X-ray induced degradation of ancient pigments (45)
12.20-12.40 Golikov, V. - Nastichenko, O. - Pshenichnova, Y., The analysis of dyening technology of the 4th-8th cc. polychrome coptic textiles from the Louvre Collection (107)

Poster Discussion 2.
12.00-13.00 Sessions Field Archaeology, Experimental Archaeology, Provenance
Discussion moderators: A. Hesse, P. Reynolds, Y. Maniatis, M. Bakos

General Discussion / Closing Address

13.40-14.30 Miklós Bakos, Ferenc Szikossy, Michael Tite

Poster session 1.

1 biomaterials

291 Aveling, E.M. - Heron, C. - Larsson, L. Mesolithic gums and glues: analytical investigations and archaelogical implications
16 Baumer, U. - Koller, J. Characterisation of ancient pitches derived from pine wood by GC and GC/MS
23 Berdnikov, S. An osteological analysis of elk /Alces alces L./ bones from excavations in the Lubana Lake Basin, Eastern Latvia
24 Berzsenyi B. - Gyulai F. The archaeobotanical analysis of the Middle Bronze Age settlement at Bölcske - Vörösgyír
25 Beuls, I. - De Cupere, B. - Van Mele, P. et al. Present-day ovicaprine herding: relevance in the reconstruction of ancient herding at Roman Sagalassos
32 Buckley, S.A. - Stott, A.W. - Evershed, R.P. Characterisation of Embalming resins from ancient Egyptian mummies
40 Chaya, H., J. Exploratory testing of archaeological soils
48 Collins, M.J. - Child, A.M. - Waite, E. R. et al. Bone biopolymers, plugging the credibility gaps
53 Craig, O. E. - Collins, M. G. - Stacey, R. et al. Screening for proteins on the ancient potsherds
68 De La Cruz Baltazar, V. - Edwards, H.G.M. - McColm, I.J. et al. Studies on the state of preservation of archaelogical bone
72 De Reyer, D. - Pilbout, S. - Dennebouy, N. et al. Medieval textiles: Ancient DNA and analyses of metal threads made of animal substrate
89 Ezzo, J. A. Long-term dietary change in the Southern Channel Islands, California: The evidence from San Nicolas Islands
94 Farswan, Y. S. Reconstruction of paleodietary behaviour of archaeofaunal remains of Garhwal Himalaya, India
112 Gulson, B.L. - Jaric, J. - Rainbird, P. - Thomas, R.G. The application of isotopic analysis in the study of Pacific Islander population Dynamics
115 Gyulai F. Chemical and Nutritional Analysis of Food Remains from Hungary / Central Europe
123 Hoogewerff, J. - Kralik, M. - Berner, M. et al. The Origin Of The Tyrolean Iceman Documented By His Bone (Geo)Chemistry
139 Jerem, E. - Rudner, Z. E. Anthracological investigations at Sopron - Krautacker
135 Jim, S. - Stott, A.W. - Ambrose, S.H. et al. The complimentary use of bone cholesterol and collagen stable isotopes for paleodietary reconstruction: Results from animal models
145 Kaup, Y. - Etspüler, H. - Koller, J. et al. Skeletal embalming and natronisation in the Old Kingdom conserves alkaline phosphatase
150 Koller, J. - Baumer, U. The investigation of prehistoric birch pitch find by GC and GC/MS
158 Lazos, L. - Pena, A. - Barba, L. A method for the identification of copal resin in archaeological materials
175 Medzihradszky, Zs. The traces of the human activity in the pollen diagrams of West Hungary
176 Middleton, W. D. - Price, T. D. A teoretical model using strontium isotope ratios and differnial bone remodeling rates in various skeletal elements
186 Olkhovsky, V. S. - Veselovskaya, E. V. On the population of the Aral and the Caspian region during the early Iron Age
191 Panczyk, E.- Ligeza, M. - Walis, L. Analysis of sarcophagi fillings of Egyptian mummies from the Archaeological Museum in Cracov
192 Papagrigorakis, M. - Panagiaris, G. - Vossou, A. et al. From diagenesis to fossilization of buried human teeth
211 Regert, M. - Dudd, S.N. - Pétrequin, P. et al. Chemical investigations of organic materials preserved in Neolithic ceramic vessels from lake-dwellings /Chalain lake, Jura, France/
215 Richards, M. - Hedges, R.E.M. Reconstructing Human Diet in the Neolithic of North-West Europa using Bone Stable Isotopes

2 dating

4a tech/prov metals

4b tech/prov ceramics/glass

257 Tsolakidou, A. - Kilikoglou, V. - Day, P.M. Chemical characterisation of calcareous Bronze Age pottery fabrics from Central Crete
269 Vnukov, S. Method of formalized comparative petrological analysis of ancient ceramic and its application to the Greek amphorae
274 Wang, Ch. - Xu A. Preliminary research on the Provenance of Pottery Zun with big mouth of the Dawenkou Culture

4c tech/prov stone/pigment/plaster

4 Ali, M.F. - Bianchetti, P.L. - Talarico, F. et al. Production and characterization of Egyptian blue and green frit
9 Attanasio, D. - Platania, R. - Armiento, G. et al. The establishment of new Electron Spin Resonance Marble Database
20 Benea, M. - Müller, H.W. - Schwaighofer, B. The single Roman marble quarry in Romania
49 Conati Barbaro, C. - Lemorini, C. Techno-typological and functional analysis of the lithic industry of the Copper Age site Le Cerquete-Fianello (Maccarese, Rome)
54 Crisci, G.M. - De Francesco, A.M. - Lanzafame, U. New non-destructive analytical method in X-ray fluorescence to trace back the origins of archaeological obsidians
63 Daraban, L. - Cosma, C. - Cozar, O. et al. Obsidian provenance studies
74 Dobosi, V. T. - Biró, K. T. Prehistoric and classical stone quarries ("mines") in the Carpathian Basin
75 Dominguez-Bella, S. - Ramos Munoz, J. - Morata-Cespedes, D. et al. Raw materials, source areas and technological relationships between minerals, rocks and prehistoric non-flint stone tools from the Atlantic band, Cadiz province, SSW Spain
291 Ilani, Sh. - Rosenfeld, A. - Dvorachek, M. Mineralogy and chemistry of a Roman remedy from Judea, Israel
154 Kuleff, I. - Djingova, R. - Arnaudov, M. - Gergova, D. Provenance study of iron age amber from Bulgaria
183 Nikl A. - Szakmány Gy. - Biró K. Archaeometrical studies of Neolithic stone tools from Tolna county, Hungary
203 Polykreti, K. - Michael, Ch. - Maniatis, Y. Authenticating ancient marble monuments with Thermoluminescence
249 Szakmány, Gy. - Starnini, E. Petrographical analysis of polished stone tools from some neolithic sites of Hungary
259 Tuncoku, S. S. - Caner-Saltik, E. N. - Böke, H. Pozzolanic properties of some Medieval masonry mortars
266 Vandenabeele, P. - Wehling, B. - Moens, L. et al. Characterization of pigments in Mercatellis manuscripts by total reflection X-ray fluorescence and Raman-microscopy
83 Elekes, Z. - Uzonyi, I. - Gratuze, B. et al. Characterisation of obsidian from the Carpathian source region with different analytical methods

general archaeometry

140 Jovanovic, B. The impact of the Archaeometry on the recent prehistoric research in the Central Balkans

Poster session 2.

3 field archaeology

2 Agris, L. - Ilze, L. - Laimdota, K. Multidisciplinary study of the human impact at the Eini site, Lubana Plain, Eastern Latvia
3 Aidona, E. - Sarris, A. - Kondopoulou D. et al. A detailed study of the archaeological site of Kitros (N. Greece) by combined magnetic and spectroscopy methods
8 Arzhantseva, I. Alanian sites of the 1st mil. A.D. in the North Caucasus. Their topography, building technique and geological evaluation
21 Benech, Ch. - Tabbagh, A. First field trials of a new double frequency E.M. Slingram apparatus CS150
56 Cross, G. M. Comparison of Probe Resistivity and Electromagnatic methods for Archaeological Prospection
57 Cross, G. M. - Williams, E.H. High Resolution Seismic Imaging of Archaeological Remains: field trials in Greece
87 Ergenekon, B. An ethnoarchaeological comparison: The Kerkenes archaeological survey and the legend of Kerkenes city and the Keykavus Castle

111 Gucek, M. - Stokin, M.L. - Oven, K. - Piccolo, M. Evaluation and interpretation of archaeological resources using non-destructive methodologies. Three case studies.
152 Kovalevskaia, V. Mapping of the archaelogical facts
153 Krivanek, R. Geophysical survey and its verification on archaeological sites in Bohemia
161 Link, K. Application of digital spectrophotometry and geophysical prospecting to the analysis of archaelogical activity areas
195 Pavlish, L.A. - Redford, D.B. Preliminary geoarchaeological report: Tel Kedwa, Sinai, Egypt
209 Puszta S. Results of Archaeomagnetic Prospecting in Hungary
208 Puszta S. Magnetic Prospecting in the Proximity of the Town (Problems of data collection and processing)
220 Sampietro, M. M. - Sayago, J. M. Site evolution at Tafi Valley, Northwest Argentina. A geological approach
222 Sarris, A. - Ball, S. - Georgila, K. et al. A Geophysical Campaign at the Neolithic Settlement of Kandou - Kouphovounos (Cyprus)
224 Sarris, A. - Vafeidis, A. - Mertikas, St. et al. Ancient Itanos (Erimoupolis, Lasithi): Creating an archaeological site as a remote sensing laboratory
238 Skripnikova, M. - Arzhantseva, I. - Sedov, S. Pedological studies as a means of reconstructing patterns of Alanian terrace agriculture in the north Caucasus
240 Stanescu, F. - Sonoc, A. Statistical analysis concerning the determination of some probably measuring units utilisated in the ancient Dacian buildings /1st c. B.C. - 1st c. A.D./ in the Orastie Mountains (Romania)
246 Sümegi P. - Kertész R. - Hertelendi E. Environmental change and Human Adaptation in the Carpathian Basin at Late Glacial / Postglacial Transition
256 Trejo, C. Characterization of a sedimentary matrix by particle size and chemical analysis to determine activity areas in a quarry tunnel at Teotihuacan, Mexico
288 Zilivinskaya, E.D. The technical arrangement of the bath-houses in the Golden Horde and its genesis
85 Erdogar, N.J. - Özer, A.M. - Yyldyrymi, H. et al. Application of principal components analysis and edge enhancement techniques for the detection of prehistorical sites in Central Anatolia

4a tech/prov metals

27 Bezúr, A. What's beneath the surface? - A look at metal working techniqes from the Central Andes
37 Calliari, I. - Magrini, M. - Dabala, M. et al. Chemical and microstructural characterisation of Paleovenetian bronze thin plates
41 Chernykh, E. N. - Rovira, S. Early metallurgy in the Eurasian steppe: minerals and slags analysis from Kargaly /Russia/
52 Cowell, M. - La Niece, S. - Rawson, J. A study of Later Chinese Buddhist Metalwork
77 Doonan, R. Defining significance: problems in dealing with Cu-As and Cu-As-Sn alloys
159 Ercanli, L. Structural studies on the metallic artifacts of Phrygian period
92 Farquhar, R. M. - Williams, P.J. - Pavlish, L.A. et al., Metallographic examination of prehistoric copper from the Great Lakes region of North America
104 Giumlia-Mair, A. - Lehr, M. Experiments on ancient patination processes of black bronzes
124 Horváth, F. - Költő L. - Balla, M. et al. About our symbol - Complex analysis of the Szeged-Szillér depot find
130 Ingo, G.M. - Chiozzini, G. - Tucci, P. et al. Determination of the iron ore source exploited for early iron smelting at Tell Afis /north-western Syria/ through microchemical studies
133 Jacanovic, D. - Madas, D. The quantitative and statistical analysis of Late Bronze Age - Early Iron Age deposits in Serbia
156 Kasztovszky, Zs. - Vaday, A. Prompt - gamma activation analysis of roman broches
164 Maclean, P.I. - McDonnell, J.G. A study of antimony bronze alloys from the Late Bronze Age of the Carpathian Basin
174 McGeehan, V. The complexity of copper mineral acqusition in the Aegean, Third Millenium BC.
201 Pernicka, E. - Begemann, F. - Schmitt-Strecker, S. Ai Bunar and more: Multi-centered copper production in the south-east European Chalcolithic
202 Pifferetti, A. A. The copper metallurgy in the Condorhuasi-Alamito Culture of Argentine Northwest (200-400 A.D.)
207 Prychodnyuk, O. - Prychodnyuk, Y. New data on the technologies of Jeweller Products of Pastyrske Fortified Settlement
293 Sertok, K. - Palmieri, A. M. - Squadrone, F. F. An archaeometallurgical survey in the ancient mining area of Hadim-Bozkir
247 Szabó, G. Archaeometallurgical investigation of the LBA bronze objects in the Carpathian Basin
250 Vályi K. Glockengiesserei und Bronzeschmelzöfen im Hof des Klosters von Szer vom Anfang des 13 Jhs.

4b tech/prov ceramics/glass

4c tech/prov stone/pigment/plaster

5 theme session experimental archaeology and its impact on scientific archaeology

general archaeometry

1. Tin Bronze Metallurgy in Transformation: Analytical Investigation of Crucible Fragments from Tell Judaidah, Amuq (Turkey) Dating to circa 3000-2900 BC

A. Adriaens*, B. Earl, K.A. Yener*****

*University of Antwerpen, Department of Chemistry, Universiteitsplein 1, B-2610 Antwerpen, Belgium
**Heathercliffe, Sennen, Penzance, Cornwall, TR19 7AX, UK
***The Oriental Institute, The University of Chicago, 1155 E 58th Street, Chicago, IL 60637

Between 1932 and 1938 the Oriental Institute of the University of Chicago excavated several sites in the Amuq valley in the Hatay province, Turkey. The sites have held great interest for early metals researchers ever since the discovery of the six Amuq G polymetallic figurines and a crucible with a tin rich copper encrustation from Tell al-Judaidah, which are to date, the oldest tin bronzes in the Near East. Several copper artifacts from Phase G (c. 3200-2900 BC) contain appreciable tin contents as well. Indications exist of copper utilized since the earliest period if incipient agriculture, the Neolithic, Phase A. Important hints to the presence of an innovative metal technology exist from the subsequent Chalcolithic period: alloying copper first with arsenic in Phase F levels (c. 4500-3500 BC), and nickel rich alloys and tin in Phase G.

In the study we have concentrated our work on the examination of the residue adhering to the inner surface of the Phase G crucible. Electron probe X-ray microanalysis (EPMA) and secondary ion mass spectrometry (SIMS) were used to obtain detailed compositional analyses of the material. The data were compared with products obtained by experimental simulation of copper and tin smelting under different conditions. The goal of the latter essentially existed in assisting the interpretation of analyses of excavated metal industry products from the Amuq. Results were able to demonstrate that the Amuq residue is a result from alloying copper and tin. The latter implies that the metal alloy preparation was actually done at the site.

2. Multidisciplinary study of the human impact at the Eini site, Lubana Plain, Eastern Latvia

Lacis Agris* - Loze Ilze - Kalnina Laimdota*****

*Geological Survey of Latvia
**University of Latvia, Institute of History of Latvia
***University of Latvia, Faculty of Geographical and Earth Sciences

The Eini site is located in Lubana Plain (Eastern Latvia) which is unique by its direct reflections of the Holocene events and rich in archaeological finds and discoveries with 27 Stone Age settlements dated by 80 ^{14}C dates. The aim was to collect and integrate data from geological, geophysical, topographical investigations of the site, palynological analyses of two cores - Eini Lake (int. 0.0-6.3 m, 170 samples) and Eini site (int. 0.0-1.57 m, 87 samples), radiocarbon dating and archaeological and archaeozoological studies in order to attempt a coherent reconstruction of changes in the landscape and cultural history in Eini site.

New palynological data, a set of geological and archaeological studies in the area demonstrates in detail the Holocene vegetation development and the increase in human impact. The studies of the sediments from both cores (Eini Lake and Eini site) provide comprehensive information of the vegetation history and environment development and fixed a limited human impact (the presence of anthropogenic indicators - Plantago lanceolata, Plantago major/media, Rumex acetosa/acetosella, Polygonum aviculare, Brassicaceae) on the local environmental conditions during the Atlantic time (AT2) Neolithic. The palynological indications suggest a fluctuating character of human activities. The first few Cereales are found at the Middle Atlantic, but the real start of the introduction of Cereales is likely to have happened at Subboreal (int. 0.9-0.6 m Eini site section), Late Neolithic, when hunting and fishing dominated, but early farming had a secondary subsistence strategy. Human impact on the environment is traceable in both the investigated diagrams: a relatively short-term minimum of Corylus is accompanied by the decline of Ulmus and Tilia and the increase in the meadow and ruderate community graphs along with the appearance of Cereales.

This kind of research is necessary to carry out in all settlements in this region.

3. A detailed study of the archaeological site of Kitros (N. Greece) by combined magnetic and spectrometry methods

Aidona E.*, Sarris A., Kondopoulou D.*, Sanakis Y.*****

*Geophysical Laboratory, University of Thessaloniki, 54006 Thessaloniki, Greece.
**Institute of Mediterranean Studies, F.O.R.T.H., Rethymnon, Crete, Greece.
***Nuclear Research Center "Demokritos", Athens, Greece.

The archaeological site "Louloudia - Kitros" was created in 479 A.D. when the Bishop of Pydna moved there after the Goths' occupation of his former seat. The complex (80x90 meters) consisted of a Basilica, the Bishop's residence and installations for the production of wine and olive oil. The settlement was destroyed by an earthquake around the middle 6th century A.D. and later on was used as the locus of workshop activity.

Soil samples were collected from several trenches within the archaeological site, as well as radial traverses around kilns, which were used for glass production. Finally, samples were collected from a long traverse, starting from the middle of the archaeological site and extending outside of the site, in order to identify the limits of the archaeological settlement. Magnetic susceptibility measurements have shown significant variations with depth. Spectrometry analysis (ESR) of these samples has shown a large amount of iron oxides and, in some cases, important contents of manganese. In selected samples, Mössbauer spectrometry analysis was applied to define the percentage content in iron oxides. IRM measurements are also in progress in an effort to refine the distinction of the samples originating from different areas of activity.

The above experiments were successful in identifying the different occupation levels and the boundaries of the archaeological site. High values of magnetic susceptibility and iron oxide content were well correlated with the periods of intense human activity. Around the kilns, the mean values of the magnetic susceptibility indicated the effect of the fire mechanism in the surrounding area and also gave some first evidence concerning the use of the kilns. Comparison of the magnetic and chemical properties of the anthropogenic soils suggests that their enhancement may be used as an index for locating areas and features of archaeological interest.

Additionally, archaeomagnetic data have been obtained from a pottery and a glass kiln of the site. The magnetic components ($D = 355^o$, $I = 62^o$, $a = 3.6$ and $D = 356^o$, $I = 51^o$, $a = 2.3$) were correlated to the reference curves compiled for Greece (Evans, 1996) and showed a satisfactory consistence for the declination but some deviation for the inclination of the recorded magnetic field values.

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4. Production and Characterization of Egyptian Blue and Green Frit

M.F. Ali*, P.L. Bianchetti, F. Talarico**, M.G. Vigliano****

*Cairo University-Faculty of Archaeology - Dept. of Conservation
**Instituto Centrale per il Restauro, Roma

The study of Egyptian blue and green frit were developed owing to the knowledge of the pigment production techniques. Most of the published works to treat the characterization and the production of Egyptian blue, while a few works deal with the green frit. The aim of the present work was to produce and to characterize green frit from pure chemical components or from Egyptian materials (desert sand, copper objects).

Grounded materials were added of sodium carbonate as flux then mixed with water or Arabic gum to get cakes and heated in a muffle furnace to various temperatures, obtained products were analyzed by XRD, colourimetric analysis and examined under mineralogical microscope. Cuprorivaite and tridymite characterize all the samples of pigments obtained at 850 ^oC and the appearance blue colour, samples heated to 1050 ^oC denote the disappearance of cuprorivaite and the appearance of a green glass (green frit). It seems that wollastonite is generally present in mixtures containing a lower amount of copper.

We observe the presence of green glass and tenorite, while cuprorivaite is absent in the samples if pigment obtained under reducing atmosphere. Results should indicate that 950 ^{o}C is a transition temperature where it is possible to observe different processes, probably due also to kinetic effects.

5. Pilot Validation Study for the use of Bromine as a tracer of Sea and Salt routes in ancient cultures

E. Aloupi*, A. Karydas, T. Paradellis**, I. Siotis*****

*THETIS - Science and Techniques for Art History Conservation Ltd., 41M. Moussourou str., 116 36 Athens
**Laboratory for Material Analysis, Inst. of Nuclear Physics, NCSR "Demokritos", 15310 Ag. Paraskevi, Greece
***Inst. of Nuclear Physics, NCSR "Demokritos", 153 10 Ag. Paraskevi, Greece

The aim of the project is to validate a new approach for the tracing of sea-salt routes in ancient material culture. Salt, on account of its importance for the human organism, has played and continues to play a significant role in the history of peoples and has on occasions been the pretext for war. In the archaeological record the production and circulation of salt can be traced from as early as the Neolithic period in Egypt and Europe. In spite of its importance, due to the fact that alkali salts are easily dissolved and are difficult to trace in ancient material culture, there is a complete lack of scientific evidence concerning salt contacts. The key-idea is the use of bromine and its compounds as a tracer of the contact between sea-water and sea-salt with ceramic and lithic artefacts or structures. Bromine offers a very powerful discriminating criterion between marine and terrestrial environments. Br occurs in the hydrosphere as soluble bromide salts. Its concentration in sea-water is 65-70 ppm while in earth's crust and streams is only 4.0 and 0.02 ppm, respectively. This is further accentuated between the marine and terrestrial biosphere (seaweed, sponges, shells, plants etc.) due to the formation of organic bromine compounds. In the case of salt and salt brines (the main source of Br in modern industrial practice) it exceeds 2500 ppm.

Experimentally, Br concentration can be measured by using the straightforward and well established X-Ray Fluorescence (XRF) technique, which through the recent development of high resolution, ambient temperature, portable instruments lends itself for quick, non-destructive, in situ measurements and surveys with sensitivity of a few ppm.

In order to validate the technique before it can be reliably applied to address archaeological questions, a series of preliminary tests and measurements were performed on ceramics and lithic artefacts subjected to contact with sea water and salt under laboratory conditions. In addition, several ceramic artefacts which are known through the archaeological record to have served as salt or salt brine containers recovered in inland burial environments were also analysed. To this effect the Br concentration was measured on fragments of shallow dishes used in the "briquetage" salt making technique, as well as on "oxygaron" vases (containing vinegar and garum, a fish sauce) found in Eleftherna, an inland archaeological site in Crete. The measurements will be compared with Br concentrations in similar artefacts for which the archaeological record excludes salt contact. The results are very encouraging and confirmed the view that the Br concentration measured as a function of depth from the surface provides a unique "sea salt" signature.

6. EDXRF study of Tupiguarani archaeological ceramics from the north of Paraná state in Brazil

Appoloni, C. R. *, Espinoza-Quinones, F. R.*, Aragao, P.H. *, Cuevas, A. M. **,*, Cesareo, R. ***, Coimbra, M. M. *, Borlino, C.C.***, do Nascimento Filho, V. F.******

*Physics Department, State University of Londrina (UEL), Londrina, PR, BRAZIL
**National Center for Scientific Research of Havana, CUBA
***Institute of Mathematics and Physics, University of Sassari, ITALY
****Physics and Meteorology Department, ESALQ, University of Sao Paulo, Piracicaba, SP, BRAZIL

The first evidences of human settlement in Paraná state are from 10000 years ago. In this region, about 1500 years ago, horticulturalists and ceramists populations appeared, represented by the Tupiguarani and Itararé groups. The Tupiguarani lived in the valley regions of the Paraná, Ivaí, Tibagi and Iguaçu rivers. The Tupiguarani sites are related to the Guarani indians ancestors. Tupiguarani populations lived in the region of the Santa Dalmacia farm at the end of the 16th century or at the beginning of the 17th century and they had contact with the colonizers, probably Spanish, due to the observed changes in the pottery production

characteristics. The Santa Dalmacia farm archaeological site was accidentally discovered in 1990 and belongs to Cambé city municipality, north of Paraná state, south of Brazil.

The objectives of this work are: to analyse the ceramic paste composition, as well as the superficial layer of the ceramic fragments, in order to get information about the pigment composition of the plastic decoration; comparison of the ceramic pastes composition between typical Tupiguarani fragments and the fragments that present characteristics of contact with the European colonizers.

The analytical technique employed was the energy dispersive X-ray fluorescence (EDXRF), in two different experimental set-ups. The first set of measurements was carried at Sassari University with two X-ray tubes (30 kV and 0.1 mA; 80 kV and 5 mA), secondary targets of silver and gadolinium, and an Amptek Si-PIN detector, thermoelectrically cooled, having an 70 mm Be entrance window and 300 mm thickness. The second one was carried at Sao Paulo University using a ^{238}Pu radioactive source and a Si(Li) detector with a Be window. X-ray spectra were processed and quantified (at Sassari and Londrina) by using the AXIL program.

The ceramic pastes can be characterized by a low Ca content, and a systematic presence of relatively high concentrations of Ti. Fe is also always present at high levels, and Ni, Cu and in some cases Zn at level of traces; Rb, Sr, Y and Zr are also present, and Ba in all samples at low concentration.

The black pigment in the pottery plastic decoration is due to the presence of Mn, the red pigment is due to the presence of Fe, while the white pigment is characterized by the presence of Ba.

Other qualitative and quantitative results were obtained for each kind of ceramic fragment group and will be also presented.

7. Techniques applied to decoration of bronze artifacts from Late Bronze Age of Burgundy (France)

Barbara Armbruster, Michel Pernot

UMR Achéologie de la Bourgogne, Université de Bourgogne, Dijon, 6, boulevard Gabriel F-21 000

This paper aims to give some results coming from an archaeometallurgical research project recently started, studying two technological aspects of bronze objects from Late Bronze Age to "Gallo-Roman" times. The first concerns the forming processes, the second is related to decoration techniques. The contribution focuses on the questions related to the manufacturing techniques and tools used for decoration. Decoration may have been executed by plastic deformation (tracing, repoussé, punching, stamping) or by cutting off metal (engraving, chiselling, spinning, abrasives). For understanding necessities and cultural choice as well as technological changes, it is important to find characteristic features for distinguishing the two techniques. Special interest lies on the execution of incised ornaments on sheet as well as on massive bronze objects, with incisions having mostly a linear traces of geometric design.

The Late Bronze Age hoards of Burgundy are rich in sets of exceptional quality. Some examples will be selected for the presentation of technological details. Various groups of decorated objects are associated in the hoard of Blanot (Cote-d'Or). Predominantly techniques of plastic deformation can be studied on flasks, vessels, bracelets, rings and other jewellery. The hoard of Villethierry (Yonne) includes pins with decorated massic head, worked by spinning on a lathe. A set of tools, used in decoration of metal work was found in the hoard of Génélard (Saone-et-Loire). The study aims to find features in tool marks determining and distinguishing the mentioned operations of the metal worker.

The technological information was obtained by the study of Burgundian bronze artifacts, combining optical observation for the identification of tool marks, metallographic examination, X-ray photography and metal analyses. Ethnoarchaeological and experimental studies were also considered. A multidisciplinary approach in the study of ancient metallurgy and metalwork is proposed.

8. Alanian sites of the 1st mil. A.D. in the North Caucasus. Their topography, building technique and geological evaluation

Arzhantseva, Irina

University of Moscow Fac. of History, Archaeological Dept. 1 Tverskoi Iamskoi Pereulok 14-19 125047 Moscow, Russia

A series of heterochronous Alanian settlements of the 1st -early 2nd millennia A.D. have been singled out as standard sites for the present study. The Alans formed a powerful union of Iranian-speaking tribes that played an important role in the North Caucasus and Southern Russia at the time. While Alanian burial sites have been well studied, their settlements have been neglected. Besides traditional archaeological investigation, geo-archaeological research has been undertaken. Since the majority of the said sites are fortified towns on mountain ridges, the making of large-scale topographic maps pinpointing all visible building remains is of primary importance. We succeeded in mapping fortified towns of Kiafar, Gornoe Ekho, and Achipse using the method of all-round measuring of relief alterations. The method in many cases has proved to be more effective than the aerial photograph and has enabled us to evaluate the pattern of the sites in question, while the aerial photographs are useless, if a site is afforested or its relief too complicated.

We have also examinated building materials and their origin. Special attention paid to the building technique has enabled us to date the sites in question more accurately and to estimate the degree of cultural influence of adjacent regions such as Byzantium and Transcaucasia.

The geological evaluation of the sites has enabled us to investigate the geological situation at the time of the formation of a site as well as the nature and intensity of its deterioration and the way of its conservation in modern ecological conditions.

9. The Establishment of a New Electron Spin Resonance Marble Database.

D. Attanasio *, R. Platania **, G. Armiento **, M. C. Emanuele***

*Chimica dei Materiali
**Metodologie Avanzate Inorganiche e
***Strutturistica Chimica del CNR, P.O.Box 10, 00016 Monterotondo Staz., Roma, Italy

Recent work from this laboratory has confirmed that ESR spectroscopy may yield valuable information concerning the provenance determination of classical marbles, provided that the data analysis is carried out using a suitable, properly constructed database. Coupling of ESR results with some other physico-chemical method (isotopic analysis, neutron activation analysis or others) may reduce or eliminate the remaining uncertainties and provide a definitive answer to the marble provenance problem. In addition ESR measurements are reasonably simple and fast, they require limited sample amounts (ca. 30 mg) and almost no sample preparation.

On these basis we have decided to re-examine the whole subject and to set up a comprehensive, totally new electron spin resonance database, starting from scratch.

The variables taken into account are the intensity and linewidth of the Mn^{2+} impurity commonly present in marbles, the fraction of dolomitic Mn^{2+}, which is also frequently detected, plus the occasional presence of other paramagnetic impurities. Additional non ESR variables (grain size and others) are being considered for inclusion into the database. Particular care has been devoted to the standardization procedures of data collection and analysis, so as to obtain data which can be easily reproduced and expanded by other users.

Up to now more than 300 samples from at least ten different, historically relevant Mediterranean quarries have been measured. In addition we have considered other relevant aspects of the problem. Among others they are the detailed examination of parameters variability within a single quarrying district or within single blocks of different dimensions, as well as the effect of weathering on the electron spin resonance parameters. Some work has been also carried out on non-white marbles (“Cipollino Verde”).

All the data have been analyzed with the aid of multivariate statistical techniques. Selected examples and case studies will be presented and discussed.

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10. Analysis of some Metallic Objects from the Necropolis of *Saticula* (Sant'Agata Dei Goti, Benevento, Italy)

Giuseppina Balassone*, Giovanni Di Maio, Maria Boni*, Maria Fariello*****

*Dipartimento di Scienze della Terra Universitá di Napoli
**GEOMED S.A.S.
***Sovrintendenza Archeologica per le province di Salerno, Avellino e Benevento

In some of the tombs (T. 26 and T. 139) of the Sannitic necropolis of Saticula (Sant'Agata dei Goti, Benevento), spanning in age between the 6th and the 4th century B.C., a few very peculiar rings have been found, made of a dark, partly altered metal alloy, and with a circular or ellipsoidal setting hosting various figures in relief (athlete, running animal, human face etc.). More in particular, owing to their association with well dated ceramic material, the rings can be assigned to the second half of the 4th century B.C.
On these objects several types of chemical and mineralogical studies have been performed, ranging from X-ray diffractometry, to SEM and Electron Microprobe semiquantitative and punctual quantitative analysis, in order to investigate the nature (and the proportions) of the metals present in the alloy, as well as their alteration products. On the following Table are listed the more characteristic compositions recorded on some of the analyzed ring fragments.

	A	B	C	D	E
Pb	94.95	94.9	82.01	0.71	95.75
Sn	0.78	3.08	14.29	97.14	0.14
Ag	0.86	0.92	1.02	2.09	0.75
Cu	0.11				3.6
Al	0.12	0.17		0.15	0.16
Total	96.82*	99.07	97.32*	100.14	100.4

* some Pb can be found as oxides, carbonates etc.

A: bronze-coloured matrix
B: silver-grey areas at the border of A
C: dark-grey areas with high relief
D: inclusions in A with very high reflectivity
E: punctual analyses in A with variable chemical composition

As can be seen, the alloy consists mainly of Pb, in dominant proportion on Sn, less Ag (probably associated to Sn) and sporadic Cu. The proportion of tin in the alloy, however, is not always constant, ranging from an average of few % to almost 100% in selected areas of the rings, probably due to immiscibility processes during imperfect smelting.

11. Geophysical Studies of Archaeological Structures under the Pavement at Mexico City

Luis Barba, Agustin Ortiz

Laboratorio de Prospección Arqueológica, Instituto de Investigaciones Antropológicas, UNAM. Ciudad Universitaria. México D.F. 05410, email: barba@servidor.unam.mx, Tel/Fax: (5)622-9651

Old cities around the world share problems like the overlapping of several cultural layers. This implies the question, how to study previous structures preserving modern constructions? High resolution geophysical techniques provide some answers. Preserving buildings on top, geophysics supply information concerning extension and depth of buried structures. This kind of information leads subsequent archaeological excavations to verify and obtain detailed information.

Mexico City is one of these cities. Prehispanic settlements are under the pavement of the present urban development. Studies performed at Coyoacan have demonstrated that topographic, magnetic, electric and radar surveys can identify the presence of buried structures under the pavement, even though there is some degree of interference characteristic of urban environment. This synoptic approach, where techniques complement each other, permits a better and more confident interpretation of geophysical results.

12. Some Analyses of Glazes from Assur in Mesopotamia/Iraq

Hans-Georg Bartel, Horst Hennig, Günter Kauschka

Humboldt University Berlin, Institute of Chemistry

The Berlin Vorderasiatisches Museum SMPK has a large collection of objects from excavations at Assur in Mesopotamia/Iraq, operated by WALTER ANDRAE and his team between 1903 and 1914. Several glazes of objects from this collection were studied:

Old-Assyrian spacer beans (glazed sintered quartz, 18^{th} century BC)

Neo-Assyrian glazed pottery and knob plates ($10^{th} - 7^{th}$ century BC)

Fragments of Parthian sarcophagus lids (2^{nd} century BC – 3^{rd} century AD)

The aim of this study is to compare glazes from Assur produced in different pre-Islamic periods with those of other sites in ancient Mesopotamia. The composition of the glazes and the chemical nature of their colorants were of specific interest.

The studies were carried out using a Akashi Alpha-9 scanning electron microscopy (SEM) fitted with a qualitative energy-dispersive Röntec X-ray spectrometer (EDX).

The results obtained are:

(i) Generally, the compositions of the Assur glazes produced in periods (b) and (c) are similiar to those ones excavated in Nippur [2], Nimrud [3], Kish [4], Niniveh[4], Uruk[5]. They are all alkaline glazes. The presence of lead in yellow samples is due to its use as a colorant.

(ii) The methods of glazing are the application of glaze at the time of (b) or (c) and self-glazing at the time (a).

(iii) Green and blue glazes are always coloured by CuO, yellow ones by PbO, and black ones by MnO/FeO. Silica was only used as colorant and opacifier in white glazes. Red coloured parts observed in green glazed Parthian sarcophagi are caused by hematite crystals.

As an example, the comparison of Parthian glazes from Assur with some other glazes produced in Mesopotamia is shown in the following table:

Average composition (wt-%) for some glazes of Mesopotamia

site/time/reference	SiO_2	Al_2O_3	Na_2O	K_2O	CaO	MgO	Cl	SO_3	P_2O_5	Fe_2O_3	CuO
Assur/Parthian	66	4	11	4	7	4	1	1	tr	2	<1
Nippur/1400 BC/[2]	64	2	14	2	6	6		1		1	3
Nimrud/715 BC/[3]	63	<1	17	3	6	5		1	tr	tr	3
Uruk/201 BC/[5]	65	3	9	2	7	5	1	1	2	2	2
Kish/Parthian/[4]	70–75	4	7	2	6	4				3	
Niniveh/Parthian/[4]	70–75	4	6	4	4	2					

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These studies were supported by Deutsche Forschungsgemeinschaft

13. Obsidian trade - the South-Eastern connection

Yannis Bassiakos*, Katalin T. Biró, Vassilis Kilikoglou***

*Laboratory of Archaeometry, NCSR Demokritos, Aghia Paraskevi, Attiki 15310, Greece.
**Hungarian National Museum, Dept. of Information

Obsidian is among the well known markers of cultural relations and trade in prehistory. As its conditions of formation are very special, it is found in a limited number of districts and localities within Europe. Within the framework of a Greek - Hungarian bilateral collaboration project, two focal point of this exchange system are studied: the Aegean obsidian sources and the Carpathian source region. The main purpose is to find adequate discriminating features, with minimum damage to the object. In the first phase, investigations are concentrated to geological samples which are studied in a parallel manner. This approach is most important because interaction of the distribution zones have already been demonstrated by single items. These very remarkable pieces of occurrence, however, were found outside the typical area of distribution for the two source districts where obsidian finds are extremely rare and, consequently, more precious - both to contemporary inhabitants of the region and also to present day archaeological research.

Routine techniques of analyses are applied on source collected samples (NAA, XRF) complemented by mineralogical and petrological analyses. Moreover, a database approach is used to collect all discriminating features for a safe and reliable source identification. In the second phase of the project, special emphasis will be given to "problem areas" and potential contact zones.

14. ESR spectroscopy of calcitic encrustations on archaeological finds, serving as authenticity test

Y. Bassiakos*, C. Doumas**

*Lab. of Archaeometry, NCSR «Demokritos», 15310 Ag. Paraskevi Attiki, GREECE
**Univ. of Athens, Dept. Of History and Archaeology, University of Athens, 157 84 , Zografou, Athens, GREECE

Terrestrial calcite encrusting archaeological pieces of art (mainly statues or vases) is often created during millennia of accidental burial in the earth.

This material is usually removed from the archaeological surfaces during conservation. However it may provide valuable information concerning the authenticity of the objects, in cases when the context is not completely known. By means of Electron Paramagnetic Resonance spectroscopy the signal at g=2.0007 can easily be detected on small pieces of these calcitic crusts. The existence of that signal provides indisputable evidence for the authenticity of the relative object.

Recent archaeological inquiry on the authenticity of precious museum objects has enabled successful implementation of the above spectrometric study. The results definitely showed authenticity of the related objects.

EPR spectroscopy on calcitic crusts, regarded as an authenticity test, has the unique advantage of not affecting the object itself. Additionally the process is easy, quick and requires a very limited mass of the material (0,1 gr.) for the entire measurement.

On the other hand the application is confined only to objects layered with the above kind of encrustation. Also it is known that not every calcitic encrustation - even formed since some millennia - show detectable EPR signals. On unfavourable circumstances the lack of any signal does not automatically mean that the object under investigation is fake.

On-going study includes detailed analyses on radio-nuclides of the encrustation, EPR spectroscopy in low temperatures, application of the process to archaeological finds from sub-marine environments (g=2.0033), ivory and bone archaeological objects (g=2.0018).

15. Metallurgical evidence for local copper exploitation at Akrotiri, Thera: First Results

Y. Bassiakos*, A. Michailidou**

*Lab. Of Archaeometry, NCSR «Demokritos», 15310 Ag. Paraskevi Attiki, GREECE
**Research Centre for Greek and Roman Antiquity, N.H.R.F., 48 Vas. Constantinou, Av., 116 35 Athens, GREECE

The pre-volcanic basement of Thera island belongs to the Cycladic crystalline belt, often bearing metalliferous parageneses. Copper mineralization in the form of the oxides malachite ($CuCO_3.Cu(OH)_2$) and chrysocolla ($CuSiO_3.2H_2O$) is well known in the country rock, exposed at two sites of the caldera, namely at Thermia and Athinios, hosted in the low-grade metamorphic formations.

Metallurgical studies were carried out on two crucibles, several pieces of high siliceous vitrified material and one piece of semi-molten cupriferous green/blue schist, which come from the LBA excavation at Akrotiri, most of them recently discovered and presented here for the first time.

Samples of the iron-copper mineralization along with the including Theran were also mineralogically and geochemically analysed.

The existing results (Optical Microscopy, XRD, SEM, EDXA, ICP) provide strong indications that copper smelting/melting activity took place at Akrotiri, using the local metal sources.

By further analytical studies any possible correlation between Theran copper sources and Akrotiri copper objects will be investigated.

16. Characterisation of Ancient Pitches derived from pine wood by GC and GC/MS

Ursula Baumer, Johann Koller

Doerner-Institut, Barer Strasse 29, 80799, Munich, Germany

Wood tar produced from pine wood was the origin of the pitches widely used in the past as glue, sealing material, water-proof protective cover, lubricant and disinfectant. For millennia it was extracted from the resinous wood of pine trees in a slow smouldering process (kiln carbonisation). Tar may also be obtained directly by dry destillation of the balsamic resins collected from these trees.

In historical times pine pitches played an eminent role as protective coating and sealing material in shipbuilding. Hence, many of the historical 'resin samples' in our investigation were taken from this field (caulking material).

Traces of pine pitch were also found in Roman wine amphorae and in materials used to embalm Egyptian mummies in the era of the Old Kingdom. In more recent time (18th century) wood tar was used as mortar glue in floor mosaics.

The present investigations were carried out by gas chromatography, while accurate peak identification was achieved by gas chromatography/mass spectrometry.

The results showed evidence of natural resins components (bio-markers) and of products formed thereof by destructive destillation (degradation-markers). This blend of bio-markers and degradation-markers is formed for two reasons: a) in the kiln carbonisation process heat isomerisation reduces all but two of the resin acids originally present in the wood, viz. stable dehydroabietic acid and residuals of abietic acid; b) under destructive destillation conditions wood extractives are decomposed and resin portions are partially aromatised. This leads to the formation of terpenoid hydrocarbons such as retene from resin acids.

When kiln carbonisation occurs under excessive temperatures it is retene that is predominantly being formed, whereas dry destillation under pronounced oxygen influx leads mainly to the formation of oxo-dehydroabietic acid.

Moreover, compounds (vinegar and methanol) released from wood in the course of dry distillation lead to the formation of resin esters. Pitches obtained directly from balsamic resins do not contain these compounds and, therefore, no resin esters either.

Wood tars from conifers are therefore differentiated from other pitches on account of the following three characteristic components: Dehydroabietic acid, retene and methyl dehydroabietatd. Based on these characteristics the caulking materials and the contents from the amphorae are therefore considered wood tars but not the mortar glue where no evidence of resin esters was found.

17. Sample Size Considerations in Provenance and Related Studies

M.J. Baxter, S. Westwood

Dept. of Mathematics, Statistics and OR, The Nottingham Trent University, Clifton Campus, NOTTINGHAM NG11 8NS, UK.

Provenance studies of ceramics, glass and metals frequently use multivariate statistical methods to identify structure, or its absence, in compositional data sets. The paper reports on work aimed at providing guidance on the sample sizes needed to detect different kinds of structure. This was stimulated by investigations into the sample sizes needed to detect non-normality in lead isotope data, but has wider application.

Given a sample of n specimens, measured on p variables, multivariate methodology is often used to exhibit separation into two or more groups. How large should n be to demonstrate separation convincingly, or show that a sample is homogeneous? This is difficult to answer, since it depends on the structure which is usually unknown in advance of data collection. An idealised model for an homogeneous data set is that it has a multivariate normal distribution. Departures from normality, that exhibit multi-modality, indicate structure in a set of data. Simulation of mixtures of normal distributions allows investigation of the sample sizes needed to detect non-normality. Similarly, sub-sampling from large and real data sets that exhibit structure allows the same question to be addressed.

We report on some simulation studies, with applications to lead isotope and glass compositional data sets. Although some conclusions are rather obvious (e.g. small samples are usually adequate to identify well separated groups), the main finding is that much larger sample sizes than those often used, or recommended, may be needed to identify informative patterning in some common areas of archaeometric application.

18. Ancient pine tar technology: Correlation between manufacturing methods and composition

Curt W. Beck*, Edith C. Stout*, Karen Lee*, Dieter Todtenhaupt, Andreas Kurzweil****

*Amber Research Laboratory, Department of Chemistry, Vassar College, Poughkeepsie, New York 12604, USA
**Arbeitsgruppe Teerschwele, Museumsdorf Düppel, 14163 Berlin, Germany

Among the prehistoric and early historic methods of manufacturing pine tars in Central Europe are the *Meiler,* in which an earth-covered stack of wood is partly burned and partly pyrolyzed, and the double-pot method, in

which wood chips in a perforated ceramic vessel are pyrolyzed by external heat and the tar is collected in a second vessel bellow. Experimental tars made by both methods and remains of archaeological tar found at Spandau near Berlin have been analyzed by ^{13}C nuclear magnetic resonance spectrometry and their individual constituents have been determined quantitatively by combined gas chromatography - mass spectrometry in order to correlate the composition with the manufacturing method. Both experimental tars contain comparable amounts of resin acids, but in the double-pot tar the degree of esterification (37%) is more than twice that found in the *Meiler* tar (16%), indicating a higher operating temperature. The same conclusion follows from the higher degree of aromatization in the double-pot tar (40%) over that in the *Meiler* tar (32%). The composition of the archaeological tar differs radically from that of both experimental tars in that it contains a large number of oxidized resin acid that cannot have been formed in the manufacturing process, but are the result of post-depositional weathering. The compositional data illustrate the problems and the promise of technological inferences from chemical analysis.

19. Characterization of Colombian and Ecuadorian obsidian sources and Prehispanic obsidian trading

L. Bellot-Gurlet *, O. Dorighel *, G. Poupeau *, Th. Calligaro **, J.-C. Dran **, J. Salomon **, R. B. Scorzelli *, A. M. Rossi *****

*Groupe de Géophysique Nucléaire, UPRES-A N°5025 of CNRS and Université Joseph Fourier, Institut Dolomieu, 15 rue Maurice Gignoux, 38031 Grenoble, France. E-mail : poupeau@ujf-grenoble.fr
**Laboratoire de Recherche des Musées de France, 6 rue des Pyramides, 75041 Paris cedex 1, France. E-mail : dran@aglae1.culture.fr
***Centro Brasileiro de Pesquisas Fisicas, rua Dr. Xavier Sigaud 150, 22290-180 Rio de Janeiro (RJ), Brazil. E-mail : scorza@novell.cat.cbpf.br

Progress in sourcing studies of obsidian artefacts in the Northern Andine Area (NAAr) calls for a better knowledge of potential source characteristics. We present new sources and revisit the chemical characterization of NAAr geological obsidians.

Results are given for samples of the Rio Hondo (Colombia) and the Sierra de Guamani (SG) (Ecuador) sources previously analysed. New samplings include obsidians from the Mullumica and Callejones SG flows. The Mullumica flows deserve a special effort of characterization, due to their mixed magma compositions, because they are often cited as possible sources for NAAr artefacts.

Obsidians from newly sampled potential sources are in Ecuador that of Rio Guambi (downward the SG), two outcrops on the Cotopaxi volcano (30 km S of the SG) and in Southern Colombia that of Rio Granates and pseudo-tektites from the Cali region.

For the first time, obsidian sources of the NAAr are characterized by ICP-AES/MS (35 element contents determined). As PIXE analyses (13 elements) on natural and internal surfaces are used in artefacts sourcing studies in the NAAr, the relative merits of ICP and PIXE for the discrimination between sources will be commented.

Other source obsidian parameters will be discussed : their fission track ages, used for composition/age group definitions, and Mössbauer and ESR data, as part of an on-going program on the potentialities of these approaches in obsidian sourcing.

These data will be compared to the results obtained so far on artefacts for the study of obsidian procurement and trading in NAAr prehispanic cultures.

20. The Single Roman Marble Quarry in Romania

M. Benea *, H. W. Müller **, B. Schwaighofer ***

*Universitatea "Babes-Bolyai" Cluj-Napoca, Catedra de Mineralogie,
**Str. M. Kogalniceanu 1, RO-3400 Cluj-Napoca
***Universität für Bodenkultur Wien, Institut für Angewandte Geologie, Peter Jordan-Straße 70, A-1190 Wien

A research project has been carried out by an interdisciplinary team (geology-archaeology) in order to establish the provenance of some roman marble artefacts from different Romanian museums. One of the conclusions was

that the single roman marble quarry, proved by geological and archaeological arguments, was those from Bucova (Caras-Severin County).

The maximum grain size of the calcite granoblasts, the accessory constituents and the structure were established with the aid of a polarising microscope. The isotope ratios and the chemical analyses (ICP-MS) were obtained with a mass spectrometer "Micromass 602C" in GTI-BVFA Laboratories in Vienna. The deviation from a conventional standard (PDB) was expressed as $\delta^{13}C$ and $\delta^{18}O$ in parts per thousand (‰).

The isotopic ratios, plotted in a $\delta^{13}C$ versus $\delta^{18}O$ diagram are showing 3 individual fields. Keeping in mind the place from where the samples were collected and the isotopic ratios, it was demonstrated that $\delta^{18}O$ decrease from the central part of the marble lens to the contact with the crystalline schists. In the roman quarry from Bucova, located in the central part of the marble lens, the isotopic composition is uniform on a length of 10-12 m. The differences between values are less than -0.72‰ $\delta^{18}O$ and less than 0.22 ‰ $\delta^{13}C$.

21. First Field Trials of a New Double Frequency e.m. Slingram Apparatus CS150.

Ch. Benech*, A. Tabbagh**

*UMR 7619, Département de Géophysique Appliquée, Université Paris VI
**UMR 7619, Département de Géophysique Appliquée, Université Paris VI / Centre de Recherche Géophysique, 58150 Garchy

Thirty years ago, a series of experiments achieved in Great Britain established that low frequency (between 1 kHz and 10 kHz) E.M. Slingram apparatus using two magnetic dipoles could be used in order to measure the apparent magnetic susceptibility in archaeological context. Following these first experiments, measurements performed with the SH3 prototype (1.50 m intercoil distance and 35° inclination of the coils) proved that the simultaneous measurement of both apparent conductivity and apparent susceptibility was feasible. Intercoil spacing of 1.50 m proved to be a convenient compromise between depth of investigation compatible with most archaeological sites and a reasonable lateral resolution for the location of the features. Ten years ago, after intensive field use and synthetic modelling, it was established that perpendicular coil orientation was optimal in terms of depth of investigation without increasing the intercoil distance. Moreover, the use of a double frequency might offer the possibility of getting the quadrature susceptibility.

We present here the first series of tests of the CS150 apparatus (conductivitymeter-susceptibilitymeter of 150 cm intercoil distance) which has perpendicular (PERP) coils configuration and operates at 4 kHz and 10 kHz frequencies. It has been used over both artificial features at a test site (Garchy, France) and over archaeological sites (Iron Age and Roman Period). Thanks to an automatic acquisition system, it offers the possibility of measuring while moving, which enables to survey an area of the order of 2 ha per day (at 1 meter profile separation), this rate being equivalent to the one of continuous electrical systems developed in Garchy (MUCEP).

22. Etruscan tin-rich slags from Populonia (Tuscany, Italy): a preliminary report

Benvenuti M. *, Mascaro I. *, Strillozzi B. *, Tanelli G. *, Donati L. **, Romualdi A. *, Settesoldi R. ***, Sorice P. *****

*Dip.to di Scienze della Terra, Univ. Di Firenze (Italy)
**Dip.to Scienze dell'Antichitŕ, Univ. Di Firenze (Italy)
***Sovrintendenza Archeologica della Toscana (Italy)

The Gulf of Baratti, extending beneath the Etruscan town of Populonia, has represented one of the most important early iron metalworking centres in Europe as witnessed by the huge heaps of slags discharged over five centuries (VI-I cent. BC) by the Etruscans and the Romans. In addition to iron, however, Etruscans are thought to have also exploited and smelted base-metal (Cu, Pb, Sn) in the Baratti area (cf. Crew, 1991), although the only direct evidences of this are so far represented by some copper slags described and analyzed by Sperl (1980).

At the beginning of a research project on metal production in the Populonia area, we have analyzed a number of slags from the so called "A" Building in the Poggio della Porcareccia industrial zone (VI-IV century BC).

Several samples of slags were taken from an embankment constituting the foundation of a IV cent. BC-building. They include both tapping and furnace slags of small size (on average 130 cm^3), mostly magnetic, composed of dominant fayalitic olivine and wüstite ± magnetite and quartz. The occurrence of micron-sized droplets of metallic tin (bulk contents in the order of 0.01-0.03 %) is especially noteworthy. This feature, together with the presence of metallic Bi and W-rich phases in the groundmass, could fingerprint the processing of base-metal ores of "inland" provenance, i.e. coming from the nearby Cu-Pb-(Zn, Ag, Sn) Campiglia M.ma-M.te Valerio deposits.

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23. An osteological analysis of elk (Alces alces L.) bones from excavations in the Lubâna Lake Basin, Eastern Latvia.

Sergey Berdnikov

University of Latvia Riga, Latvia, e-mail: sb50002@lanet.lv

The Lubâna marshy meadows are one of the most important Stone Age investigation regions in the East Baltic area. This study deals with elk bones from the Abora, Zvejsalas, Zvidze and Malmuta River Estuary sites, dated from the Mesolithic and Neolithic periods.

A total of 12120 animal bones, tooth and antler fragments were unearthed during excavations led by J. Loze in 1964 -1990. Elk was the animal species that was most exploited by the human population. Its bones occupy the first place among all herbivores in this material, as well as in materials from the entire Eastern Baltic, allowing to make a complete osteological analysis of this species.

Some problems related to quantification are examined, such as the estimation of the numbers of individuals of elk for each site. Two quantitative methods are used here: counting of the numbers of fragments and of the minimum numbers of individuals (MNI). Bone measurements were made for all fragments. These results were compared with K. Paaver`s analyses (1965) of previously excavated materials from Lubâna and with bone data from other Eastern Baltic Mesolithic and Neolithic sites.

The results are additional to K. Paaver`s data. The ecology of the area is discussed with respect to the vegetation history and the adaptation of elk.

24. The archaeobotanical analysis of the Middle Bronze Age settlement at Bölcske-Vörösgyír

Brigitta Berzsenyi, Ferenc Gyulai

Archaeological Institute of the Hungarian Academy of Sciences Budapest

The analysis of the archaeobotanical site material (Bölcske-Vörösgyír) allows us to reconstruct a more specific period of the domestic Bronze Age agriculture and summarize the questions regarding this period. As agriculture can not be separated from the climatic conditions we first examined the vegetation and the domestic Middle Bronze Age culture management, followed by the life style of Bronze Age people.

Fortunately Bölcske-Vörösgyír site samples taken from several areas reveal the presence of grain crop remains with the attendant weed flora.

The examination of the above mentioned specimens revealed species of not yet found in other Bronze Age excavations (in Hungary). There is a continuous development between two cultures (the early period of the Nagyrév culture and the Middle Bronze Age Vatya culture) when examined from point of view both archaeobotanical and archaeological.

From the plant remains found in the different layers of the site we can deduce that the inhabitants were not only growing cereals and legumes but they were also collecting wild fruits. The most important grain was the wheat. Barley was secondary in importance. Among the chaff wheat we found emmer (Triticum turgidum subsp. dicoccum). However spelt (Triticum aestivum subsp. spelta) was rarely encountered. The consumption of

legumes (such as lentils, peas, broad-bean) was considerable and were augmented by other species during the Middle Bronze Age bitter vetch (Vicia ervilia).

As there were very few non-grain remains in the samples found on the sites we can make the conservation that the cultivation of these crops used several techniques in removing unwanted weeds and the chaff leaf. Furthermore these weeds seeds also tell us that the soil was furtive and fertiliser (manure) free.

After the analysis of the Bronze Age remains found at the sites we can assume that the inhabitants in their search for vitamin rich nourishment looked to the fruits and berries found nearby. The following samples gave proof to the human consumption stock piling and possible preparation of grain: dewberry (Rubus ceasius), elder (Sambucus nigra), red elder (Sambucus racemosus), cornelian cherry (Cornus mas), blackthorn (Prunus spinoza).

Based upon the results of the examination of the above material we can assume that the settlers at these sites were established plant cultivators.

25. Present-day ovicaprine herding: relevance in the reconstruction of ancient herding at Roman Sagalassos

Ingrid Beuls*, Bea De Cupere, Paul Van Mele***, Marc Waelkens******

*GOA 'Concerted Research Action 97/2', Catholic University Leuven, 3000 Leuven, Belgium
**IUAP P4/12, Royal Museum of Central Africa, 3080 Tervuren, Belgium
***Department of Plant Protection, Faculty of Agriculture, Can Tho University, Can Tho, Vietnam
****IUAP P4/12, Catholic University Leuven, 3000 Leuven, Belgium

In a study of the faunal remains excavated since 1990 at Sagalassos (Burdur Prov., Turkey), information on subsistence patterns and animal husbandry practices have been gathered. Considering the importance of ovicaprines at Sagalassos, a more detailed study on their historical use and management was started. Therefore, a reconstruction of the former diet, the absolute age and season of death seemed most informative. By establishing an unambiguous relationship between the diet and dental microwear on recent ovicaprine teeth, an attempt is made to interpret the dental microwear on fossil teeth. Detailed qualitative and quantitative information on the food consumed by modern animals, is gathered through the direct observation method. It is attempted to determine the age and season of death of the animals through a comparative study of the growth rings in recent and ancient tooth cementum. To identify the excavated teeth to species level the possibilities of the ultrastructure of the enamel and of the stable isotopes of carbon are explored.

26. Authenticity of Iron Warrior on Horseback

R. P. Beukens *, L. A. Pavlish **, G. C. Wilson *, R. M. Farquhar******

*IsoTrace Laboratory, University of Toronto, Toronto, Ontario M5S 1A7
**Archaeometry Laboratory, Department of Physics, University of Toronto, Toronto, Ontario, M5S 1A7
***Turnstone Geological Services Ltd, P.O. Box 130, Station "B", Toronto, Ontario M5T 2T3; IsoTrace Laboratory, University of Toronto, Toronto, Ontario M5S 1A7
****Department of Physics, University of Toronto, Toronto, Ontario M5S 1A7

A Korean cast iron representation of a "warrior on horseback" of a form identical to fifth and sixth century ceramic vessels was examined. The ceramic figures appear to function both as container and dispenser of fluids, whereas the cast iron object does not have this function. The cast iron horse's core, once filled with casting sand, is open and does not allow the storage of fluids. At first, this apparent lack of functionality cast some doubt upon the authenticity of the object; but, the appearance of both clay and iron horse figures has been documented in the Korean archaeological record. Scholars have reported the appearance of clay and iron horse figurines, wearing saddles and bits, that appear to be votive objects.

Steel objects can be dated by radiocarbon analysis if charcoal was used in the manufacture. Direct radiocarbon analysis using AMS has yielded a ^{14}C content of 1.65 q 0.16 pMC, equivalent to an apparent age of 33000 B.P. This implies that instead of charcoal, coal was being used in the manufacture of the steel. In the past, it has generally been assumed that the use of coal in Chinese and Korean steel making did not occur until relatively recently in China. However, some research suggests that coal was used earlier. We examine cast iron artifacts from the First Millennium, BC and AD of Chinese contexts to test for the earliest coal use in iron production.

27. What's beneath the surface? - A look at metal working techniques from the Central Andes

Aniko Bezur

Department of Materials Sciences and Engineering, 520-621-2106 (phone) Mines 135, 520-621-8117 (fax)The University of Arizona, bezur@u.arizona.edu Tucson, AZ 86721

This presentation will discuss the range of metal working techniques employed from 1000 AD to 1540 AD in the Upper Mantaro Valley, Peru. During these five centuries the population of the region underwent important changes in socio-political organization, which in turn had implications on the economy. Changes in the distribution, amount and composition of the metal goods, especially copper and copper-alloy artifacts, have been correlated with the incorporation of Wanka chiefdoms into the Inca state around 1450 AD. During the Inca occupation the overall amount of copper objects increased and access to them also widened to include an almost equal proportion of commoners to elites. The debut of bronzes also dates to the Inca period. Bronze objects did not, however, replace copper and arsenical copper artifacts in the archaeological record of the Mantaro Valley. The coexistence of objects with distinct compositions prompted this study, which documents whether changes in the alloy compositions were accompanied techniques of working. Metallography, SEM/EDS, and ICP-OES are used to examine microstructure and composition.

28. ESR Dating the Archaeological Site at Tsagaan Agui, Mongolia

Bonnie A.B. Blackwell*, John W. Olsen, A.P. Derevianko***, D. Tseveendorj****, A.F.R. Skinner*****, M. Dwyer******

*Dept. of Geology, Queens College, Flushing, NY, 11367-1597, USA & the Graduate Center, City University of New York, & the NY Consortium in Evolutionary Primatology, bonn@qcvaxa.acc.qc.edu;
**Dept of Anthropology, University of Arizona, Tucson, AZ, 85721-0030, USA, olsenj@u.arizona.edu;
***Institute of Archaeology and Ethnography, Russian Academy of Sciences, Novosibirsk, Russia;
****Institute of History, Mongolian Academy of Sciences, Ulaanbataar, Mongolia
*****A.F.R. Skinner, Dept. of Chemistry, Williams College, Williamstown, MA, 01257, USA, anne.r.skinner@williams.edu;
******Townshend Harris Highschool, Flushing, NY, 11367, USA.

Tsagaan Agui Cave lies south of the Gobi Altai massif. Sedimentary fill includes intercalated loess, sand, and clay units, with some soil horizons, as well as ironstone concretions, gypsum, *éboulis*, gravel beds, alluvial and terra rosa deposits in deep layers. In Pit 2, Layer 3 contained Levallois-like points, while Layers 4 and 5 had flakes and burin-like tools, among other artefacts. Deeper layers yielded retouched flakes, burins, notched tools, and scrapers. ESR was used to date seven subsamples from one *Equus* and one cervid tooth, both from Layer 4.

ESR dating uses the radiation-sensitive signal found in well crystallized fossil tooth enamel, but not in modern teeth to date fossil teeth. The equivalent radiation dose needed to produce the observed ESR signal is the integral with respect to time of the natural, environmental dose rate experienced by the tooth after its deposition. Since the age depends on the uranium (U) uptake history assumed, three limiting cases are calculated assuming early U uptake (EU), continuous (linear) uptake (LU), and recent U uptake (RU), respectively the minimum, median, and maximum ages. ESR isochron dating requires numerous subsamples from large mammal teeth, but eliminates *in situ* dose measurements or sediment sampling, because the tooth acts as its own dosimeter. The teeth yielded a mean age 70.6 $\pm$ 6.3 ka (EU), 85.1 $\pm$ 6.3 ka (LU), and 99.7 $\pm$ 6.8 ka (RU). The preliminary isochron gave an LU age of 97 ka with an external dose rate of 301 mGray/y. $^{230}Th/^{234}U$ dentine dates should clarify which U uptake model is best. Therefore, Layer 4 dates from at least 70 $\pm$ 7 ka, but may be as old as 100 $\pm$ 7 ka.

29. Evidence for oxidised lipids in archaeological ceramic vessels

Helen A. Bland, Martine Regert, Richard P. Evershed

School of Chemistry, University of Bristol, Bristol BS8 1TS, UK

Solvent extractable lipids preserved in ancient ceramic vessels are proving to be a value source of information relating to vessel use and palaeodiet (Evershed et al., 1997). Assessments on the origins of these components rely on a detailed knowledge of their chemical alteration during vessel use and burial. In order to provide new

information on lipid degradation in archaeological pottery, chemical investigations (gas chromatography, GC, and GC/mass spectrometry, GC/MS) have been performed on ceramic vessels recovered from both arid and water-logged burial environments: Qasr Ibrîm, Upper Egypt, ca. 6th century AD and Chalain lake dwellings in Jura (France), Final Neolithic, ca. 3000 BC, respectively.

GC profiles of total lipid extracts (TLE) of the Qasr Ibrîm vessels revealed the presence of a series of dicarboxylic acids, with azelaic acid being the predominant component. The TLEs of the Chalain samples were free from oxidised lipids, however, when the insoluble solvent extracted residue was saponified in order to investigate compounds chemically bound to the pot matrix, a mixture of components were obtained dominated by dicarboxylic acids and mono- and dihydroxy fatty acids. These components result from oxidation and/or hydroxylation of the double bonds of unsaturated fatty acids (Gillan and Johns, 1982). This constitutes the first evidence for the presence of lipid oxidation products in archaeological ceramics providing important information concerning the fate of unsaturated lipids in pottery vessels. These results will have potentially important consequences for the assignment of natural sources of commodities processed in ceramic vessels.

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30. Point analysis and provenance of ceramics: a first approach

M. Blet*, R. Chapoulie, I. Uzonyi***, M. F. Guerra*, B. Gratuze***

*Centre de Recherches Ernest-Babelon, C.N.R.S., 3D rue de la Férollerie, F-45071 Orléans cedex ; babelon@cnrs-orleans.fr
**Centre de Recherche en Physique Appliquée á l'Archéologie, Maison de l'Archéologie, Esplanade des Antilles, Domaine Universitaire, F-33405 Talence cedex ; chapouli@montaigne.u-bordeaux.fr
***Institute of Nuclear Research (ATOMKI) of the Hung. Academy of Sciences, P. O. Box 51, H-4001 Debrecen ; uzonyi@cseles.atomki.hu

Global chemical characterisation of ceramic bodies are commonly used to determine their provenance and also the workshops where they were manufactured. However, in some cases, the chemical characterisation of its different mineral inclusions should be considered for provenance determinations. In fact, the trace element contents of the mineral inclusions found in different volcanic areas with recent volcanism may be characteristic of a provenance.

The analyses of the mineral inclusions are ticklish, as those inclusions are not easy to identify on thick sections of the ceramics and point methods have to be used. Here the applied analytical techniques are PIXE, SEM and LA-ICP-MS. These different point methods give the complementary information we can obtain on the inclusions concentrations at present.

We started by analysing known mineral inclusions from known provenance: olivines, augites, orthoses, sanidines, garnets. The concentrations obtained by the three methods, mainly for trace elements, show if they are uniformly distributed through the silicates and if it is possible to discriminate between different origins. We are also able to appraise detection limits of each technique and their possibilities for this kind of analysis.

As there are three different volcanic areas in Italy, these techniques are applied to a few roman amphorae samples from Pian di Spille in the Latium and Mondragone on the Campanian coast, as well as to samples from the wreck of Le Grand Congloué (submerged near Marseilles).

31. Isotopic Analysis of Roman Lead Objects from Southern Italy: Hypothesis on Their Provenance

Maria Boni*, Giovanni Di Maio, Robert Frei***, Costanza Gialanella******

*Dipartimento di Scienze della Terra Universitá di Napoli
**GEOMED S.A.S.
***Geologisches Institut Universität Bern, Isotopengeologie
****Sovrintendenza Archeologica per le province di Napoli e Caserta

In the last twenty years Pb-isotopic analysis has been often applied to archaeological provenance studies. Our group, consisting of archaeologists, metallogenists and geochemists, took recently the opportunity to investigate

a few Roman objects found in two different localities of Southern Italy: at the Ischia island and in the town of Pompeii. In Ischia the analyzed objects belong to an area, located near the Carta Romana beach, possibly hosting a smelting center. They consist of lead ingots, lead fragments, chunks of galena ore and small concentric artifacts of lithargirium, derived from in situ cupellation processes. Pb-isotopic analyses from these objects gave the following results for the galena ore:

$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
18.338	15.651	38.505
18.272	15.647	38.442

The data from the lead ingots and fragments, and from the Pb-oxydes are:

$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
18.760	15.727	39.138
18.674	15.670	38.931

The Pompeii objects, mostly consisting of fragments of fistulae from the roman aqueduct, gave results (data are still preliminary) spanning between 18.10 `and 18.66 ($^{206}Pb/^{204}Pb$), between 15.63 and 15.72 ($^{207}Pb/^{204}Pb$) and between 38.21 and 38.98 ($^{208}Pb/^{204}Pb$).

The isotopic values of the lead objects from Ischia point to an origin (also substantiated by the seals on the ingots) from the Spanish mines of Nova Carthago, whereas the galena ore could be derived either from the Tuscanian mines or from other Spanish ores, of possible Mesozoic age.

The data measured on the fistulae of Pompeii point, instead, to a more complex origin, possibly involving many successive smelting and mixing processes. In fact, the Pb-isotopic values show a continuum on the CR-SK growth curves, with two end members, one of which coincides with the average data of the Lower Cambrian mines in Sardinia and the other with the Miocenic volcanic-hosted ores of south-eastern Spain.

32. Characterisation of “Embalming Resins” from ancient Egyptian mummies

S.A. Buckley, A.W. Stott, R.P. Evershed

Organic Geochemistry Unit, School of Chemistry, Cantock’s Close, University of Bristol, BS8 1TS

There has long been a fascination with the mummies of ancient Egypt. Despite this however, surprisingly little is known about the so-called “art” of mummification. In fact very few analytical studies have been carried out to gain insight into the sources and nature of the “resins” employed in mummification [1-5]. A number of preservatives have been proposed, including true resins, e.g. coniferous resins (diterpenoids) and non-coniferous Pistacia resins (triterpenoids), gum resins, e.g. frankincense and myrrh, bitumen, pitch, honey and beeswax.

We now have the opportunity in our laboratory to carry out a comprehensive analytical study on a relatively large number of ancient Egyptian mummy samples from a wide range of dates, status’, geographical locations and contexts. In particular, a focus will be a thorough and systematic approach to the study of a number of mummies, carrying out round body sampling. This is an important aspect of the research since the literature suggests that materials were applied to various parts of the body depending on the particular purpose and significance. Due to the complex nature of the aged organic materials likely to be present we have employed a dual approach utilising: (i) solvent extraction followed by GC/MS, and (ii) a combined sequential TD-GC/MS (310°C/10s) and Py-GC/MS (610°C/10s) (Chemical Data Systems 1000 Pyroprobe) methodology to allow the convenient study of both “free” and “bound” biomarkers deriving from the “embalming resins” in these samples. A distinct advantage of employing sequential TD-GC/MS and Py-GC/MS is the small sample sizes (ca. 0.1 mg) required allowing rapid screening of a larger number of samples and micro-scale analysis facilitating the essentially non-destructive analysis of the mummified bodies, thus ultimately aiding sampling from historically valuable museum specimens. However, solvent extraction also provides some valuable

information which is not

obtained using TD alone. This demonstrates that more than one approach may be necessary if the “resins” are to be satisfactorily characterised.

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33. Archaeometric Preliminary Study of Volcanic Rock Millstones from Pompei - the Problem of their Provenance

L. Buffone*, S. Lorenzoni, M. Pallara**, E. Zanettin****

*Soprintendenza archeologica di Pompei, Italy
**Universitá degli Studi di Bari, Dipartimento Geomineralogico, Bari, Italy

29 samples of "Pompeian" type and "disc" type millstones from Pompei have been studied by both petrological and chemical methods, to define their lithological constitution. Moreover, field researches have been performed in the Bolsena-Vico-Bracciano and Roccamonfina regions to locate the source area of the millstones.

The millstones studied are constituted of leucite-pyroxene (±olivine, sanidine, haüyne) tephrites and tephrites-phonolites belonging to four lithological groups, different in composition and/or structure and attributable to different volcanic formations. Only one "disc" type millstone is constituted of basalt.

P. Nicotera (1950) considers Roccamonfina volcano the probable source of the Pompei millstones. Instead, D.P.S. Peacock (1986) states that the millstones of Pompei come from a lava flow of the Orvieto zone. Our researches indicate that the Pompei millstones come from different localities. The tephrite millstones are attributable to the Roccamonfina volcano, and precisely to the lava flows of its western slopes, facing the Garigliano river. The tephrite-phonolite millstones are attributable to the lava flow outcropping near Orvieto. The basalt millstone is referable to the Mt. Etna volcano. Only a few millstones might come from the Bolsena-Vico-Bracciano area.

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34. DNA techniques in Archaeometry. News and progresses.

J. Burger, B. Grosskopf, S. Hummel, B. Herrmann

Institute of Anthropology, Buergerstrasse 50, 37 0 73 Goettingen, Tel: 49-551-39 96 85; e-mail: jburger@gwdg.de

This paper shows the materials for which and the extent to which DNA analysis can be a useful tool in archaeometry. In the framework of an archaeometric project at the Institute of Anthropology, Goettingen, the content of both historic and prehistoric objects is analysed. The objects are of different types, such as: prehistoric stone artefacts, parchments, glues, various contents of vessels, and prehistoric rock art paintings.

The paper will focus on the identification of the animal or plant species of origin of a specimen by ancient DNA analysis. The accuracy of the DNA method will be compared with other techniques such as crossover immuno-electrophoresis (CIEP) or enzyme-linked immunoabsorbant assay (ELISA).

DNA results are given for rock art pigments and blood residues on stone tools.

35. Correlation of barium and strontium during trophic-level biopurification and its osteoarchaeological implications

James H. Burton, T. Douglas Price, W. D. Middleton

Department of Anthropology, University of Wisconsin-Madison

In order to more fully understand the relationship between diet and bone levels of barium and strontium, we analayzed by ICP spectroscopy thousands of modern mammal bones, plants, and soils. Our results reveal a strong correlation between barium and strontium, relative to calcium, with increasing trophic position as a result of biopurification.

This correlation indicates that bones present excellent statistical averages of local environmental barium and strontium levels and thus that strontium isotope ratios in bone can reflect regional geology despite intrinsic local variability in soil Sr87/86 ratios. This is further supported by observed homogeneity in bone Sr87/86 ratios.

A second implication of this correlation is that, by measuring both barium and strontium in fossil bones we can assess their post-mortem contamination directly rather than relying on proxies such as Ca/P ratios and crystallinity indices.

36. Chemical and mineralogical alteration of ceramics from a Late Bronze Age kiln at Kommos, Crete: the effect of firing temperature

J. Buxeda i Garrigós*, V. Kilikoglou, P.M. Day***, L. Joyner*****

*ERAUB, Dpt. of Prehistory, Ancient History and Archaeology, University of Barcelona, c/ de Baldiri i Reixac, s/n, 08028 Barcelona, Spain.
**Laboratory of Archaeometry, N.C.S.R. Demokritos, Aghia Paraskevi, 15310 Attiki, Greece.
***Department of Archaeology and Prehistory, University of Sheffield, Northgate House, West Street, Sheffield S1 4ET, UK.

One of the most secure procedures for the formation of control groups in pottery provenance studies using chemical analysis, has been considered to be the use of kiln wasters, which are assumed to produce chemical profiles representative of local production.

The excavation of a pottery kiln dating to the Late Minoan I period at Kommos provides an opportunity for the analytical investigation of a certain production assemblage. Fifty-seven samples were analysed by INAA, XRF, thin section petrography, SEM and XRD, to characterise, in chemical and mineralogical terms, the ceramic fabrics produced in the kiln and to investigate their technology. The majority of the pottery analysed belonged to three major, calcareous petrographic fabric groups, differentiated from each other on the basis of the inclusions' grain size.

Chemical data, however, revealed some extreme variations in the alkaline elemental contents, which did not coincide with the idea of a common provenance. Further examination by XRD and SEM has provided important information about the mineral composition and the firing temperatures of each sample. It is clear that the chemical groups correlate with the firing temperature of the different vessels. This is explained as selective alteration and contamination in the burial environment, related to the existence of different characteristics (mainly, in mineralogy, vitrification and microstructure) in the fired products.

Kiln sites contain pottery of widely varying firing temperature, therefore the result of this study provide an important observation on the use of such material in control groups. The use of combined mineralogical and chemical techniques is recommended in order to avoid erroneous conclusions.

37. Chemical and Microstructural Characterisation of Paleovenetian bronze thin plates

I. Calliari, M. Magrini, M. Dabala, E. Ramous

Dep. of Mechanical and Management Innovation, University of Padua, Via Marzolo 9, 35141 Padova, Italy

The present paper concerns the first chemical and microstructural study of paleovenetian thin plates. During an excavation in Vicenza (Italy) in 1959, 200 thin plates decorated with punch and chisel, with rectangular and

circular shape, were found. The decorations follow the paleovenetian people style, but Celtic and Etruscan influences are evident. Paleovenetian is the name given to the Indoeuropean population living, in the 1st millennium BC, in the territory currently known as Veneto (North-Eastern Italy).

The plates were produced from V to II century BC with votive aims. As their artistic value and good condition, any analysis has been never previously performed on these findings.

In the present paper the chemical and microstructural characterization of 14 samples is presented.

All the samples were examined with non-destructive techniques (SEM, EDS, and EDXRF). A small fragment was observed with SEM in cross section and analysed with AAS to confirm the composition data obtained with the other methods.

The thin plates are bronze made at low Sn and Pb content, in a few samples Fe and Zn traces were found. Cu-oxide and Sulphur compounds were evidenced on the surface.

The chemical composition, microstructure, surface element distribution and thickness of corroded layers were determined, the production technology was investigated.

38. Evidence between manufacturing techniques and use in archaeological ceramics

Capel, J.*, Linares, J., Huertas, F.**, Najera, T.*, Molina, F.*, Navarrete, M.S.***

*Department of Prehistory and Archaeology, Univ. Granada, Spain
**Department of Physicochemical and Geochemical Mineral, CSIC, Granada, Spain

In this paper we are studied one hundred eighteen three ceramics vessels belonging to the Late Neolithic Age and Late Bronze Age, originating in the Spanish archaeological sites. The settlements are located in the province of Granada (South of Spain), and province of Ciudad Real (Central Spain).

These materials have been investigated by X-Ray Diffraction, Chemical and Physical Analysis and Thin section.

The results obtained show evidence that these vessels were manufactured with a particular purpose in accordance with the utility of ceramic. Data confirmed the existence of three clearly differentiated groups, one consisting of cook ceramics, the second group is consistent with other pieces to store cereals, while the third group corresponds to the ceramics with no precise use.

Finally, we come to the conclusion that there is evidence of relation between manufacturing processes (content and size of the degreaseant, presence and absence of carbonates and porosity), and use of ceramics.

Acknowledgements:
This work has been supported by the PS-0230 project of Spanish DGICYT.

39. Identification of the provenance of archaeological ceramics from contents in Trace Elements and Rare Earth Elements

Capel, J.*, Linares, J., Huertas, F.**, Fiore, S.***, Molina, F.*, Orfila, M.***

*Department of Prehistory and Archaeology, Univ. Granada, Spain
**Department of Physicochemical and Geochemical Mineral, CSIC., Granada. Spain
***Istituto di Ricerca sulle Argille, CNR, Potenza, Italy

The objective on this research aim was two-fold: first to attempt to identify the origin of ceramic vessels and, second, to access the predictive capacity of this method employed from the archaeological standpoint,

Forty two samples are studied. These ceramics belonging to the Late Bronze Age and the Roman Period. The archaeological sites to locates in the Granada, Andalusia, (South of Spain).

Data from chemical analysis confirmed the existence of clearly differentiated groups and permit to remove different clays supplying quarries, in the same geographical area, for the ceramic vessels manufacturing.

Acknowledgement:

This work has been supported by the PS-0230 project of Spanish DGICYT.

40. Exploratory Testing of Archaeological Soils

Henry J. Chaya

Department of Anthropology, State University of New York at Albany, 146 North Walnut Street, Beacon, NY 12508 USA, Email: hchaya@juno.com

Chemical and physical properties of archaeological soils are valuable indicators of past human settlement activity. Results from archaeological soil analyses indicate factors such as intensity and location of population and middens. For most archaeologists, cost and portability of such studies are important.

A study of archaeological soils from two sites is described; an Aleutian Island site occupied for perhaps 4,000 years by marine hunter-gatherers and a pre-historic Mohawk Indian site in the Mohawk Valley of NY State, USA. This paper describes simple analytical procedures to determine soil phosphorus (total, organic, and inorganic),organic carbon content, pH and electric conductivity of moist soils. In the process, measured soil properties were compared to artifacts found at both sites in the same soil. Students can perform most of the analyses. In the field, measurements of pH and soil conductivity are performed by portable equipment so that both of these properties can be measured on the same sample preparation.

At times, interesting and useful correlations were found between properties of a soil sample and the artifacts found at the site.. In the field, portable testing of soil can give a probable indication that something of value is being excavated, an immediate help in the direction of further excavation. Laboratory evaluation of our soil samples and other artifacts demonstrated that rapid exploratory testing gave a quick indication of further profitable work. The analytical procedures described are simple and rapid. The equipment is portable and economical to obtain.

41. Early metallurgy in the Eurasian steppe: minerals and slags analysis from Kargaly (Russia)

E. N. Chernykh*, S. Rovira**

*Academy of Sciences, Moscow
**Museo Arqueológico Nacional, Madrid

Kargaly (Orenburg, Russia) is a vast copper-bearing region in the Eurasian steppe. Minerals are located as pockets, thin veins and substitution fillings in the sandstone of the area. Thousands of pits and galleries excavated from Late Bronze Age up to 19th century are visible.

After a survey of all mining districts, digging seasons have been located at Gorny, a prehistoric site where copper production was the main economic activity. Slags, mineral storage place, moulds, fireplaces, raw copper, instruments and so one have been found. Radiocarbon dates span between 1700-1500 cal BC.

Archaeometallurgical research objectives are focused, in a first step, in the determination of the copper smelting technology. Then, copper minerals, slags and copper prills have been analysed using X-ray fluorescence spectroscopy (EDX), scanning electronic microscopy and conventional metallographic techniques.

Mineral use to be copper carbonates (malachite, azurite), with gangue constituted by silica and small amounts of calcium, iron, aluminium, barium and potassium oxides. Very low percents of trace elements such as silver and antimony have been detected.

Well-formed slags (fayalite type) are very scarce, being abundant the furnace conglomerates rich in copper prills and cuprite. Copper sulphide is also formed, as mate nodules and prills rim. There are no tapped slags.

The analytical set leads us to draw the features of a primitive copper smelting process with low copper recovery rate because of the difficulty to achieve temperature for a good separation of metal and slag.

42. Biomarkers for Ancient Tuberculosis

Angela M. Child*, David E. Minnikin, Ali M.S. Ahmed**, Andrew Chamberlain***, Mark S. Copley*****

*Newcastle upon Tyne, NE1 7RU, UK
**Department of Chemistry, University of Newcastle, Newcastle [1]Fossil Fuels and Environmental Geochemistry, Drummond Building, University of Newcastle, upon Tyne, NE1 7RU, UK
***Department of Archaeology and Prehistory, University of Sheffield, Northgate House, West Street, Sheffield, S1 4ET, UK

If there is a disease which signals poverty, it is tuberculosis (TB) - indeed for archaeological populations, no other reliable marker is available. Unfortunately, the "diagnosis" of ancient tuberculosis (TB) is fraught with problems. It relies, currently, on finding bone lesions consistent with tubercular disease only to be expected in a low percentage of the diseased population and on the demonstration, in those lesions, of an insertion element, IS 6110, diagnostic for the Mycobacterium tuberculosis complex. We present a novel alternative - the survival of lipids in ancient ceramics, coprolites and bog bodies suggests that characteristic tubercular lipids (mycolic acids) may be biomarkers for tuberculosis (TB). Mycolic acids are stable 60 to 90 carbon, 3-hydroxy, 2-long alkyl branched fatty acids which are major, covalently bound components of the cell envelope of mycobacteria.

Preliminary studies showed the presence of mycolic acids in mediaeval bones [2]. The Newcastle Infirmary site, excavated in early 1997, has provided material for an in-depth investigation. Historical records show a high death rate due to "consumption" and some of the bones show lesions characteristic of TB. Mid-shaft rib samples, chest cavity soil samples and distal soil samples were collected. Standard chromatographic profiles of mycolic acids were generated from M. tuberculosis using a selective extraction protocol and high performance liquid chromatography analysis of methylanthryl esters with fluorescence detection [1]; archaeological material was processed in the same manner. Results obtained show a very close agreement with recorded death rates - we believe we have a biomarker for ancient TB.

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43. Archeometry at the Aquincum Museum

Alice Choyke

Aquincum Museum, Budapest

Traditionally, the tools archaeologists use in trying to understand the past have usually included the form and style of the objects found during excavations together with the location and type of the sites they are found in. These are all things that can be described and measured by the archaeologists themselves either in the field or later in the laboratory. However, with the growth of technological possibilities in other research areas, new vistas are opening for archaeologists. They are now able to ask questions which can be best answered by data not immediately available by ordinary archaeological methods.

For a number of years, specialists in the departments of Prehistoric and Medieval archaeology at the Budapest Historical Museum and Roman archaeology at its branch museum at Aquincum have increasingly exploited the expertise of scientists in numerous ways.

Excavation is a very expensive process. New remote sensing geomagnetic methods developed by Sándor Puszta and his team of Fractal Bt. in the Geophysical department of Loránd Eötvös University have enabled our archaeologists to confirm and pinpoint the locations of sites and features within them without resorting to more intrusive methods such as digging.

Archaeologists also rely on specialists to tell them something about the animals and plants our ancestors here in the territory of modern day Budapest exploited. As finer excavation methods, including screening and flotation, are employed whole new species, especially fish have been found by the archaeozoologist at the Aquincum museum, Alice Choyke. Recently plant remains have begun to be regularly studied from Roman period excavations: Ferenc Gyulai, of the Archaeological Institute of the Hungarian Academy of Sciences and now

Orsolya Dálnoki, a student in the Institute of Archaeological Sciences of the Loránd Eötvös University have collected seed samples and subjected them to analyses using a special Macintosh based image processing system enabling them to measure larger quantities of seeds.

Archaeologists also wish to know something about the physical environment ancient people lived in as this can have a strong limiting effect on where they located their settlements and why these settlements were abandoned. Reconstructing the soil formation processes at archaeological sites can be a powerful tool in understanding local environments. György Füleky, chairman of the Department of Agrochemistry and Pedology at the University of Gödöllő has begun to regularly test soil types from excavations in areas both outside the Military town and in the Civil town.

More details of the environment can be provided by studying the kinds of wood, often preserved through burning, found on archaeological sites. This can yield important data to specialists on the history of a tree species in Pannonia but also more clues on the climatic circumstances ancient peoples lived in. Károly Babos of the Department of Plant Organology of the Loránd Eötvös University has carried out a number of studies in this regard. András Grynaeus, who runs the Dendrochronology Laboratory in the Institute of Archaeological Sciences of the same university has also examined large timbers from a site outside the Aquincum Military town.

Another constant problem archaeologists are faced with is dating the settlements they find and, especially judging the relative dates of the features within them. Until now specialists have had to depend on typological dating methods, radiocarbon dating and potentially dendro- chronological studies. Péter Márton of the Institute of Geophysics of the Loránd Eötvös University has studied numerous ovens and fireplaces from various periods in the hope of establishing a timeline through archaeomagnetic dating of burnt features. Curiously, while this dating method has proven effective for dating burnt features at prehistoric and medieval sites, multiple samples taken from burnt Roman features display much more variability. The reason for this interesting discrepancy is unclear and awaits future work.

The final category of research where archaeologists at our museum have regularly turned to specials is that of material analysis. Such analyses can take the form of X-rays to determine the exact nature of corroded iron objects or details of the manufacture of other metal artifacts. Gábor Hutay of the restoration department at the Hungarian National Museum, Ottó Léc and József Király of the Isotope Institute of the Hungarian Academy of Sciences and Márta Járó of the Hungarian National Museum have carried out such valuable work for us.

Work has also been carried out on the material of grinding bowls and plaster to attempt in the former case to distinguish individual workshops (failed) and plastering on walls in complex archaeological structures. Work on the former was done by Sándor Józsa of the department of Geology of the Loránd Eötvös University. L. Kriston at the Criminology Institute, Márta Járó have worked on the latter kind of problem.

Questions about trade and economic systems are frequently posed by archaeologists, especially those working in proto-historic periods. Locations of local and foreign quarries from where the stone of walls and statues come from tell us something about the value of individual objects and economic connections on local and international levels. Pál Müller of the Geology Department of the Loránd Eötvös University, Ferenc Schweitzer, and Müller from Vienna have worked on identification of stone wall materials and statuary material for the Aquincum museum. The results have not always been expected but always useful.

It has been our experience at the Budapest Historical Museum that bringing in specialists has allowed us to broaden the scope of the questions we can ask about past lifeways. Sometimes the answers we get are unexpected and often lead to entirely new questions. In the future it is our hope, not only to continue but to increase the regular use we make of new scientific developments in other fields.

44. TL-Dating of Chichen Itza, Yucatan, Mexico

Heajoo Chung, Peter Schaaf, Angel Ramírez

UNAM Ciudad Universitaria Circuito Exterior s/n 04510 Mexico City, Mexico

Chichen Itza is a Postclassic (A.D. 1000-1400) archaeological site in northern part of Yucatan peninsula of Mexico. Chichen Itza was understood as the last glory of Mayan civilization, invaded by the Toltecs, the Central Mexican military power about A.D. 1000. The dating of Chichen Itza is based upon Spanish chronicles, however, there is a lot of discussion surrounding the chronology. Mayan archaeologists claimed that when the Toltec's Tula was flourishing (A.D.: 1200-1400), Chichen Itza had already declined. This argument is sustained

by C14 dating of archaeological sites in northern Yucatan, in which we have no dates that surpass A.D. 1000. But researchers still debates this topic, and therefore, the precise dating of the site is fundamental for understanding the history of the city.

We have abundant diagnostic ceramics from this period which contain volcanic glass and quartz. We tried to date the last firing time of these ceramics by thermoluminescence analysis, thus providing complementary ages obtained by a different method. The result will help to establish a more complete chronology of the history of Chichen Itza.

45. X-Ray Photoelectron Spectroscopy Studies of the X-Ray Induced Degradation of Ancient Pigments

Enrico Ciliberto, Giuseppe Spoto*

*Dipartimento di Scienze Chimiche, Università di Catania, Viale A. Doria 6, 95125 Catania (Italy)

X-rays constitute an important tool for studying works of art. X-ray radiography, xeroradiography and other X-ray imaging techniques provide options for a so-called non-destructive evaluation of works of art. Moreover, analytical information is often obtained by in situ operating XRF spectrometers. All these methods have been used on a variety of archaeological and artistic objects including painted artefacts.

In the present work the authors have studied the effects of X-rays on some important organic pigments in use since the time of ancient civilisation. Four different pigments have been considered in particular: i.e. madder lake, cochineal lake, alizarin lake and yellow saffron. All the pigments studied have been prepared following ancient original formulae from natural dyestuffs extracted from plants and insects with the exception of the alizarin lake prepared using commercial sources.

X-ray photoelectron spectroscopy (XPS) has been used to study the compositional alterations suffered by the pigments after exposition under a standard X-ray source. The analytical technique used allowed the authors to identify different levels of alteration in the irradiated pigments because the XPS sensitivity and acquisition rate appeared to be consistent with the evolution of the modifications studied. Qualitative and quantitative evaluation of the XPS spectral modifications provided some chemical information about the decomposition studied.

46. Archaeometry of gold finds from prehistoric Sardinia

Annamaria Cincotti, Cirillo Atzeni

Dipartimento di Ingegneria Chimica e Materiali, Universita' degli Studi di Cagliari, Piazza d'Armi, 09123 Cagliari - Italy
Tel.: (39)-70-6755073; Fax: (39)-70-6755067, e-mail: acincot@ndchem4.dicm.unica.it

Archaeological finds are generally studied by means of non-destructive analytical techniques. However, these techniques prevalently provide information concerning the surface's state of the material. Metallographic investigations on microsamples allow to get a complete archaeometric characterization of metallic artefacts. The aim of this work was to study five finds made of gold alloy: a complete neckring found at "Bingia 'e Monti" (Gonnostramatza, dated about 2000 B.C.) during archaeological surveys, a decorated lamina fragment found in the Pirosa cave at Su Benatzu-Santadi (dated between Cypriot Late Bronze Age and Iron Age) and three diadems, in which 'ox-hide' copper ingots of the Late Bronze Age are impressed, coming from a judicial attachment happened in Santadi. To obtain surface analyses an optical stereomicroscope and a scanning electron microscope + EDS were employed. Finds' surfaces are constituted by gold-silver-copper alloys, about 80% Au, 17% Ag, and 3% Cu regarding the four laminae and 51 % Au, 45 % Ag and 4 % Cu regarding the neckring. In all cases, the surface patina is richer in gold than the bulk. Iso-oriented, thin lines are visible at the microscope, probably due to a polishing with a cloth or a soft hide and some natural abrasive. The surface of Santadi objects shows the presence of inorganic small particles inserted in the metal, probably deriving from the soil in which the laminae were buried. Metallographic structures of Santadi fragment and of one diadems do not show any intergranular corrosion. Su Benatzu find has got 127 1 13 Kg/mm^2 of microhardness Vickers, and the diadem 91 1 10 Kg/mm^2. The scattering of these values is probably due to differences in the hammering and in their chemical composition.

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47. Isotope fingerprinting of ancient tin

Robin Clayton, Noel H. Gale, Zofia Stos-Gale

Isotrace Laboratory, University of Oxford, UK

The sources of tin in the Late Bronze Age (LBA) remain a significant unresolved problem in eastern Mediterranean and Aegean archaeology. Muhly (1985) has written: "It is remarkable that, after twenty years of intensive scholarly investigation and fieldwork, we still have no hard evidence regarding the sources of tin being exploited by the numerous and widespread bronze industries of antiquity"; twelve years later the situation remains unchanged. Lead isotopic methods have successfully identified the provenance of various metals (Pb, Cu, Ag) used in ancient metallurgical processes of the region, thereby elucidating prehistoric trading routes and aspects of LBA economic history and the peoples involved. Identification of the pathways of tin into LBA civilisations using Pb isotopes from likely source ores is complicated by the multistage nature of the leads involved, in contrast for example to the relative success experienced in matching copper based metals and artefacts with various locations in the Cypriot massive sulphide ores, which contain lead of rather simpler geological history (Stos-Gale et al. 1987).

A Leverhulme Trust funded research project into these questions in Oxford is based primarily on a two part investigation of the isotopic composition of ancient tin ingots and of tin ores from various mineralisations. One component relies on the measurement of lead isotope ratios in pure tin ingots, mostly from the Late Bronze Age shipwreck of Uluburun (Kas) excavated off the Turkish coast by INA Texas, and comparing them with the lead isotope characteristics of cassiterites from various European occurrences. The second part will include analyses of the tin isotope composition of the same samples, and of tin extracted from prehistoric bronzes from Minoan, Mycenaean, Cycladic and Cypriot archaeological sites. Preliminary, medium precision, analyses of the isotopic composition of tin extracted from such bronzes (Gale 1997) has shown that the large changes in isotopic composition predicted by Budd and Pollard to arise from melting and other anthropogenic processes do not exist. Exploratory high precision work by Begemann shows, however, that there is a measurable difference of tin isotopic composition for tin extracted from bronzes on the one hand from central Europe and on the other hand for bronzes from the near and middle East. At this stage of research the observed dichotomy of tin isotopic composition might indicate the use of different tin sources in these different regions, but the evidence does not at present allow this to be a certain inference.

We will discuss the results obtained so far in Oxford. The methodology of the analytical procedures developed for the project will be described, and lead isotope compositions measured for Bronze Age tin ingots from various parts of the Mediterranean will be presented in comparison with those of cassiterites. The scope of the proposed work bears not only on archaeological science but also on the application of an untested isotopic system to ore geochemistry.

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48. Bone Biopolymers, Plugging the Credibility Gaps

Matthew J. Collins*, Angela M. Child*, Emma R. Waite*, Oliver Craig*, Michael S. Riley, Robert Hedges***, Cees Vermeer****, Robert Sokol******, Keith Gelsthorp******, Herve Bocherans*****

*Fossil Fuels and Environmental Geochemistry, (Postgraduate Institute); NRG, Drummond Building, University of Newcastle, Newcastle upon Tyne NE1 7RU

**Water Resource Systems Research Unit, Department of Civil Engineering, University of Newcastle, Newcastle upon Tyne NE1 7RU

***Research Laboratory for Archaeology and the History of Art, Oxford University 6 Keble Road, Oxford OX1 3QJ

****Department of Biochemistry, University of Limberg, Maastricht, The Netherlands
*****Trent Regional Blood Transfusion Centre, Longley Lane, Sheffield S5,7JN
******Laboratoire de Biogéochimie Isotopique, Case 120, Université P. et M. Curie, Paris, France.

Across the field of ancient biomolecules lie gaps of credibility which mark boundaries between disciplines. Protein survive for decades in forensic science, survival, while archaeological 'proteins' can survive for millennia; palaeontological 'protein' however, seems to be a much more robust material altogether, and claims for the immunological detection of fossil proteins span the Phanerozoic. Over a number of years we have been investigating the survival of bone proteins, both in the laboratory and field.

The fate of proteins is strongly related to their size, structure and composition. Large helical molecules, such as DNA and collagen, melt and albumin denatures whereas osteocalcin, which is small and binds strongly to the mineral surface, is very robust. Predictions based upon high temperature experiments show that only osteocalcin will survive into deep (geological) time.

If, then, osteocalcin has the potential to survive, is it the solution to the problem of radiocarbon dating highly degraded bone or as an alternative to collagen for age at death determinations? Examination of the fate of biopolymers in bones from a Neolithic site at Bercy offers an alternative view, since the diagenetic loss of these molecules did not to follow the paths predicted by our experiments. Osteocalcin survived well when the integrity of the mineral had been maintained, as did collagen.

49. Techno-typological and functional analysis of the lithic industry of the Copper Age site Le Cerquete-Fianello (Maccarese, Rome)

C. Conati Barbaro*, C. Lemorini**

*Museo delle Origini, Dipartimento di Scienze Storiche, Archeologische e Antropologische dell'Antichitá, Universitá "La sapienza", Roma
**Istituto Italiano di Paleontologia Umana

The lithic industry recovered at the Copper Age site of Maccarese-Fianello has been subjected to techno-typological study and functional analysis, the results of which are here reported. This industry is mainly composed of flakes and almost entirely obtained from flint cores. Side-scrapers and denticulates are the most common tools, as well as flakes with use retouch and choppers, while bifacial tools, as arrowheads and daggers, represent a smaller percentage.

The main interest in the study of the Maccarese-Fianello lithic industry rises from the scarce knowledge of similar assemblages belonging to Rinaldone settlements. The study of the industry provides several interesting developments: the study of the raw material origins, the technological analysis aiming to reconstruct the "*chaines opératoires*" adopted for the production of the artifacts. Moreover, thanks to stereomicroscope and metallographic microscope scanning, the detection of macro- and micro-wears allows the identification of the tools function, both for the actions and for the materials. The microscope determination of the exploited edges of tools is accompanied by the consideration of their morphological features (thickness, contour, section), which are tightly connected to their function.

50. Archaeometrical studies on ancient glassy materials and obsidians using Bucharest Cyclotron

Bogdan Constantinescu

Cyclotron Laboratory, Institute of Atomic Physics, PO BOX MG-6, Bucharest, Romania

The analyses of source materials combined with analyses of archaeological objects could distinguish from pieces produced in different regions. This is the case of obsidians. Chemical differences that occur during preparation of materials will affect the elemental composition and could be used for the identification of technologies and workshops involved. This is the case of glass objects. We analysed obsidians samples (objects and minerals) from north-west region of Transylvania, Byzantine bracelets pieces (10th-12th centuries) from Dobroudja and feudal (17th-18th centuries) domestic glassy objects from Bucharest area. Three methods were used: in air PIXE, XRF and FNAA (especially for light elements: Na, Mg, Al, Si). For in air PIXE, 3-5 MeV proton beam obtained from 6.5 MeV Cyclotron nominal regime protons extracted into air through 20 mm aluminium foil strikes the sample after 8-10 cm. X-rays were detected through reflection, using a horizontal

HPGe detector. XRF measurements were done with a spectrometer consisting of 30 mCi 241Am annular gamma-source, a vertical Si(Li) detector and a conventional electronic chain. To produce fast neutrons, deuterons, accelerated up to 13 MeV bombarded a thick (166.5 mg/cm2) Be target placed at 20 against the incident beam (up to 20 mA). The absolute intensity flux on free air, at 10 cm behind the Be target was 1.824108 n/cm^{2}WmC, with a neutron average energy of 5.24 MeV at 0. For obsidian identification of geological sources for the analysed objects is presented (e.g. Bocsa-Salaj, Zam, Calinesti-Hurca). A typical obsidian composition for relevant elements is: Fe: 2.1%, Mn: 0.15%, Ti: 0.1%; Rb: 350 ppm, Ba: 2100 ppm, La: 50 ppm, Ce: 150 ppm, Nd: 60 ppm. For the Byzantine bracelets pieces, colorants (Mn, Fe, Cu, Zn, Sn, Sb, Pb) and opacifiers (Sn, Sb, Pb) were determined and a classification of the objects was done. A typical composition is: SiO_2: 70.6%, Al_2O_3: 1.8%, MgO: 0.9%, Na_2O: 8.4%, CaO: 2%, K_2O: 3.9%, MnO: 0.5%, Fe_2O_3: 6.1%, CuO: 0.8%, PbO: 7.6%, Zr: 700 ppm, SnO: 0.9%; BaO: 0.3%, Ce: 150 ppm, La: 60 ppm, Nd: 50 ppm. For feudal objects, a provenance identification based on main colorant (Ti, Mn or Fe) and opacifier (As) was effectued.

51. Analysis of some Ancient and Middle Age coins by neutron activation and X-ray fluorescence

C. Cosma, L. Daraban, T. Fiat, D. Ristoiu, D. Boros, T. Tarsu

Faculty of Physics, Babes-Bolyai University, 3400 Cluj-Napoca, Romania

Neutron activation method was applied to determine the Ag, Au and Cu elements contained in ancient Roman and Greek coins or in Middle Age Hungarian coins (emitted by Bela II and Coloman), all from treasures discovered in Transylvania, Romania.

The coins and standard samples were irradiated in the same conditions in a thermal neutron flux supplied by Am-Be and Pu-Be isotopic sources system, providing 6,6*10^7 neutrons/sec. The nuclear reactions used to analyse gold and silver are: ^{197}Au (n, γ) ^{198}Au, ^{107}Ag (n, γ) ^{108}Ag ($T_{1/2}$= 2.5 min) and ^{109}Ag (n, γ) ^{110}Ag ($T_{1/2}$= 24 s).

The copper generates two $\beta+$ active isotopes ^{64}Cu and ^{62}Cu. In both cases the spectra were recorded using NaI (Tl) or Ge (Li) detectors. The method allows to determine the title of the silver alloy and to establish the fake or underrairate coins.

By means of the impurity content we obtained the correlation diagrams that can offer useful information for the study on the silver provenance. The coins were also classified according to the results obtained from X-ray fluorescence analysis, by determining the ratios of several elements as Pb/Ag versus Fe/Cu, Pb/Fe versus Ag content and Cu/Fe versus Ag content.

Significant clusters are obtained regarding the "print" of the elements composing the coin alloys. It is also to be mentioned that the Middle Age coins contain gold up to 1,64% that is easy to be debuted in the Ag alloy. The gold is also present in the silver ore but at that time their separation was not possible.

52. A Study of Later Chinese Metalwork.

Michael Cowell*, Susan La Niece* Jessica Rawson**

*British Museum
**Oxford University

This paper is concerned with the composition, construction and decoration of later (mostly post 15th century AD) Buddhist Chinese metalwork in the British Museum Collections. It follows on from a study of Chinese copper alloy coins (Bowman et al, 1989) which revealed changes in brass production from the 16th century.

The metalwork components of over 70 artefacts (figurines, vessels, bells etc.) have been analysed using atomic absorption spectrophotometry (AAS) or inductively coupled plasma atomic emission spectrometry (ICPAES). Decoration (gilding, inlays and pigments) were analysed by X-ray fluorescence (XRF) and X-ray diffraction (XRD) and the construction of a selection of items was investigated by radiography.

The Chinese were comparatively late in adopting brass, or zinc-containing alloys, for this class of metalwork even though they were familiar with its manufacture. In common with the coinage, brass was not extensively

used until the 16th century which contrast completely with Tibetan and Nepalese practice where it was employed from the 12th century.

The alloys used for the Buddhist metalwork are more variable than those used for the contemporary coinage. The zinc content is lower and gunmetal or mixed alloys are more frequent. In common with the coinage, the later metalwork tends to have higher zinc contents. Whilst the use of brass is more likely from the 16th century onwards, the amount of zinc or other alloying components does not assist with defining date of manufacture. The trace element composition of the brasses, particularly the cadmium content which increases from the early 17th century, may be more useful in this respect.

Mercury, as opposed to leaf, gilding was more frequently found on artefacts with low lead contents. The range of pigments found was similar to that on Tibetan figurines and included azurite, lazurite and hydrocerrusite. An unusual pigment encountered on a late 14th century figurine was cobalt blue, possibly applied as a glass frit, which has been reported previously in this context by Beguin et al (1982). The cobalt pigment in our example contains associated elements which are compatible with the material imported into China prior to the mid. 15th century and widely used to decorate porcelain.

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53. Screening for Proteins on the Ancient Potsherd

Oliver E. Craig*, Matthew J. Collins*; Rebecca Stacey, Carl Heron**, Robert J. Sokol***, Keith Gelsthorpe*****

*Fossil Fuels and Environmental Geochemistry, Drummond Building, University of Newcastle, Newcastle upon Tyne, NE1 7RU, UK

**Department of Archaeological Sciences, University of Bradford, Bradford, BD7 1DP, UK;.

***Trent Regional Blood Transfusion Centre, Longley Lane, Sheffield S5,7JN, UK

Despite early claims of exceptional preservation of serum proteins on stone tools, recent criticisms have caused some controversy in the subject. With a greater understanding of protein diagenesis on mineral surfaces, it is thought that ceramics may provide a better environment for long term protein preservation due to there larger surface areas and high porosity. This study aims to assess ceramic surfaces for their ability to bind and preserve protein residues over archaeological time-scales. This involves screening tests (including pyrolysis mass spectrometry, measurement of carbon isotope ratio and measurement of the carbon to nitrogen ratio) to highlight the degree of molecular preservation and to select samples for further immunological analysis.

Particular emphasis is placed upon analysis of milk residues to ultimately shed light upon the use of disputed early linear European milk pots Ceramics have been obtained from Iron Age (Easingwold, North Yorkshire, UK) and ethnographic contexts. Simulated pots have also been constructed and used to cook a variety of foods in order to investigate processes of organic accumulation in the vessel wall.

Amino acids have been detected at very low levels on archaeological pots identified using the screening methodology. The use of simulated controls which have been artificially aged may tell us whether this is a feature of archaeological pottery or whether conditions may arise which allow preservation of intact proteins. If former is true, and proteins are less abundant on sherds than lipids, then it will be even harder to explain their apparent preservation on stone tools.

54. New non-destructive analytical method in X ray fluorescence to trace back the origins of archaeological obsidians

Crisci G.M., De Francesco A.M., Lanzafame U.

Dipartimento di Scienze della Terra – Universitá della Calabria – 87036 Arcavacata di Rende (CS) - Italy Tel: +39.984.493637, e-mail: crisci@unical.it

A non-destructive analytical method has been pointed out using X- ray fluorescence (XRF) aimed to determine the provenance of finds made of lithic materials having a microcrystal or glasslike homogeneous matrix.

In the determination of the provenance a major limitation to the use of traditional chemical methods is due to the impossibility to tamper the samples. In fact the most used techniques of analytical chemistry (X-ray fluorescence, atomic absorbance) expect a preparatory phase that tampers the samples.

The non-destructive methods, like neutron activation, electron microscopy etc., show further and more important limitations, like the high analytical cost (neutron activation) or the possibility to analyse only the most abundant elements and not elements in traces, that are usually more significant than the major elements.

The starting point of the new method for the determination of the provenance of the obsidians has been the individualization of a chemical-physical like quantity that could permit to compare, in a discriminating way, the archaeological obsidians from those taken directly from the outcrop zone. The new X-ray fluorescence method is based on the X-ray intensity ratio of two chemical elements, properly chosen, and simultaneously analysed. In this case, it is possible to determine the origin of an unlimited number of samples without absolutely tampering them.

Such methodology has given good results in the study of the provenance of the obsidians of west-central Europe, Greece and Cappadocia (Turkey).

The method has been used for a first application in studying and determining the origin of the archaeological obsidians but, as it seems by preliminary studies, may be also used in the determination of the provenance of flints.

55. Experimental firing of clays using salt water

Michael Jost Von Der Crone, Marino Magetti

Institute of Mineralogy and Petrography, University, Pérolles, CH-1700 Fribourg (Switzerland)

Redfiring clays turn to a pale yellow or even white when prepared with saltwater. The bleaching is limited to the surface and enters not more than about 1 mm in the sherd's body.

In this study natural clays as well as synthetic clay mixtures were used. The fired samples have been studied by XRD, HT-XRD, XRF, INA, Mössbauer spectroscopy, SEM and electron microprobe. During drying, the water soluble NaCl, mineralogically halite, is enriched in the border of the ceramic product. The best bleaching is achieved with addition of 1-1.5 wt. % NaCl to the dry CaO-rich natural clays resp. 2-3 wt. % to the dry CaO-rich synthetic mixtures and firing temperatures in oxidizing conditions at 900-950 ^{o}C. After firing, the yellow to whitish rim of these products is composed mainly of quartz, plagioclase and pyroxene as well as gehlenite (depending on the CaO-content) with no hematite, contrasting to the red-coloured core of the samples which contain much hematite, but less pyroxene and plagioclase. NaCl accelerates the mineral decomposition and catalyzes the neo-formation of Ca-silicates, which incorporate the iron in their structure. In the initially halite-rich border, gehlenite and pyroxene appear even at temperatures of 700 ^{o}C. After firing, the rims have lost K, Na and Rb when compared to the cores.

56. Comparison of Probe Resistivity and Electromagnetic Methods for Archaeological Prospection

Guy M. Cross

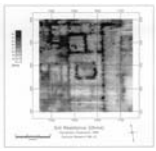
Fitch Laboratory, British School at Athens

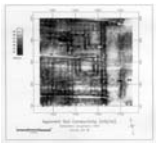
A large scale electrical resistivity survey of Stymphalos, a Late Classical-Hellenistic town buried in lacustrine sediments associated with seasonal flooding of Lake Stymphalia in the Greek Peloponnese (Papamarinopoulos, et. all. 1989), has revealed much of the orthogonal plan of the ancient town and has played a central role in preliminary interpretation and subsequent excavation of the site. However, recent uncertainty over land title and access to overlying agricultural fields has diverted excavation activity away from the town center to the acropolis and other areas of the site. Consequently further geophysical prospection is required to direct the focus of these excavations and, concurrently, to establish a more complete picture of ancient Stymphalos.

To evaluate the potential of the electromagnetic induction method as an alternative to twin-probe resistivity mapping, coincident, high-density surveys were conducted over a prominent rectangular anomaly, detected by the original resistivity survey. The surveys were conducted at approximately the same time on consecutive days under effectively the same environmental conditions (no intervening precipitation). In addition to assessing the

relative merits of the two methods for Phase II geophysical investigations at Stymphalos, the surveys provide an illustrative comparison-contrast of the two prospection methods under ideal field conditions.

A 40 m by 40 m area was surveyed at a 0.25 m sample interval along east-west transects separated by 0.5 m. Electromagnetic measurements of apparent electrical conductivity were acquired at ground level using a Geonics EM-38 in vertical dipole mode (horizontal coplanar) with sensor boom oriented parallel to transect. Coincident soil resistance measurements were acquired at medium sample rate (0.5 seconds/sample) using a Geoscan Research RM-15, with 0.5 m twin-probe configuration.





In addition to comparing the clarity and resolution of resulting data images, consideration is given to data acquisition rates, depth sensitivity and a statistical analysis of measurement precision. Findings indicate that despite relatively infrequent use for archaeological prospection, the electromagnetic method can be an effective and time efficient alternative to probe resistivity surveys.

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57. High Resolution Seismic Imaging of Archaeological Remains: Field Trials in Greece

G. M. Cross*, E. H. Williams**

Department of Geophysics, University of British Columbia
**Department of Classics, University of British Columbia

The potential of the reflection seismic method to yield cross-sectional images of the subsurface was recognized early on in the development of archaeological prospection. However, despite the mixed findings of reported experiments, it was generally concluded by the early 1970s that seismic exploration techniques were of limited value due to restricted resolution and the comparatively small-scale nature of archaeological remains (Tite, 1972; Aitken, 1974). Subsequent applications of acoustic techniques in connection with marine archaeology were decidedly successful and prompted attempts to adapt these higher frequency "acoustic" techniques for use on land. However, despite promising developments, the ill-fated reputation of seismic prospection has largely endured (Scollar et al., 1990).

Meanwhile seismic reflection technology has been revolutionized in connection with recent developments in environmental and groundwater geophysics and, in light of these developments, a research programme has been underway at the University of British Columbia to reassess the potential of high-resolution reflection seismic techniques for archaeological investigation (Cross, 1995). On the basis of a thorough theoretical review of factors controlling seismic detection and resolution, this work led to the development and testing of a prototype data acquisition system, combining "off the shelf" technology and special purpose instrumentation. Experimental soundings acquired over a full-scale subsurface model demonstrated the capability of the system to detect and image features on the scale of archaeological interest. In fact, a direct comparison between seismic results and coincident 100 MHz ground penetrating radar soundings confirm that the seismic method is capable of similar resolution.

Here we present the findings of preliminary field experiments conducted in connection with on-going archaeological excavations at two sites in Greece. Although results are promising, field trials identified a number of critical deficiencies. At Stymphalos in the Greek Peloponnese, where remains of the Late Classical-Hellenistic town are buried at shallow depth in lacustrine deposits associated with seasonal flooding of Lake Stymphalia, direct arrivals constituted a restrictive source of interference, masking reflections-diffractions from archaeological features. At a second site, Phalasarna, a maritime port of the fourth century B.C. on the north-west coast of Crete, the host soil is poorly sorted and highly consolidated. As a result, variations in source-coupling efficiency gave rise to substantial variability in wavelength characteristics, making identification of coherent events difficult. System refinements, currently underway to address these limitations are discussed. Despite pitfalls, results indicate that the method is viable and may have a significant future role in archaeological prospection.

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58. The Chemical Analysis of 11th Dynasty Mummified Bovine Soft Tissue From Egypt

Dr. János Csapó*, Zsuzsa Csapó Kiss*, János Csapó Jr.*, László Bartosiewicz****

*Faculty of Animal Science, Department of Chemistry and Biochemistry, Pannon Agricultural University, Kaposvár
**Institute of Archaeological Sciences, Loránd Eötvös University, Budapest
***Janus Pannonius University, Faculty of Natural Sciences, Pécs

Animal remains identified during the excavations of the hilltop Temple of Montuhotep Sankhkara (Thoth Hill, Thebes) included the mummified remains of a young heifer's leg. It was recovered from the north-western foundation deposit and originated from the right thoracic limb of an animal that was approximately 2 years of age.

Pieces of dry tissue (including skin and tendons) were removed from the palmar side of the metacarpal region. Chemical analyses of the 4000 years old sample revealed a remarkably good preservation of proteins and high concentrations of sodium. The amounts of ammonia and free amino acids, indicators of protein decomposition were low. Of the amino acids, sulphur containing cystine and remains of keratin were barely detectable. Cystine is one of the least stable amino acids, and as such is known to have decomposed even in significantly younger samples of wool.

While soft tissue preservation in the dried cattle leg was most probably due to spontaneous mummification in the windy and arid hilltop environment, the meat's pre-depositional treatment with salt cannot be excluded.

59. In what way, for what and with what limits can amino acids and amino acid racemization be used in archaeometry?

J. Csapó*, J. Nyberg, B. Malmgren**, Zs. Csapó-Kiss*, J. Csapó Jr.*****

*Pannon Agricultural University, Faculty of Animal Science, Kaposvár,
**University of Goeteborg, Geological Centre,
***Janus Pannonius University, Faculty of Natural Sciences, Pécs

After reviewing previous attempts to use the extent of amino acid racemization (AAR) for the determination of the age of archaeological samples containing proteins, we present our own approach. Before starting amino acid racemization research, a new method was elaborated for protein hydrolysis with very low racemization of amino acids. The hydrolysis was performed at high temperature (170 ^{o}C) for a short time (30 min) which caused very low racemization compared to the original (110 ^{o}C, 24 h) method. Subsequently the D- and L-amino acid content of fossil bone samples of known age (radiocarbon method) was determined by HPLC after precolumn derivatization. Based on the half-lives of racemization obtained and plotting the D/L ratio as a function of time for various amino acids, calibration curves were obtained which can be used for the age determination of fossil bone samples in the range of 2000-500.000 years. Another method is presented for the determination of age of textiles in the range of 100-1800 years. This method is based on the determination by amino acid analyser of the age-dependent alteration of amino acid composition of proteins. Cystine, methionine and tyrosine content decreased, while cysteic acid content increased with age. Prediction equations were developed as linear regressions of age of wool based on cysteic acid, cystine and tyrosine content.

60. The homogeneity-examination of plano-convex ingots using EPMA

Zoltán Czajlik - Kamilla G.Solymos

Loránd Eötvös University, Budapest

As was noticed in previous publications[1], the examination of samples taken from the surface-zone of the plano-convex ingots (generally from a single point) is open to strong criticism. The focus of criticism has been the dubious homogeneity of plano-convex ingots. It is questionable, whether even a very detailed examination of a small (a few cubic-millimeter) sample is representative of the ingot?

The plano-convex ingot fragments from the Hungarian-French excavations at Velem were restored with non-traditional methods[2]. This technology, that uses no chemicals and stabilizing-materials, is preferred not only from the viewpoint of further examinations, but also shows the layered structure of plano-convex ingots. This structure was formerly noticed only in some cases[3]. The layers that became visible by the naked eye are as follows (listed from the convex to the flat side):

- heavily porous layer with traces of gas bubbles
- compact, thick, homogeneous layer
- dark gray layer, whose cleaned surface is rapidly covered by sulphure excretions
- thick, homogeneous, compact layer

This structure can be followed especially well on the plano-convex ingot No.V93.F4, in the other cases the layer with strong porosity on the convex side could not be identified. This ingot was previously analyzed by using EPMA, but only in the surface-zone. The phases, indicated in that 1995 study may be summarized as follows:

- pure copper phase, within which
  a lead-rich sub-phase with some antimony and copper as well as
  silver containing inclusions were found.

New analyses were aimed at testing the inhomogeneity of the ingot and analyzing the composition of the layers noticed macroscopically. For the purposes of these examinations the ingot was cut to expose its cross-section, polished and analyzed by both microscopically and by using EPMA in the entire cross-section.

Results

Proceeding from the convex to the flat side, grosso modo the same layers could be distinguished as had been established by macroscopic observation:
- compact layer formed by the lead- and copper phases, especially rich in lead along the convex border where sporadic quartz-inclusions also occur. These latter occur in the outermost, porous surface-zone. (A)
- a dark gray layer that contains mainly copper-sulphide, close to the composition of covelline (Cu_2S). This composition corresponds to copper-sulphide-phases, generally found during previous analyses. It is only this layer that does not display "artificial" patterning (B)
- The thick layer on the flat side, similarly to layer A, also contains metallic copper and lead phases (C).

Within the macroscopically compact layers, the percentage of the lead is higher along the border. Presumably, this lead is not of natural origins, but is very likely indicative of the use of lead-oxides (as an alloying ballast material).

Summary

Total cross-section EPMA-analysis has shown, that strata within "layered" ingots are more or less inhomogeneous. On the basis of previous and new analyses it is obvious, that the small samples, taken from the surface-zone, or from the inside of the ingot show but a small difference in composition. This difference, however, usually does not modify the most important conclusions relevant to geological (origins) and technological (production) interpretations.

Our examinations confirmed the impression, (previously tested at several points on the external surface of the same ingot), that composition of elements usually does not differ within the same ingot, the percentage of these elements, however, does.

Elements occurring in small quantities or as inclusions, as well as rare phases, may be absent in small samples measuring only a few cubic millimeters. Ingots with layered structures and their inhomogeneity point to the importance of cleaning the surface sampled, and the careful selection of the point to be sampled. It can also be

stated, that the ingots are not mixtures of metals, but semi-products with relatively stable percentile compositions on the inside. Further examinations are needed to understand "layered" ingots, which occur obviously more commonly than was thought

Notes

[1]Zoltán Czajlik - Ferenc Molnár - Kamilla G. Solymos: Angaben zu den spätbronzezeitlichen Metallrohmaterialversorgung am Velem-St.Veit Berg (Westungarn). Archäologie Österreichs 6(1995) 30-35.

[1]We acknowledge to the restorers in the County Museum of Székesfehérvár.

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61. Polished stone between Neolithic and Bronze Age in Northern Italy

C. D'Amico, M. Bernabo' Brea, G. Felice, E. Montagnari., G. Morico ,G. Nenzioni, S. Occhi, A. Pedrotti, A. Pessina, E.Starnini, (and others)

Universita di Bologna Dipartimento di Scienze Mineralogiche, Piazza Porta S. Donato 1 40126 Bologna Italy

The authors present the status of the research carried out as a project of the Italian National Research Council (CNR) for studying the circulation of prehistoric polished stone implements in Northern Italy.

The studied period spans from early Neolithic to Bronze Age. In the last decade petroarchaeometric knowledge on polished stone has made some remarkable progress, thanks to systematic studies of several important collections. A few lithologies proved to be dominant, in particular alpine eclogites and jades (Na-pyroxenites). Most outcrops of these rocks are located in the Western Alps, at the Italian watershed. However the prehistoric populations seem to have preferred secondary, alluvial deposits and Oligocene conglomerates, where the above mentioned lithotypes are available in the form of natural pebbles and cobbles. Possible production areas and workshops have been localised in some places in southern Piedmont, Liguria and south-western Lombardy. Petroarchaeometric analyses (microscopic examination, thin sections, XRD, more occasionally chemical -XRF, AAS - and microprobe analyses) have been conducted so far on nearly 1000 objects, coming from several prehistoric sites of northern Italy. These results are presented together with a comparative analysis of the various assemblages. Some trends regarding the use of Neolithic-to-Bronze Age stone resources and circulation in Northern Italy and Europe can already be suggested.

- a) The production of polished stone tools in Northern Italy seems dominantly dependent upon western sources. Besides prevalent eclogites and jades, serpentinites and, more occasionally, omphacite schists and metabasalts, glaucophane schists, retromorphic green schists, chlorite schists, nephrites, etc. can be mentioned.

- b) Jades and eclogites have been widely exported to Europe (Britain, France, Rhine region, Austria, Moravia, etc.) as normal and ceremonial axes. A comparison on a European scale deserves attention.

- c) The more distant sites from the raw-material sources in north-eastern Italy show a remarkable contribution of local lithologies (in particular Triassic acid tufites), as well as a modest contribution from Transalpine sources of the Danubian-Carpathian areas (actinolite schists, andesites-dacites, silexites).

- d) A significant change of lithic refurnishment to the sites can be observed between the late Neolithic and the Copper Age, when basaltic (l.s.) rocks from the Appennines (Emilia), or serpentinites and basic rocks from the Eastern Alps and/or Dinarides (Trieste region) become dominant.

- e) Different lithologies seem to be selected for the different categories of polished stone tools, i.e. cutting-edged tools (axes, adzes, chisels) and ceremonial axes vs hammer-axes, vs bracelets and pendants, because of either functional reasons connected with the rock properties, or diachronic change in lithic exploitation.

62. The study of some physical control methods of precious and semiprecious stones

L. Daraban, L. Cociu, V. Znamirovschi, C. Cosma, G. Borodi, T. Fiat, La. Daraban

Faculty of Physics, Babes-Bolyai University, 3400 Cluj-Napoca, Romania
Institute of Isotopic and Molecular Technology, 3400 Cluj-Napoca, Romania

Different experimental techniques were researched in purpose of precious and semiprecious stones authentication. A first method was the determination of the respective mineral density with the hydrostatic balance. Thus rubies and sapphires were determined and strasses excluded which were presented as zircon. The analysis by X-ray fluorescence method was applied for the Cu determination from turquoise and for Fe and Mn from obsidian. At this last one also origin studies were made. Because of the necessity of checking the crystallographic structure analyses were made by X-ray diffraction on amethysts, lapis-lazuli's, sapphires and rubies, obtaining characteristically diffraction spectra. Net constants were calculated and the crystalline structure determined (for example a quartz type alpha, presented as false topaz). Also some images of diffraction were obtained by Lane method on photographic plate, in purpose of the fake distinguishing from glass, from the authentical crystals. The rubies were researched by RPE, obtaining information about the Cr^{3+} ion, which gives the red colour and also about the hexaedrical groups from the Al_2O_3 crystal, which is the host net.

63. Obsidian provenance studies

L. Daraban, C. Cosma, O. Cozar, V. Simon, V. Znamirovschi, M. Salagean, A. Pantelica

Faculty of Physics, Babes-Bolyai University, 3400 Cluj-Napoca, Romania
Institute of Physics and Nuclear Engineering, P.O. Box MG-6, R-76900, Bucharest, Romania

The "stamp" method applied to put into evidence impurity elements appearing beside the major chemical components of the ores offers the possibility to identify their provenance sources. The aim of this paper is to establish the provenance sources of prehistoric obsidian found in archaeology sites from Romania.

The discrimination parameter may be computed as function of the element content. In this diagram the points corresponding to the obtained data are disposed in clusters which allow to localise the provenance source of the investigated samples. The investigated obsidian samples (from Fratelia and Parta near Timisoara and Iclod near Cluj) together with two obsidian samples arising from known sources (Melos and Sardinia) were activated by neutron irradiation in the nuclear reactor and analysed by gamma spectroscopy.

The samples are also investigated by EPR and XRF methods in order to obtain more information about the obsidians characteristics and to confirm their provenance sources.

Our results lead to the conclusion that the Neolithic obsidian samples are arising from the Carpathian group (Slovakia) denoting trade or economic exchange relations along the rivers Tisa-Timis and Tisa-Somes, having in view that the obsidian samples are found more hundred kilometres far from the sources. According to the Carpathian group classification in two types C (1) and C(2) corresponding to the major elements and according to our earlier results the provenance area for the analysed samples is Cejkov and Kasov (Slovakia).

64. Distinction of Pottery Workshops - A Comparison of Experimental and Archaeological Material

Malgorzata Daszkiewicz*, Ewa Bobryk**

*Ceramic consultant for archaeologists, ARHED, ul.Ogrodowa, 8m95, Pl-00 896 Warszawa, Poland
**Faculty of Chemistry, Warsaw University of Technology, ul.Noakowskiego 3, Pl-00 662 Warszawa

The tools mostly used to distinguish local and imported pottery are chemical analysis and thin section studies. When the raw materials had been the same, e.g. because of a geologically uniform region, we may not find any significant differences in chemical composition nor in the kind of temper. Of course, this does not prove that there had been only one workshop. In such cases, possible differences in the technological process of pottery making can be used to distinguish workshops. In our presentation, mainly the preparation of the body and firing will be regarded. A large variation of firing temperatures applied in a single workshop may be caused by the inhomogeneous distribution of temperatures within the kiln and other accidental influences. Also, to obtain a well fired product, a given ceramic body should be fired within its characteristic range of temperatures which will be the same in different workshops in case the same raw material was used. The other important process, the time-consuming preparation of the body, may be less susceptible to accidental deviations and therefore better suited to identify different workshops. The final products then are grouped according to their ceramic properties which, given the same raw material and the same formula, depend on the way of how the body was prepared to make it homogeneous and to work out air. Determination of the ceramic properties (apparent density, open porosity and water absorption) of original and refired sherds, as well as thin section studies and

chemical analysis by WD-XRF, were used to distinguish groups. Interpretation is based on experiments with calcareous and non-calcareous potter's clays prepared in different ways and fired at various temperatures. Forty-five samples of Roman Sigillata from excavations of the kiln area in Rheinzabern, Germany, as a test case, yielded technological groups which correspond to archaeologically distinguishable workshops.

65. Firing Experiments and Technological Studies of Clay and Etruscan Tiles and Ceramics from Poggio Civitate (Murlo, Italy)

Malgorzata Daszkiewicz*, Gerwulf Schneider**

*Ceramic consultant for archaeologists, ARHED, ul.Ogrodowa 8m95, Pl-00 896 Warszawa, Poland
**Arbeitsgruppe Archäometrie, Freie Universität Berlin, Fabeckstr. 34/36, D-14195 Berlin, Germany

Excavations by Erik Nielsen and co-workers at the Etruscan site of Poggio Civitate (Murlo), south of Siena, yielded evidence for the production of tiles, architectural terracotta and various types of pottery during a limited occupation period between 7th and 6th cent.B.C. Including the ceramic material used for crucibles and tuyeres for bronze casting, there is a large variety of ceramic fabrics. The analysis of the finds and a survey for local raw materials aimed to answer the question which materials had been selected and how they had been prepared for the very distinct purposes. The main emphasis, therefore, was in determining the technological properties of the materials. Experimental firing of clays and refiring of artefacts at various temperatures was done and the changes in ceramic properties analysed. Thermal analysis, XRF, XRD and thin section studies showed that a very special local material, deriving from ophiolithic rocks, was used for tiles, coarse and fine wares, as well as for crucibles and tuyeres. This raw material, found at a distance of a few kilometres from the site, mainly consists of a weathered gabbro sufficiently plastic because of a high smectite content. This material is more refractory than all other local clays (therefore, it was used in a workshop on experimental bronze casting, organised in 1995 in Murlo by Edilberto Formigli). The largely available local calcareous clays had not been used at the site. Most buchero vessels, as the most typical Etruscan fine ware, are from non-calcareous clays and not locally made. It is shown how in archaeoceramological studies experiments and technological analysis adds significant information to chemical and thin section analysis.

66. Ferro-Chalcolithic phase in West Bengal

Asok Datta

Dept. of Archaeology Calcutta University, 51/2 Hazra Road, 700019 Calcutta, India

The entire proto-historic phase in West Bengal has been earlier designated as Chalcolithic culture. But in view of the discovery of large number of iron objects from different excavated Chalcolithic sites, the terminology was modified as Ferro-Chalcolithic. This nomenclature too does not seem to convey a meaningful proposition for the historical growth in West Bengal. But for the present purpose, we shall continue to use the term Ferro-Chalcolithic.

The Proto-historic culture in West-Bengal roughly spans over one thousand years. Iron tools have been found from different levels of this Proto-historic phase indicating a fair amount of knowledge in iron metallurgy. The tools comprise spearheads, points, daggers, chisels, axes, pegs, nails, rods, sword-blades, sickle, slags, ores, etc. Chemical and metallographic studies show progressive changes in technology over time. The development of this technology in West Bengal can be traced in three different stages - each stage being characterised by its own identities. In the final stage, the hardening and quenching methods were observed in an iron sickle from Pandurajardhibi which is recorded as the earliest evidence of this technology in India. It appears that the presence of a strong iron technology in the proto-historic phase was largely instrumental for bringing about a major change in economy during 3rd/4th cent. B.C. in lower Bengal which marks the beginning of historical period in West Bengal.

67. Carbon-14, tree rings, ice cores and chronology

Dayton, John E.

Institute of Archaeology, London

The paper will discuss the impact of Carbon 14 on Archaeology, then the effect of the corrections. Next, the evolution of the mature tree ring chronologies will be mentioned, and finally evidence from the Polar Ice Cores that has given precise dates for major volcanic events in the Second Millennium B.C. will be discussed.

For Archaeological Chronology the key date is that of the eruption of the island of Thera (Santorini) in the Aegean which covered diagnostic pottery on which, until now, the chronological system of the whole of the Near East, Egypt, Mesopotamia, and the Aegean has been based.

The paper will discuss briefly these synchronisms, and the great gaps in the present system. It will criticise the "subjective glee" with which archaeologists have uncritically accepted the date of 1626 B.C. for the Thera eruption, and propose a different chronology based on the Ice Core and Tree Ring data.

The author is an impure scientist (geologist, metallurgist, and mining engineer) and has been an archaeologist for the last thirty years, and considers that the purer scientists involved in Archaeometry should know what the archaeological problems are.

68. Studies on the State of Preservation of Archaeological Bone

V. De La Cruz Baltazar*, H. G. M. Edwards, I. J. McColm***, A. M. Pollard***

*Department of Archaeological Sciences
**Chemistry and Chemical Technology
***Department of Industrial Technology, University of Bradford, Bradford BD7 1DP, UK

The state of preservation of skeletal remains is a concern for archaeological research as poor preservation often makes them unsuitable for physical and chemical analysis. It is important therefore to be able to evaluate systematically the state of preservation of the materials to be studied.

This paper reports the initial results of a research that applies several analytical methods to the study of the organic and inorganic fractions of bone. Total, deproteinized and demineralized archaeological human bone of different states of preservation as well as fresh bone were used to evaluate the feasibility of using Fourier Transform Raman Spectroscopy (FTRS) for the characterization of archaeological bone. As Fourier Transform Infrared spectroscopy (FTIR) has been widely used to study bone apatites, a comparison of FTRS and FTIR is presented. Other methods of interest are discussed, including some mechanical properties of bone.

69. Application of Diatomological Analysis (Provenience) in Archaeological Ceramics: an experimental approach

Guillermo De La Fuente

Escuela de Arqueología - Universidad Nacional de Catamarca - Argentina

Although diatom analysis has been used as an adjunct to archaeological enquiry for over 30 - 40 years, there are very few publications exemplifying its use, and diatom results are often relegated to specialists appendices in archaeological reports.

Provenience analysis of ceramic artifacts is a relatively new field of diatomology - archaeology interdisciplinary research and it has a great potential for solving archaeological problems related with clay sourcing for ceramic production in the past.

In this paper we present an overview of the main applications of diatomological analysis in archaeological research emphasizing in the studies that focus in provenience analysis of archaeological ceramic artifacts through out a study case from Chaschuil Region, Tinogasta, Catamarca Province, Argentina.

Some methodological and technical aspects of this research are discussed in order to evaluate the significance of this archaeological bio-indicator for the study of (1) clays sources for ceramic production in the past, (2) local versus non-local clays exploitation and (3) spatial mobility of ceramic artifacts.

70. Technological properties of some medieval glazed pottery in Anatolia

Demirci, Sahinde*, Caner-Saltik, Emine N., Türkmenoglu, Asuman***, Böke, Hasan**

*Chemistry Department, Middle East Technical University, 06531 Ankara, Turkey

**Materials Conservation Laboratory, Architecture Department, Middle East Technical University, 06531 Ankara, Turkey
***Geological Engineering Department, Middle East Technical University, 06531 Ankara, Turkey

The medieval glazed pottery in Anatolia contains a strong typology group in appearance as fine sgrafitto decorated ceramics. In this study twenty such pottery pieces coming from Ephesus, Iznik and Korucutepe archaeological sites have been investigated. The glazes of these pottery items are mostly yellow and green colored with white slips.

The pottery samples have been analyzed to determine the properties of body, slip and glaze parts in terms of raw materials composition, firing temperature and glaze characteristics.

Investigations were done by using optical microscopy, scanning electron microscopy coupled with energy dispersive analyzer, Fourier transform infrared spectroscopy and X-ray diffraction analyses.

The results show that the pottery bodies have some vitrification. The state of vitrification have been discussed in terms of iron, calcium and clay minerals content as well as firing temperature. The slips are mainly composed of quartz and mica with low vitrification. The glazes are high lead glazes of above sixty percent content. The glaze composition have been characterized in terms of mineral composition, homogeneity and colorants.

71. Composition of 'façon-de-venise' and Venetian glass found in Antwerp, Belgium

I. De Raedt*, K. Janssens*, J. Veeckman, F. Adams***

*University of Antwerp, Department of Chemistry, Universiteitsplein 1, B-2610 Antwerp, Belgium
**Excavation Department of the city of Antwerp, Godefriduskaai 36, B-2000 Antwerp, Belgium

Antwerp, one of the largest ports of Europe in the beginning of the 16th century, was an important centre for the manufacture and import of glassware and is especially known for its trade in Venetian and 'façon de Venise' glass. Archaeological excavations have yielded a large number of glass finds, probably due to activities such as the import and trade of glass objects and of raw materials as well as the local manufacture of glassware. Within this extensive collection of finds an important number of Venetian and/or 'façon-de-Venise' glassware of different shapes and types was encountered, some of which may have been imported, but of which the majority is assumed to have been manufactured locally.

The aim of this work is to find out whether there was local production of these kinds of glass vessels in Antwerp and how this local production can be distinguished from 'real' Venetian wares.

A representative set of about hundred glass vessels from different excavation sites in the centre of Antwerp was selected for major element analysis by EPXMA (electron probe X-ray microanalysis) and their trace element content was determined by means of SR-XRF (synchrotron radiation induced X-ray fluorescence analysis).

The analysis results were compared with compositional data of glass of well-known origin. Several compositional groups are distinguished: one containing glass objects with a composition resembling Vitrum Blanchum glass ('common' Venetian glass), several groups which show no resemblance to the other groups and one group with a composition similar to cristallo glass (Venetian luxury glass). These compositional data will finally be compared with the composition of 'façon-de-Venise' glass found in different locations of the Southern Netherlands.

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72. Medieval Textiles : Ancient DNA and Analyses of metal threads made of animal substrate

Dominique De Reyer, Sandrine Pilbout*, Nicole Dennebouy*, Monique Monnerot***

*CNRS - CGM 91198 Gif sur Yvette
**Laboratoire de Recherche des Monuments Historiques 29 rue de Paris - 77420 Champs sur Marne

The weaving of luxury fabric is known to have been an active and important industry in Central Asia, Middle East and around the Mediterranean sea. Nothing is known of the history of the textiles except that they were preserved in European church treasuries or tombs. Attempts to sort out which 13th to 14th century textiles have historically been woven, were made on the basis of styles and patterns. But this method has resulted in a confusion of conflicting attributions because of the freedom with which motifs and patterns moved from one part of the world to another along the trade routes linking the Mediterranean with China.

In addition to identifying criteria by which textiles can be distinguished, technical analysis have revealed structural differences in the formation of the selvages, the combinations of fibres and the composition of metal threads (1).

The metal threads found in these textiles consist most commonly of strips of animal substrate (membrane, leather, parchment) that were silvered and/or gilded on one side, and either woven flat, or wound around a core and then woven.

The animal organic substrate can be examined in order to specify the identity of the treated skins. Access to ancient DNA provides the opportunity to study the genetic material of animal substrate and identify the species used for the production of the strips. A molecular tool using mitochondrial l-rRNA is developed (2). The sequence of the chosen fragment is suitable for differentiating cow, goat, sheep and pig (all domestic animals possibly used for the substrate production). Assuming that the treated skins used for the manufacturing process are related to the animal population of the geographic area, comparative studies can point out sufficient evidence to propose a more precise place of production.

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73. Application of synchrotron microdiffraction coupled with X ray fluorescence microprobe to the determination of the iron making processes by identification of inclusions in archaeological artefacts

Dillmann P.*+, Fluzin P., Chevallier P.*****

**UPRA A0423 CNRS Paléométallurgie du fer et cultures, IPSE, 90110 Belfort Cedex, France
*URA 6066 CNRS, Division matériaux, UTC, BP529, 60205 Compičgne Cedex
***LURE, Université Paris-Sud, Bat 209D, 91405 Orsay, France and LPS, CEN Saclay, France

The observations of the metallographic structure of archaeological iron artefacts illuminate the working processes used to obtain the objet, but cannot determine its reduction process (direct or indirect). To obtain this information, it is useful to study the crystallisation of inclusions (impurities coming from the smelting and working) that can give indication about old smelting processes.

The last progress in microanalysis with synchrotron radiation is offering new prospects in this area of research. Thus we developed a new experimental method to collect a number of information about inclusions composition and microstructure. We used synchrotron radiation focalised on few square micrometers by a Bragg Fresnel Multilayer Lens (BFML) to set up a microdiffraction method coupled with micro X-ray fluorescence (XRF). We complete this analyses by classical Energy Dispersive Spectrometry (EDS) coupled on an Scanning Electronic Microscope (SEM).

We present here the first results of the analysis and comparison of the composition and phases of inclusions entrapped in different archaeological artefacts representatives of the evolution of ironmaking from Gallo-roman period to the 19th century. We also made analysis on iron samples coming from experimental smelting and considered as References for the present results. This results shows that certain phases (especially containing aluminium or phosphorus) appears only in particular processes and could be discriminant phases between direct and indirect process.

74. Prehistoric and classical stone quarries ("mines") in the Carpathian Basin

Viola T. Dobosi, Katalin T. Biró

Hungarian National Museum, Budapest

Hungary is not very rich in mountainous areas composed of rocks with valuable physical and aesthetic qualities for tool-making and / or building purposes. About 90% of the territory is covered by young terrestrial sediments. In historical (and, prehistorical) periods, however, the Carpathian Basin formed closed economical unit with very rich resources, both for agriculture and mining. Cultural entities considered by most periods comprised extension in the framework of the Carpathian Basin, often transsected by the river Danube - notably, also in antiquity ("Pannonia" versus "Barbaricum"). Therefore, relevant petroarchaeological studies must be set in this framework. This aspect is realised by our contemporary prehistoric raw material comparative collection (BIRÓ-DOBOSI 1991) and the former large catalogue (and collection) of Zoltán SCHAFARZIK (1904).

Raw material exploitation and mining is documented in Hungary since the turn of the Middle / Upper Palaeolithic period. The most typical object of prehistoric mining is different types of siliceous raw materials, i.e., flint, chert etc., used for the production of chipped stone artefacts. Obsidian is also important for this purpose, though - at least in Hungary - no traces of mining could be observed yet in the exploitation areas. Flint mines tend to be in use mainly during the Neolithic period, though very important and complex mines are known from the Bronze Age as well.

By the Late Neolithic, the first metal ore (typically, copper ore) mines appear. There are no direct proofs for prehistoric ore mines in the Carpathian Basin. Indirect proofs, i.e., a very rich and authentic Copper Age and local workshops on the settlements indicate the importance and possible existence of such mines.

The number and quality of sources concerning Roman quarries and mines is essentially increased compared to prehistoric mining. These proofs can be divided into two parts: archaeological evidences like tools, traces of exploitation and various stone objects - sculptures, memorial stones, building stones etc., as well as written documents commemorating the high degree of organisation of mining activity.

The present day territory of Hungary is not specially rich in raw materials. Considered together with the other territories of the Carpathian Basin, it is an important economical unit. For prehistoric trade as well as raw material supply and trade in antiquities, this territory should be emphatically considered.

75. Raw Materials, Source Areas and Technological Relationships between Minerals, Rocks and Prehistoric Non-flint Stone Tools from the Atlantic Band, Cadiz Province, SSW Spain

S. Dominguez-Bella*; J. Ramos Munoz; D. Morata-Cespedes*; M. Perez**, V. Castaneda****

*Dept. Cristalografía y Mineralogía, Estratigrafía, Geodinámica y Petrología y Geoquímica. University of Cádiz. Puerto Real. 11510. Cádiz. SPAIN.

**Prehistory Area. Dept. Historia, Geografía y Filosofía. University of Cádiz. 11003. Cádiz. SPAIN.

Non-flint stone tools of different archaeological sites of the Atlantic Band of Cádiz province (SSW Spain), are studied. These sites have chronologies between Lower Palaeolithic and Chalcolithic (III millennium B.C). They are always coastal or interior open air enclaves.

Preliminary results of our mineralogical and petrological studies (X-Ray diffraction, optical microscopy and macroscopic characterization) of these materials were compared to the petrological characteristics of some samples from geological units of this area, with the aim to determine the authoctonous or alloctonous character of these, and their possible source areas. Our results show a predominance of two lithologies: dolerites and sandstones. Both have a local procedence and they are non-regularly distributed at the prehistoric sites. Some other lithologic types appear, in general with an alloctonous procedence, like exotic lithic materials as variscite green-beads or cinnabar, present in dolmens of the Cádiz province, and with raw areas distant at least several hundreds of kilometers of these sites.

Statistic balance between lithologic character, type and/or utility of stone tools, was made, showing a clear relationship between many lithologies and use. In this sense, we are shown a predominance of lithologies of

high resistance to the abrasion and low fragility (good mechanical behaviour). From these type of rocks, dolerites are predominte, and they are specially used to make axes. Other similar materials have an alloctonous origin and a minor utilization range, as amphibolite, sillimanite and jasper.

From these studies we can obtain interesting conclusions about the production mode, the life, the raw materials,

the source areas of these and the technological level of the hunters-gatherers, tribal and classist societies that lived at this geographical area.

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76. Mineralogical and Chemical Characterization of Roman Wall Painting from Medina-Sidonia, Cádiz, Spain

S. Dominguez-Bella, D. Morata-Cespedes

Dept. Cristalografía y Mineralogía, Estratigrafía, Geodinámica y Petrología y Geoquímica. University of Cádiz. Apdo.40. Puerto Real, 11510. Cádiz. SPAIN.

Cádiz province, placed at SW Spain is a very important archaeological zone, with vestiges from Lower Palaeolithic to the present. Its strategic location (north border of Gibraltar Strait) made of this an important geopolitical center at different moments of its history, as occurred during the Roman Empire, in which it was an important center of commerce. Different towns are developed at this time, well communicated between them by roman causeways, and joining agricultural and mineral production centers, with the marine harbor installations and fishing factories.

One of these towns was Assido (nowadays Medina-Sidonia), an important agricultural center on the Cádiz countryside, placed in a strategic elevation, and communicated by the causeway between Hispalis (Sevilla) and Baelo (Bolonia). Different Roman constructions (water conduction, sewage system, etc.) were recently excavated, and dated at first century A.D. (S. Montañés, 1993).

Different samples of wall painting, which appear as filling material of one of these constructions (Espíritu Santo Street, at the Medina Sidonia village), are studied. They present different pictoric styles, with human and animal representations and floral / geometric motives.

Analytical techniques as X-ray diffraction, optical and electronic scanning microscopy, energy dispersive spectrometry and infrared spectrometry are utilised, identifying as principal pigments, many minerals and synthetic materials. In these painting samples, we have identified at least seven different colours. Many other observed painting tones, were obtained by mixtures between them. These colours are: white, black, red, ochre, yellow-ochre, green and blue.

White colour pigment is mainly made of calcite; black colour paint, of lamp-black; red of hematite; ochre of goethite, yellow-ochre of goethite-hematite mixtures; green of celadonite and blue of a synthetic compound, the Egyptian Blue, obtained from the friture process of calcite, quartz and copper rich residues. Mineral components of painting are compared with possible source areas of raw materials and with other Roman archaeological sites of SW Spain area.

The compositional and textural features of plaster were studied by optical and scanning electron microscopy, and X-ray diffraction. At least four differentiated layers appear at this plaster. Paint is deposited on an arriccio, a finishing coat usually made with marble dust. The intonaco was made by two or three successive layers in which sand grains are the principal component, in general with quartz, K-feldspar, plagioclases and rock fragments. Third and/or fourth layers also present brick fragments and a high porosity. For the first time, exoscopic characterization of quartz grains of the plaster and of different sand samples proceeding from different geological sources suitable as raw material, are compared to dilucidate the raw area of this material, employed by the roman craftsman.

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77. Defining significance:Problems in dealing with Cu-As and Cu-As-Sn alloys

Roger C.P. Doonan

Ancient Monuments Laboratory, English Heritage 23 Savile Row, London

Although copper-arsenic alloys are an almost ubiquitous phenomenon in the world's metallurgical traditions, it still remains a contentious point as to the level at which arsenic should be considered a useful addition to the alloy. Whilst some scholars have arbitrarily drawn a boundary at 1% arsenic, below which arsenic is thought to have no significant effect on the alloys properties, other scholars have conducted experiments to ascertain at what level arsenic creates significant differences in mechanical properties, such as hardness, and tensile strength. Other more anthropocentric studies have concentrated on defining useful levels based on other properties more perceivable to humans such as colour and even smell.

This paper addresses aspects of Cu-As alloys which have hitherto not received appropriate attention. Virtually all studies have focused on the arsenic content and properties of the finished artefact and the relationship to its perceived function. Such teleological studies have erroneously ignored the major events in the sequence responsible for artefact production. The introduction of the concept of the "*chaine operatoire*" reminds the investigator that the properties of an alloy should be considered not only in terms of the finished artefact but also in terms of the melting regime, the casting regime, and the working regime.

Results of laboratory-based experiments are presented which indicate that arsenic concentrations significantly lower than those that could be thought of as useful for enhancement of mechanical properties or colour, offer advantages in terms of producing a sound casting-specifically by avoiding the unwanted formation of copper oxides. High arsenic values are often reduced during melting and casting to below what is often considered useful. This sacrificing of arsenic as a deoxidiser means that low or residual arsenic levels can sometimes be thought of as ghosts of former higher levels and should therefore not always be judged as inconsequential.

Although examples of Cu-As-Sn alloys have also been documented in prehistory, the general trend seems that arsenic and tin were kept separate. Some scholars have taken this to be evidence that ancient smiths recognised the different alloys and intentionally manipulated them. This has been assumed without any detailed examination of the alloys themselves. The results of laboratory experiments are presented here which elucidate the complex interactions between these three elements and the implications for the intentionality of Cu-As alloys are discussed.

78. The Use of Stable Carbon Isotopes in the Identification of Dairy Products in Archaeological Ceramics

Stephanie N. Dudd*, Richard P. Evershed**

*Organic Geochemistry Unit, School of Chemistry,
**University of Bristol, Cantock's Close, Bristol, BS8 1TS, UK.

Information on vessel use, food consumption patterns and animal exploitation plays an important role in the reconstruction of the economy, status and organisation of an archaeological site. Secondary evidence is often the most commonly available source of information, for example, our knowledge of the importance of dairying in antiquity has been gleaned predominantly from kill patterns[1] due to the lack of direct evidence. In the absence of faunal remains, however, a reliable and robust method of deriving information on animal exploitation and, in particular, dairying has remained elusive until now.

We have shown that variations in the stable carbon isotope compositions ($\delta^{13}C$ values) of subcutaneous fats from ruminant (ovine and bovine) and non-ruminant (porcine) animals[2] provide a means of distinguishing between the remnant fats preserved as residues in archaeological pottery. Further work has shown that clear distinction can be drawn between the stable carbon isotope characteristics of milk fat and adipose fat from ruminant animals, based on fundamental biochemical differences in their formation. The variations are based upon differences in the $\delta^{13}C$ value of the $C_{18:0}$ fatty acid and are essentially due to routing and energy balance in the body during lactation[3].

Here we present the results of compound specific stable carbon isotope analyses, obtained by GC-C-IRMS, and compositional data for fat extracts from archaeological pottery assemblages in the UK. Significantly, the data

indicate that different sites exhibit distinct patterns of resource utilisation in association with ceramic vessels. In this work the potential for the use of stable carbon isotopes in the identification of degraded fats is realised, with the most significant achievement being the identification of dairy products which are otherwise undetectable.

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79. An Early Medieval pottery workshop from the 9th Century at Reinach/Switzerland

Micheline Duruz, Marino Maggetti

Institute of Mineralogy and Petrography, University, Pérolles, CH-1700 Fribourg (Switzerland)

50 samples from a Carolingian pottery workshop were studied.

1) The kiln is built of a CaO-poor clay (n=4) with a very fine-grained temper (2 - 8 Vol. %).

2) 30 sherds from both kilns form a homogeneous, CaO-poor reference group. They are richer in granitic temper (14 - 38 Vol %) than the kiln structures. These temper fragments have been intentionally added. The original clay is similar, but not exactly the same as the one used for the kiln structures. One sherd has a calcitic temper.

3) 10 pottery fragments from the building are very heterogeneous in both the chemical and mineralogical composition. The granulometry of the granitic, artificially introduced temper (16 - 25 Vol. %) shows a wide variation. The original clays are different from the clays of 1) and 2).

4) The pottery was fired under weak reducing conditions at temperatures in the range of 650-850 ^{o}C.

5) From five local clays, only one is CaO-poor and matches the composition of 1) and 2).

80. Metallographic Examination of Sand Cast Copper and Bronze

Mark Eccleston, B.S. Ottaway, Maria Scordara, Scott Seibel, Nathaniel Stevenson

Dept. of Archaeology & Prehistory, University of Sheffield, UK

A brief overview of the archaeological evidence, or the lack of it, for the use of sand moulds for casting copper and copper-based artefacts and ingots in prehistory will be given. Archaeological evidence from Central Europe, Greece and the Aegean, Asia Minor, the Levant, Egypt and South East Asia will be incorporated into the study. It will be suggested that the use of sand moulds, rather than clay, stone or metal moulds was much more common during the Chalcolithic and Early Bronze Age than hitherto accepted.

Experimental castings will be carried out using pure copper and ten percent tin bronze in moulds with varying proportions of sand and clay. The cooling rate of each casting will be measured and samples from the casting will be subjected to metallographic analysis using optical microscopy. We will show what effect different compositions of sand moulds has on the cooling rate and microstructure of copper and tin bronzes. The results of the metallographic analysis might point towards a reason for change to other moulding material in the later Early Bronze Age.

81. The Enigma of the Emerald Green -Medieval Lead Glass Vessels la Heraclius

Gerhard Eggert*, Harald Hillebrecht**

*Landschaftsverband Rheinland / Rheinisches Landesmuseum Bonn
**Institut for Anorganische Chemie der Universitate Bonn

A hitherto unknown group of medieval lead glass vessels (some 70% PbO, only traces of Na and K) from North West Europe was established by screening methods; its connection to a unique contemporary recipe of Heraclius (De coloribus et artibus Romanorum III, 8) was reported in Heidelberg 1990. Later analyses by Wedepohl et al. confirmed these results. Now, to clarify the nature of the colours in these objects (bright yellow and emerald green transparent, red opaque) and further details of the recipe, experimental melts of the original glass composition were performed. The intensive yellow is mainly due to iron, not lead oxide.

Variable amounts ("...put as much as you think proper...") of brass fillings were described in the recipe "if you wish to make it appear green". In Wedepohl's analyses the copper content varies and is indeed correlated with the alloying metals of medieval brass (Zn, Sn). Test melts showed that introduced as elements, not oxides, they can indeed influence the redox situation and the emerald green hue of the glass depending on the experimental parameters. The recipe recommends generally: "Keep stirring it". Further scientific details of Heraclius' unusual precise recipe are discussed. The close relationship to a group of medieval lead glass vessels justifies to name them "la Heraclius".

82. Ceramics from Tell Brak, Syria: Observations of Technological Change

Murray Eiland

University of California at Santa Cruz, Earth Sciences Department, Earth and Marine Sciences Building, Room A232, 1156 High Street, Santa Cruz, California 95064-1077

Different materials and methods of manufacture of a long sequence of ceramics (c. 4th - 2nd millennium) from Tell Brak are considered using traditional typology, surface features, petrography, and replication (forming and firing). Chemical analysis (ICP) is used to supplement other information to determine which wares were imported. Of particular interest are changes in the ceramic paste that occur over time in vessels of a similar shape, and presumably similar function. In many cases changes appear to be governed not by technological considerations, but by tradition. The trend is particularly well illustrated by shell tempered and heavy basalt tempered wares that have a limited distribution. The use of both tempers may be associated with a change in dietary habits and food preparation respectively. The use of local materials and techniques as revealed by limited ethnographic study was also valuable in considering ancient sources for fuel, clay, and temper. For the non-cohesive local clays, hair and heavy organic inclusions were used to improve workability and reduce cracking and distortion during drying. Unlike other areas that offer a relatively wide range of materials for fuel, this region's most abundant - and easily available - fuel is dung, which from micromorphological evidence of other sites has a long history of use in the region. Test-firings in the field indicate that many of the vessels recovered from Tell Brak from all periods can be easily reproduced using local materials in kilns fuelled by dung.

83. Characterization of Obsidians from the Carpathian Source Region with Different Analytical Methods

Zoltán Elekes*, Imre Uzonyi*, Bernard Gratuze, Árpád Z. Kiss*, Katalin T. Biró*****

*Institute of Nuclear Research of the Hung. Acad. Sci., H-4001 Debrecen, P. O. Box 51, Hungary; azkiss@cseles.atomki.hu

**Centre de Recherces Ernest-Babelon, C.N.R.S., 3D rue de la Férollerie, F-45071 Orléans cedex, France; babelon@cnrs-orleans.fr

***Hungarian National Museum, H-1450 Budapest, P. O. Box 124, Hungary; h5852tbi@ella.hu

The last comprehensive summary on the study of Carpathian obsidians has been published recently by Williams-Thorpe (1995), indicating that all open questions in this field have been answered. However, it seems that there are still problems to be solved. Even in the above mentioned review article the current lack of routine application of the provenancing methods was mentioned and the need for further non-destructive methods of analysis and characterization was emphasised.

Hypothetical sources in south-west Ukraine still remained unexplored and claims for Romanian sources not adequately tested. Provenance of some artefacts found in Eastern Hungarian museums is still unknown and could not be matched with known Hungarian and Slovakian sources. The characterization of further sources and artefacts by sensitive analytical methods could reveal further existing connections. The comparative raw material collection of the Hungarian National Museum (LITHOTHECA) contains a good collection of samples which we intend to complete with new samples and analyses.

Surveying the applied routine techniques it was found that very sensitive and promising techniques like LA-ICP-MS (laser ablation - inductively coupled plasma - mass spectrometry technique) or non-destructive PIXE (particle-induced X-ray emission) method are not well represented or have not been used at all for the characterization of European obsidians. A complementary method, PIGE (proton-induced gamma-ray emission) method was used only for the characterization of some Near - Eastern sources.

The LA-ICP-MS is a multielemental, cheap, fast, precise and nearly non-destructive analytical method. (It means, that small ablation crater pits of less than 0.08 mm are made, which are invisible to the eyes.) As it produces crater of about 200 mm in depth it gives information well below the surface nevertheless "punctual". The PIXE-PIGE method is less sensitive, but non-destructive, and in the case of "micro beam" mode it is capable to analyse surfaces as small as about 1 mm^2, moreover, it produces maps showing the elemental concentration distribution laterally.

In this work, a comparison of these two methods, LA-ICP-MS and PIXE-PIGE, will be presented, analysing mainly Hungarian source materials and artefacts. For comparison, results on samples from Armenia, Iceland, Mexico, Slovakia and Turkey will be included as well. Interpretation of the results has been carried out through cluster analysis on elemental concentration data.

Reference:

Williams-Thorpe O., l995, Obsidian in the Mediterranean and the Near East: a provenancing success story, Archaeometry, 37, 217-248.

84. Casting Moulds from the Upper Dnieper Region (10th-11th centuries AD)

Natalja Eniosova

Archaeological Department, Moscow State University,119899 Moscow, Russia

Stone and clay casting moulds were found wherever the traces of jewellery production have been identified. The Viking Age settlement at Gnezdovo lies on the arterial river road of the Russian state in the 9th-11th centuries has yielded a large collection of fragmentary crucibles, metal ingots and more or less finished products. It gives the direct evidence of the jewellery manufacture at this site. Casting moulds are the most important objects that will give us a lot of information about casting process, working methods, technical standards and professional skill of Gnezdovo craftsmen. The objects discussed in the present paper fall into two groups. The first group is of stone moulds which were used for the casting of: 1) lunula-shaped temple rings with imitation of granulation work; 2) round pendants with central boss and geometrical ornament; 3) nails with embossed heads; 4) buttons and weights. The moulds were made of soft fine-grained sedimentary rocks well fitted for carving. They are identified as siliceous rock of biogenic origin(opal), greenish-grey sandstone and limestone. Besides Gnezdovo the most fitted artefacts come from the West-Slavs (Moravian) and Balkan regions, Scandinavia and the Old Russian towns (Staraja Ladoga, Novgorod, Kiev). The absence of any traces of using and experimental tests have clearly shown that stone moulds could have been intended presumably for casting of metal with low melting temperature. The second group is of clay casting moulds used for the casting of tortoise brooches and possibly for trefoil and round ones. Chemical and microscopical analysis shows that moulds were made of fine clay tempered with sand, chamott and organic materials. Some fragments contain more the 50% of additions. Tempered fabric for moulds brought many advantages: it could withstand higher temperatures and became more porous, also the shrinking effect was diminished. Clay moulds from Gnezdovo show three types of fabric: clay without additions, clay with sand and chamott, clay with chamott, clay with sand, chamott and organic materials. All clay fragments from Gnezdovo belong to the piece-moulds made of two fitting pieces. The back portions of mould are always plain. The front portions have a gently rounded exterior. Some moulds have two layers of different fabrics: the inner one containing additions and lute of fine clay without any additions. Clay piece-moulds permitted a high degree of mass production because one original pattern could be used to make many moulds. A large variety of ornaments and an absence of experimental objects testify the piece-mould casting technique had been brought to Gnezdovo by Scandinavian artisans. They continued to follow the Nordic manufacturing tradition and produced the same kinds of the ornaments.

85. Application of principal components analysis and edge enhancement techniques for the detection of prehistorical sites in Central Anatolia

N.J. Erdogar*, A.M. Özer, H. Yildirim*, M.E. Özel*, S. Gülcür***, U. Esin*****

*TÜBITAK Marmara Research Center, Space Technologies Department
**Middle East Technical University, Department of Archaeometry
***Istanbul University, Department of Prehistory

Aksaray, Nevesehir and Nigde provinces in Central Anatolia were searched with remote sensing techniques. The central Anatolia is rich in prehistoric mounds, tumuli, flat settlement and ancient road remains.

The geographical co-ordinates of the archaeological sites such as mounds, tumuli, flat settlements,...etc. were measured by GPS (Global Positioning System) during site surveys to locate them on the satellite images in an accurate way. Archaeological features were investigated on Landsat TM and SPOT Panchromatic images by Principal Components Analysis (PCA) and edge enhancement techniques. PCA was applied to all the seven bands of the Landsat TM satellite image. Prewitt compass gradient mask operators were applied in the north-west, north-east and south-east directions.

The visual interpretation of PCA showed that second and fourth components have more archaeological information than the other components. The edge enhancement techniques were especially useful in observing ancient routes. This study is still continuing with new techniques and new satellite images of higher resolution, such as Indian IRS 1C.

86. Non-destructive analysis of copper alloy artefacts from Pagan Norse Graves of Scotland

Dr Katherine Eremin

National Museums of Scotland

Work is currently being undertaken on the production of a corpus of the Pagan Norse Graves of Scotland. As part of this project, many of the copper alloy artefacts from the graves have been subjected to scientific analysis. Most have previously been described as bronze without analysis. Similarly, other studies refer to most Norse copper alloys as bronze but few published analyses are available. The aim of this study was to determine the composition of the artefacts and the decorative methods employed, assess their variation, and relate the results to artefact type, source and period. The grave assemblages are diverse, with material attributed to Scandinavia, the Irish Sea area and continental North West Europe. The artefacts analysed include oval and penannular brooches, ringed pins, harness and strap fittings, and buckles. Non-destructive analysis was undertaken using X-ray fluorescence and scanning electron microscopy. The analyses indicated a range in compositions. All oval brooches, attributed exclusively to Scandinavia, were brass. Most Insular artefacts were bronze, although some artefacts with Scandinavian influence but of probable Insular manufacture were brass. The ringed pins, of Insular origin, formed a diverse alloy assemblage, including bronze, brass and gunmetal. Some artefacts reflecting Irish influence were bronze or gunmetal with appreciable levels of silver. The main decorative features were mercury gilding and tin plating, with silver wires on some oval brooches. Brass is relatively rare in Britain from the late Roman to early Medieval period. Its use in areas of Norse settlement may suggest introduction from the Continent and Scandinavia.

87. An Ethnoarchaeological Comparison: The Kerkenes Archaeological Survey and the Legends of Kerkenes City and the Keykavus Castle

Begumsen Ergenekon

When the ethnographic and ethnohistoric data collected from the Sahmuratli village is compared with Kerkenes Archaeological survey nearby some parallels are seen. Sahmuratli village in Yozgat Turkey is situated at a place which gives access to centrally placed resources such as pasture, agricultural land, water, flora and fauna, mines, seasonal labour and public services. According to the oral history that exists among the villagers about Mount Kerkenes and the Keykavus Castle on it, their origins seem to be embedded in the events that have taken place on and around the ancient city through out history.

88. Multi-Molecular biomarker techniques to identify early agricultural practices in the Orkney Islands, Scotland

R.P. Evershed*, I.A. Simpson, P.F. van Bergen*, I.D. Bull*, V. Perret*, M.M. Elhmmali*, D.J. Roberts*, S.J. Dockrill*****

*Organic Geochemistry Unit, School of Chemistry, University of Bristol, Cantock's Close, Bristol BS8 1TS
**Department of Environmental Science, University of Stirling, Stirling FK9 4LA
***Department of Archaeological Sciences, University of Bradford, U.K.

Anthropogenic soils have been identified at a number of localities in the Orkney Islands, Scotland. These soils have been dated by radiocarbon analysis and stratigraphic relationship with settlement sites dating from the medieval period to the late Neolithic/Bronze age period (c. 3500 - 2000 years BP). Thus, they provide an outstanding opportunity to reconstruct early land management activity. An approach is being employed which involves the combined use of multi-molecular biomarker information derived from the solvent extractable and insoluble organic matter fractions of soils, stable carbon isotope analysis ($\delta^{13}C$ and $\delta^{15}N$) of both individual compounds and bulk organic matter, total phosphates and thin section micromorphology. Synthesis of the analytical data and archaeological information has allowed identification of a range of organic materials contributing to the formation of these anthropogenic soils. The results suggest a range of different grass turf sources together with ash and the application of faecal material derived from a number of sources including human, pig and cow. Specific biomarker structures and distributions have allowed very clear definition of the manure inputs to the soils. Such observations suggest an intensive form of manuring practice enabling sustained arable production in a marginal landscape highly susceptible to soil erosion.

89. Long-term dietary change in the Southern Channel Islands, California: The evidence from San Nicolas Island

Joseph A. Ezzo

840 N. Alverno, USA

The entire burial collection from San Nicolas Island, California, numbering nearly 300 individuals from more than 20 archaeological sites and numerous isolated finds, was analyzed for morphological traits and paleopathology. Trace element analysis was undertaken on a subset of 74 individuals from 13 sites and two isolated contexts, and stable isotope analysis was performed on a subset of 42 individuals from this group. The bone chemistry study focused on five sites of known age: SNI-40 (4000 B.P.), SNI-16 (3300 B.P.), SNI-56 (1400 B.P.), and SNI-18 (300 B.P.). The results indicated that dietary change through time was evident, although it did not follow a linear trend. Early on in the occupation of San Nicolas Island interactions with the mainland coast of southern California appear to be quite significant, influencing the composition of island diets, and this trend recurs very late in the archaeological record. In the intervening period, there appears to be relatively little interaction with the mainland coast. A second focus of inquiry involved the identification of auditory exostosis in individuals, and its relationship to subsistence practices. Auditory exostosis results from regular exposure to cold water, in prehistoric Channel Islands populations, it occurs almost exclusively in males and has been interpreted as resulting from diving for shellfish in the tidal pools. Auditory exostosis occurs in all periods of occupation of San Nicolas Island, and the bone chemistry data suggest that shellfish was an important component of the diets throughout the period analyzed.

90. The importance of firing atmosphere in the production of coarse ceramics with calcite and chamotte inclusions

B. Fabbri*, S. Gualtieri*, S. Santoro**

* CNR, Research Institute for Ceramics Technology, Faenza, Italy
** Archaeological Department, University of Bologna, Italy

Coarse ceramics constitute about 70% of the ceramic findings in the archaeological excavations of Roman age in Northern Italy. It deals with uncoated ceramics whose body contains significant amounts of inert inclusions. They were used to realise both cooking pots, vessels for liquids and storage jars. The firing of coarse ceramics seems to have been mainly realised in pit- or pile-kilns.

In the ambit of the present research some experiments have been carried out by firing a series of specimens in pit-kiln. The specimens were realised with suitable shape and dimensions by using a body without inclusions or with inclusions of ground calcite or chamotte. The aim was to verify the behaviour of the materials during firing, as well as the microstructural and mechanical characteristics of the different mixtures. In particular, the shrinkage during drying and firing, the phase composition, the porosimetric distribution, the mechanical and thermal shock resistance were determined. To evaluate the role of the firing atmosphere, the same bodies were fired also in an electric laboratory kiln, with oxidising atmosphere.

The results point out that the firing atmosphere does not influence the characteristics of bodies containing inclusions of chamotte, while different results are obtained with calcite inclusions. In particular, pit-firing allows temperatures as high as 800°C are reached without to promote the calcite decomposition and subsequent decohesion of the artefacts as it occurs in oxidant environment. This situation determines an increase of mechanical resistance of the materials without to compromise their integrity and functionality.

91. Pottery Production and Exchange in Eleusis, Greece, during the Middle Helladic Period

E.W. Faber*, V. Kilikoglou*, E. Kyriatzi, I.K. Whitbread**, M.B. Cosmopoulos*****

*Laboratory of Archaeometry, N.C.S.R. Demokritos, Aghia Paraskevi, 153 10 Attiki, Greece.
**Fitch Laboratory, British School at Athens, Souedias 52, 106 76 Athens, Greece.
***Department of Classics, The University of Manitoba, Winnipeg, MB R3T 2M8, Canada.

The present study aims to shed some light on the complex picture of Aegean Bronze Age pottery systems, by investigating the ceramic assemblage, predominantly Middle Helladic, from the site of Eleusis. An integrated application of instrumental neutron activation analysis (INAA), thin-section petrography and scanning electron microscopy (SEM), it aims to identify different ceramic traditions, to distinguish between local and imported pottery and to verify sources of imports throughout the period.

The detailed archaeological study established eleven pottery groups, on the basis of fabric, form and surface treatment. A total of 180 samples were selected to represent these features. The results of INAA and thin-section petrography coincide to show a series of distinctive compositional groups. One of them contains mainly Middle Helladic Matt-painted pottery and is characterised by the presence of volcanic inclusions, with the most likely source being Aegina. Another contains Middle Helladic Grey Minoan pottery and comprises fine grained fabrics with inclusions not indicative of origin. Local ceramic production seems to have been limited, as the majority of the painted pottery and some coarse wares appear to have been imported, while no distinctively local fabrics were identified. The technological SEM study shows a large degree of internal homogeneity within each group, suggestive of different traditions related to different production centres.

In general, it becomes obvious that, at least during the Middle Helladic period, Eleusis was the recipient of imports coming from larger centers of production.

92. Metallographic Examination of Prehistoric Copper from the Great-lakes Region of North America

R.M. Farquhar*, P.J. Williams, L.A. Pavlish***, R.P. Beukens****, G.C. Wilson*****

*Department of Physics, University of Toronto, Toronto, Ontario M5S 1A7
**Department of Engineering, University of Toronto, Toronto, Ontario, Canada M5S 1A4
***Archaeometry Laboratory, Department of Physics, University of Toronto, Toronto, Ontario, M5S 1A7
****IsoTrace Laboratory, University of Toronto, Toronto, Ontario M5S 1A7
*****Turnstone Geological Services Ltd, P.O. Box 130, Station "B", Toronto, Ontario M5T 2T3; IsoTrace Laboratory, University of Toronto, Toronto, Ontario M5S 1A7

Since the North American peoples had not emerged beyond the primary stages of Copper Age technology prior to European contact, early archaeological studies typically assumed their tool traditions to be a more recent and thus less significant phenomenon as compared with their Old World counterparts. Recent work, however, has shown that the North American copper working traditions can be extended back to the Archaic period (*circa* 7000 B.P.) demonstrating a variety of socketed and tanged projectile points, knives, harpoons and other items which cannot be considered any less complex nor morphologically inferior to those found throughout the Old

World. In many cases, tool morphologies common to both sequences exist contemporaneously despite the certainty of two completely separate developmental sequences.

This paper presents radiocarbon and metallographic evidence from which it becomes apparent that the Archaic peoples from the Great Lakes region of North America employed a systematic process of cold-working and annealing native coppers in order to skilfully fabricate a number of artefact types. We now know that these people were turning out very complex, beautifully shaped tools and weapons as early as the seventh millennium B.P. and possibly earlier. The quality and craftsmanship of these pieces suggests that their architects possessed a good working knowledge of the mechanisms involved in annealing coppers as well as an understanding for its effects in relation to the physical behaviour of the metal.

93. European connections - Implications of lead isotope ratios in early 17th century trade kettles from Eastern Canada

R.M. Farquhar*, R.G. Hancock, L.A. Pavlish*****

*Department of Physics, University of Toronto, Canada, M5S 1A7
**Slowpoke Reactor Facility, University of Toronto, Canada, M5S 3E5
***Archaeometry Lab., Department of Physics, University of Toronto, Canada, M5S 1A7

Fragments of copper kettles are often found on early 17th century native sites in eastern Canada. These kettle remnants provide us with samples of the copper being smelted and formed in European foundries during the same period. Isotope ratios of the traces of lead in these copper artifacts contain information on the geological sources of the copper ores being mined, and possibility the extent to which metal from various deposits was being mixed in the production process.

Swedish copper from Precambrian sulphide deposits of the Bergslagen region can be clearly identified isotopically. Historical records indicate that copper mining was taking place in this region at least as early as the mid. 14th century. A second copper source, whose location has not been identified, has isotopic rations similar to many Palaeozoic European sulphide deposits. For example the mines at Mansfeld, Germany, were known to be producing large quantities of copper in the 16th and 17th centuries.

Some kettles have lead isotope ratios which lie between the values for the two above sources. Mixing of ores or smelted copper may have been taking place, or other, as yet unidentified ore sources, may have been in use. A series of copper samples believed to have been traded into Atlantic Canada by 16th century Basque merchants have an unusually broad range of antimony contents as determined by INAA (80-3800 ppm). Isotopic analyses of the lead in these samples is being undertaken to determine whether they were all produced from the same copper ore.

94. Reconstruction of Paleodietary Behavior of Archaeofaunal Remains of Garhwal Himalaya, India

Y. G. Farswan

Department of History and Archaeology, HNB Garhwal University, Srinagar -246 174 U.P. India

The present study is based on the trace element analysis of archaeofaunal remains excavated from different archaeological sites, i.e. Thapli, a Painted Grey Ware site (first mill. B.C.), Ranihat, Mordhwaj, Banderkhet, the early historical sites and Malari, a cave burial site (c. 1000 B.C.) of mid-Central Himalayan zone of India.

Based on the estimation of Carbon and Nitrogen isotope ratios, reconstruction of paleodiet in animal remains has already been studied by various workers. However, it is also established that, besides study of isotope ratios of Carbon and Nitrogen, the trace elements (Sr, Ba, Mg, Mn, Zn, Ca, etc.) are also helpful in reconstructing the paleodiet of ancient animal population. Therefore, the aim of present study is to reconstruct the paleodietary behaviour of different animal remains, like Cattle (B. indicus), Pig (S. scrofa cristatus) and Goat (C. jharal) collected from different type of archaeological sites of Garhwal Himalaya.

The bone samples were analysed through Inductively Coupled Plasma Emission Spectrophotometry (ICP) in the Laboratory for Archaeological Chemistry, Department of Anthropology, Wisconsin University, Madison, USA.

The lower values of Magnesium, Strontium and Zinc and the higher levels of Ba, Ba/Sr ratios obtained from the analysed samples of different archaeological sites of Garhwal Himalaya, indicating a higher ratio of terrestrial

diet in their diet. However, the higher ratios of Sr/Ca, Ba/Ca and lower concentration of Zinc as compared to reference, clearly suggesting that these animals, from various altitudes were particularly of herbivore group. Therefore, it is concluded that trace elements, i.e. Sr, Ba, Mg, Zn and Ca can be used to assess the diet and dietary behaviour of the ancient animal population.

95. Matters in Atomic Spectroscopy

Freirí Gándara, M.J. and Freiría Gándara, M.C

Faculty of Scicences University of Vigo, Vigo, Pontavedra, Spain.

Atomic absorption spectroscopy provides a sensitive means of determining several elements. The method is well suited for routine measurements by relatively unskilled operators. Quantitative atomic absorption methods are usually based on calibration curves, which, in principle, are linear.

When a beam of polychromatic ultraviolet or visible radiation passes through a medium containing gaseous atoms, only a few frequencies are attenuated by absorption, and the spectrum is made up of a number of very narrow (about 0.005 nm) absorption lines.

Emission and absorption spectra for both atoms and elementary ions are obtained from flames. Atomic emission spectra are produced when an atom or ion excited by the absorption of energy from a hot source relaxes to its ground state by giving off a photon of radiation. In contrast, atomic absorption takes place when a gaseous atom or ion absorbs a photon radiation from an external source. It is important to appreciate that, when the same electronic transition is involved, the energy of an emitted photon is identical to that of an absorbed photon. Thus, the wavelength of the emitted radiation is the same as the wavelength of the absorbed radiation.

In atomic absorption spectroscopy, the radiation from a special type of external source is passed through the inner cone of the flame, through a moderadiation detector. In contrast to molecular absorption methods, atomic absorption methods do not employ a continuous source of radiation but instead use sources that emit lines of radiation that have the same wavelength as that of an absorption peak of the analysed.

Flame atomic absorption spectroscopy spectroscopy is currently the most widely used of all the atomic methods because of its simplicity, effectiveness, and relatively low cost.

96. Analytical techniques used in art and archaeology

Freiria Gandara, M.J. and Freiria Gandara, M.C.

Faculty of Sciences, University of Vigo. Vigo, Pontevedra, Spain.

Analytical techniques useful for the examination of archaeological finds and works of art are discussed extensively in the scientific literature. They include molecular spectroscopies, atomic spectroscopies, x-ray tecniques, electron spectroscopies, and nuclear techniques.

IR spectra have been mostly used for identifying and investigating organic compounds, and applications have covered amber provenance, studies on pigments, varnishes, paintings, identification of dyes, etc. Ultraviolet and visible spectroscpy finds a major application in the study of fluorescent radiations emitted by pigments, oilis and varnishes. Raman spectroscopy has been used, for example, for identifying inorganic pigments.

Atomic absorption and emission have been fairly used in pottery studies. Atomic spectroscopies are also suitable for the analysis of glass and metal objects.

The most striking results have been obtained with the use of x-ray radiography for the non-destructive examination of paintings. X-ray diffraction can be used successfully for identifying inorganic pigments in paintings, and it can also be used for identification of inorganic phases and inclusions in ceramic bodies. X-ray emission is a favourite techniques for mutielemental analyses of valuable objects, even though sensitivity is lather low with respect to other techniques. X-ray fluorescence is one of the most universal techniques for achaeometric analyses and has been used in the study of a great variety of archaeological materials, from pottery to glass and vitreous materials, pigments, and metals. Electron probe microanalysis has been used in the study of pottery, glass and vitreous materials, pigments and metals.

X-ray photoelectron spectroscopy (XPS) has been used to study pottery sherds, glass, and bronzes. Major ose of Auger electron spectroscopy (AES) has been in obtaining concentration maps and profiles by non-destructive beam scanning on sample surfaces and cross sections.

Neutron activation analysis (NAA) is a most favourite technique for the analysis of works of art and archaeological items. It has been used in the analysis of stone, pottery, natural and artificial glass, pigments, and metals. PGAA or PGNAA (Prompt -ray (neutron) activatoin analysis) applications have covered elemental analysis of metal objects, and detection of moisture and voids in masonry structures. Nuclear techniques useful in the examination of works of art include also -radiography and autoradiography. Higher penetration of -rays in comparison with x-rays makes -radiography suitable for the investigation of statues, plasters and masonry. Autoradiography is particulary suitable for the non-destructive examination of paintings, where decay sequence of elements containing in pigments begins with aluminium and follows with manganese, copper, arsenic, antimony, chromium, iron, mercury, and cobalt. Lead containing pigments, however, which form the basis of x-ray examination of paintings, cannot be revealed by autoradiographies. Mössbauer effect spectroscopy (MES) is a nuclear resonance spectroscopy and has been particularly used for studying iron containing materials. Mössbauer spectroscopy can be used for obtaining informatio on firing conditions in ancient pottery production, and in the study of iron containing pigments and obsidian.

97. New developments in the analysis of archaeological ceramics by total reflection X-ray fluorescence (TXRF)

M. Garcia-Heras*, R. Fernandez-Ruiz**

*Departamento de Prehistoria . Facultad de Geografía e Historia. Universidad Complutense. 28040 Madrid, Spain
**Servicio Interdepartamental de Investigation. Facultad de Ciencias Universidad Autonoma. Cantoblanco 28049 Madrid, Spain

TXRF combines and optimizes the advantages of more standardized and well-known techniques such as ICP-MS or EDXRF. On the one hand, it can be a suitable technique for analysing multi-elemental solid phase samples without any chemical manipulation. On the other hand, it can be a powerful tool in the analysis of multi-elemental liquid phase samples obtained by acid digestion as well. Due to its geometrical characteristics (where the angle of incidence of the primary X-ray beam is about 4 min of arc) the detection limits of TXRF are 10^3 times higher than EDXRF and similar to those obtained by ICP-MS. It prevents the advantage of minimizing matrix effects because of a substantial improvement in the peak-background ratio in comparison with traditional XRF. Nevertheless, its extensive application to the analysis of archaeological ceramics has not been started yet.

A previous work carried out by ourselves showed that TXRF provided precise semi-quantitative results (at least for 15 chemical elements) with a simple sample preparation process. In that work, pottery samples were analyzed in suspension and without any chemical manipulation. The results were also compared with a clay reference material analyzed by NAA. These experimental procedures were used to characterize the first century BC Numantian pottery production from the Spanish Central Meseta. Traditionally, whenever such pottery was found outside this region, conventional approach thought that this was the outcome on an incipient trade.

This work presents the new developments carried out by TXRF in the analysis of archaeological ceramics. At the current stage of research TXRF can provide highly precise quantitative results (at least for 22 chemical elements) by means of a microwave acid digestion preparation process of the sample. In this study, such preparation process and the comparison of the results with the clay reference material analyzed by NAA are illustrated.

98. Archaeological Prospection Using GPR and Cryogenic Soil Probes

Ervan G. Garrison, Nina Serman, Kent Schneider

Department of Geology, GGS Building 1720 Peachtree Road NW, Athens, GA 30602 USA
USDA Forest Service, Southern Region, USA
University of Georgia, Athens, Atlanta, GA 30367

Site location and characterization in wetland areas or saturated soils has benefited from the combined use of ground penetrating radar (GPR) and cryogenic soil probes.

This synthetic protocol has been developed and successfully utilized in the American South over the past five years. It has been applied to both prehistoric and historic archaeological sites at working depths of 2 meters or more. The GPR systems used are standard models familiar to many workers while the cryoprobe is a variant of the types developed in Germany and Switzerland in the early 1990s. The single greatest difference between the U.S. and European versions is a complete reliance on nitrogen as the coolant in the American South due to the elevated ambient air and soil temperatures. Rapid recovery of intact, relatively uncompressed, sediment columns have been obtained for in-field comparison to GPR data of adjacent archaeological deposits. This protocol has increased confidence in the interpretation of the radar data enhancing its role in the overall characterization of the archaeological site as a whole.

99. Archeometrical characterisation and provenance studies on pottery of Velia (Southern Italy)

V. Gassner *- R. Sauer**

*Institut für Klassische Archäologie, Universität Wien, Franz Klein - Gasse 1 A - 1190 Wien, Tel. +431/31352 - 249, e-mail: Verena.Gassner@univie.ac.at

**Institut für Archäometrie und Silikatchemie, Hochschule für Angewandte Kunst Wien, Salzgries 14 A - 1010 Wien, Tel. +431/ 53 56 830

Pottery of the late 6th and 5th century from the archaeological site of Velia has been studied. Investigations were performed on both fine ceramics (black glazed ware, Ionian cups) and coarse pottery (common ware, amphorae and bricks).

The pottery was analysed by a combination of thin-section and heavy mineral analysis and only to a small extent by chemical analyses (RFA). Additionally samples of ceramic raw materials available at the region of Velia have been studied and compared with the pottery products.

For most of the common ware (decorated and non-decorated), local production can be assumed. Some fabrics however, show large similarities with raw materials and pottery products from the neighbouring town of Poseidonia (Paestum) and were probably produced there. Only very few samples of special classes of common wares like some mortaria could be clearly identified as import products (Corinth, Calabria). It can also be shown that at Velia several local clay sources and clay mixtures were used simultaneously.

The analyses of the so-called Ionio-Massaliote amphorae gave a similar result. A large part is likely of local origin. Some seem to be imported from nearby Paestum. Subordinate products originating from Calabria, Greece etc. could be also identified but only very few examples of the typical fabric of Massalia (Marseille) could be found.

Also of interest at Velia are the numerous roof tiles from the late archaic mudbrick-houses. About fifty percent of these bricks were produced at Velia using local raw materials. The source for most of the remaining roof tiles seems most likely from a production site at Ischia. A small percentage of the roof tiles may have originated probably from Calabria.

The analyses of the so called fine wares have yet to be fully completed. The small sample size, partly very fine grained fabric and vitrification due to higher burning temperatures etc. make the analyses more difficult. Furthermore the interpretation of chemical analyses is also limited at the moment due to the lack of reference analyses (RFA) available from known production sites. Initial results point to several sources outside of Velia. Only for a minor part of the studied samples can local production be assumed. The possibility that a part of the production was located at nearby Poseidonia cannot be excluded.

100. Mössbauer Study of a Celtic Pottery-Making Kiln in Lower Bavaria*

R. Gebhard*, E. Guggenbichler, K. Schmotz***, F.E.Wagner**, U.Wagner****

*Prähistorische Staatssammlung, 80535 München, Germany
**Physik-Department E15, Technische Universität München, 85747 Garching, Germany
***Landratsamt Deggendorf, 94455 Deggendorf, Germany.

Two well preserved kilns for pottery making were excavated in Osterhofen-Schmiedorf and Künzing in Lower Bavaria during the fall of 1995. Both structures date to the Celtic time on account of pottery finds from the kiln site. The kiln from Osterhofen-Schmiedorf will be discussed in detail here. It has two firing chambers of about

0.5 m in depth which are separated by a solid wall. The firing chambers are covered by a circular flue plate of about 1.6 m in diameter with ventholes of 10 cm diameter. Nothing was found of the dome which presumably had covered the kiln, while ceramics and charcoal were recovered from a hollow working area in front of the firing chambers. No misfired sherds were found.

Neutron activation analysis shows that the material from the kiln site forms a unique group when compared with other reference groups of Celtic ceramics. The kiln was systematically sampled and Mössbauer spectra were measured of several profiles taken from the walls and the bottom of the firing chamber into the surrounding loess. The samples within each profile were separated according to the colour of the material. In addition, firing experiments were performed in the laboratory using a sample of loess from the kiln site. A comparison of the Mössbauer spectra of samples from the kiln site with those from controlled firings shows that the clay in the kiln was not exposed to high temperatures for any periods of time.

* Supported by the Bund der Freunde der Technischen Universität München.

101. The Examination of the Gold Samples from Sardis and the Replication Experiments

A. E. Geckynly, H. Özbal, N. D. Meeks , P. T. Craddock

Ýstanbul Teknik Üniversitesi, Kimya-Metalurji Fakültesi, 80626 Maslak- Ýstanbul, Turkey
Boğaziçi Üniversitesi, Kimya Bölümü, Bebek-Ýstanbul, Turkey
The Dept. of Scientific Research, The British Museum, Great Russell St. London WC1B 3DG, U.K.

Sardis was the capital of the Lydian kingdom ending with the reign of King Croesus who ruled from 562 to 547 BC. His legendary wealth was from the gold found in the placer deposits of the alluvial from the Pactolus stream that flows through Sardis from mount Tmolus. The first gold and electrum coinage is attributed to the Lydians.

The excavations began at Sardis in 1958 and continue under the Harvard-Cornell expedition, but the first archaeological evidence for the purification of gold was discovered in 1968 in the area designated as Pactolus North. The excavators found and recorded the parting furnace and cupellation hollows associated with gold refining and silver recovery. The furnace bricks are found to be impregnated with considerable amounts of silver absorbed from the purification process. In addition to various refractory remains gold foil fragments, globules, cut lump, square sided tuyers and litharge cakes which physically fit cupellation hollows ware also found in this area.

In this work the scientific examination of the 36 tiny selected samples by the excavators were received from the Manisa Archaeological Museum and were studied by means of SEM and energy dispersive X-ray microanalysis (EDX). Of those 26 were in the form of foil fragments, 3 were lump pieces, 5 were in the form of minute globes and 2 were gold dust. The gold remains studied came from the 1968 excavation season and with the exception of the gold dust. The samples of gold dust were panned from the bed of the Pactolus stream by mineralogist during the survey and are kept at the Manisa Archaeological Museum.

The microanalysis results indicated that the silver content of the samples were between 0-35%. Copper content of the samples are about the same and not exceeding 2%. According to the results, half of the gold foils are pure and the others are having silver composition in the range of 1.1 to 22.8%. The surface as well as the bulk of the gold foils show either extensive or fine porosity presumably as a result of parting process. The amount of porosity seems to be related to silver content of the sample. In all the samples neither surface enrichment nor platinum group elements were detected.

The preliminary results of the examination of gold treated in a series of refining replication experiments were also discussed. The results of this work have an important bearing on the interpretation of the structure observed in the Sardis gold samples.

102. Achievements in spectroscopic investigation of archaeological objects in Hungary

E. Gegus

University of Veszprém, Hungary

Archaeological objects are often valuable or very precious materials, thus their destruction for a conventional chemical analysis cannot be permitted. However, the knowledge of their composition is an important factor to establish the origin of the finding, to clear the relationship of connected parts and pieces, to detect fakes etc. Archaeometry serves for informing archaeologists on the appropriate task: archaeometry uses mainly spectroscopic methods requiring only a limited sample quantity, or working as a non-destructive technique.

The beginning of application of emission spectral analysis methods for archaeological investigation of prehistoric bronze findings was cited in the early literature. In Hungary, emission spectrographic techniques were similarly used to analyze metal findings in arc discharge. Also the micro-spark technique was effectively adopted, e.g. to identify the origin of various parts of a procession crucifix. K. Zimmer continuously furnished information and evaluated the spectro-chemical methods, published in the literature, and applicable for the various tasks of archaeometry.

Micro-spectral-analysis method for small sample quantities in solution, as well as the arc discharge technique, helped to clarify the very delicate composition of various parts of the Roman Aquincum organ. The laser-micro-spectral analysis was used as a quasi-non-destructive emission spectrographic technique for the investigation of a wide range of archaeological findings, first of all of metal objects. Results were suitable to compare and identify prehistoric findings, as well as to detect inhomogenities characteristic of the ancient technologies.

Principally non-destructive analysis methods are the X-ray emission and fluorescence techniques. Very effective serial comparison studies were performed and cited in the literature for the identification of e.g. silver coins, or non-metallic materials, ceramics, glasses. However, there is a hard problem: the penetrating depths of X-rays in various elements are different, therefore the composition of surface layers cannot be distinguished from the base material. As a very effective ultra-micro analysis method can be counted for the future the total-reflection X-ray fluorescence (TXRF) method.

An extraordinary important handbook: Archaeometrical Research in Hungary has been collected by the Archaeometry Working Group of the Hung. Acad. Sci. and published in 1988, in which 33 original publications and 111 summaries of selected bibliography in geographical prospecting, dating, analysis of pottery, glass, obsidian, metals, metallography, numismatics, painting materials, textiles, dyes, biological materials and spectrochemical of findings are contained. A second volume of this handbook will be presented now.

103. Metal Sources at Asine in the Greek Argolid: a diachronic analysis of metal sources using LIA

Carole Gillis*, Zofia Stos-Gale, Noel Gale****

* Dept. of Classical Studies AKS Gothenburg, 41298 Gothenburg Sweden
** Oxford University, Physics Dept. Isotrace Laboratory, Keble Road, Oxford OX1 3RH United Kingdom

The site of Asine in the Greek Argolid was populated more or less continuously from the Early Bronze Age (the middle of the 3rd mill.) to its destruction in the end of the 8th c. B.C. The site shows evidence of several thriving settlements , e.g. the end of the Late Bronze Age (the Mycenaean period), and during the Iron Age down to its destruction at around 720 B.C. The site consists of several excavated areas: the acropolis, the undertown, several burial areas and another settlement area some 100 meters from the acropolis. Typical for the Bronze Age, there is no evidence of metal working *per se* but rich finds of metal objects - copper, lead, bronze, gold, silver, and tin (as foil covering for pottery in LBA chamber tombs). For the Iron Age, there is evidence of iron-working and possibly even smelting, but nothing specifically for bronze working, although many finds of bronze objects.

The aim of the project is twofold: 1) to analyze all extant metal (copper, lead, bronze and possibly silver) finds covering the 1500+ years of continuous inhabitation, to see which metal sources were in use at what period, and what social/traditional and economic significance this has for the site and the region; 2) to look at various areas of the site at specific time periods when the finds cover the widest range of contexts to see if there are metallurgic differences in coeval metal sources - for the LBA, for example, finds from rich chamber tombs, simple burials, the acropolis, simple houses and larger houses and for the Early Iron Age, houses vs. burials will be compared.

The analysis method employed is lead isotope and chemical analyses and principal component statistical analysis.

The significance of the results both archaeometrically and archaeologically will be discussed.

104. Experiments on Ancient Patination Processes of Black Bronzes

Alessandra Giumlia-Mair*, Matthias Lehr**

*Pariciusstr. 13, Regensburg
**Akademie der Bildende Künste, Nürnberg.

The results of recent analyses (Giumlia-Mair 1996; 1997) of ancient black-patinated objects, from Egypt and Palestine, dated to the 19th c. B.C., as well as Japanese experiments (Uno 1929), suggested that the colour of the patina - artificially created by a surface treatment on an alloy containing 1-2% of gold and silver, similar to the Japanese alloy shakudo - could be deliberately changed by adding small quantities of other elements to the copper-gold-silver-alloy.

Ancient texts also seem to suggest that in the ancient World and in later times in the East, different alloys, treatments and patination processes were used to produce black bronzes, inlaid with precious metals.

The authors produced different shakudo-type alloys, containing small amounts of elements such as iron, tin, arsenic, lead etc., similar to the alloys previously identified by analysing ancient objects, and carried out patination experiments, employing various processes described in several texts of different provenance.

Metallographic studies revealed notable differences in the characteristics of the various samples. The structure of the differently produced patinas and the inclusions were examined and analysed by scanning electron microscopy in the Institute of Materials Science and Applied Chemistry, University of Trieste (Italy).

The understanding of the ancient texts on this fascinating material, has been greatly improved by the experiments on the laboratory specimen. Earlier interpretations based on misunderstood statements have been corrected.

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105. The process of Neolithization of SE-Europe according to C^{14}-dates

Roland Gläser

Forschungsstelle für Archäometrie der Heidelberger Akademie der Wissenschaften, Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The process of neolithization of Europe is for a long period under debate. After the model of a „aceramic or preceramic Neolithic", similar to the cultural development in the Near East and first claimed by V. Milojcic, some other theories had arisen. A widely accepted model is the „waves of advance", proposed by Ammerman and Cavalli-Sforza at the beginning of the 70s. This model was based on uncalibrated ^{14}C-dates, which gave the impression of subsequent waves of Neolithic advance, driving the borderline between Neolithic and Mesolithic cultures up to Northwest-Europe. This model was criticised by M. Zvelebil, who denied the existence of an unflexible frontier between these two cultural stages. The ^{14}C-dates from some sites in Greece (Argissa, Sesklo, Franchthi, Knossos) suggested a transition to Neolithic during the 1st half of 7th millennium cal BC.

Before discussing these dates, one has to keep in mind, that the oldest dates for the Pottery Neolithic (PN) in the Near East are at the beginning of the 7th millennium cal BC. This means that the transition from the PPN (= Pre-Pottery Neolithic) B/C to PN A or from Mesolithic to Neolithic, respectively, has taken place at the same time.

For the Aegean and SE-Europe, ^{14}C-dates from following Early Neolithic sites are available: Hoca Cesme, Yarimburgaz and Ilipinar X in Western Turkey, Argissa, Franchthi, Sesklo and Nea Nikomedeia in Greece, Poljanica-Plateau in Bulgaria, Anzabegovo, Obre, Porodin in former Yugoslavia, Icoana in Roumania, Gyalarét and Maroslele-Pana in Hungary. Dates from some of these sites place the Neolithic before 6000 cal BC.

During the 90s some contributors to this discussion made clear, that there is no evidence for the existence of an „Aceramic Neolithic" in SE-Europe. That means, that all early dates for the Neolithic should be placed into the

Ceramic Neolithic of SE-Europe, i.e. Protoseskło in Greece, Monochrom Pottery in Bulgaria, Starcevo/Körös/Cris in Central Balkans and the Carpathian basin.

The probability distribution of the Early Neolithic dates reaches its peak in the 2nd half of 7th millennium cal BC. There is another small peak at ca. 7000 cal BC, caused by two dates from Argissa. These dates are deriving from bone collagen coming from the former aceramic layer of Milojcic´s excavation. They suggest an early phase of the neolithization process. Since the existence of this layer, formed only by several pits, can be denied, they are clearly outside the range given by the other dates. The most probable explanation is a hard-water-effect or other contamination of the bone collagen. If one excludes these two dates, the remaining dates give a timespan for the neolithization between 6500 and 6300 cal BC, not only for Greece, but also for the central Balkan, the eastern Carpathian basin and a region around the lower Danube. It is surprising, that there are no dates before 6000 cal BC in southern and central Bulgaria and in western Turkey. The most convincing reason could lie in geomorphological circumstances.

The probability distribution of the Early Neolithic dates indicates a step in the wave of advance of the PN, beginning somewhere in the Near East at around 7000 cal BC, arriving in Europe at around 6500 cal BC and surmounting the distance between Greece and the Great Hungarian Plain in 200 years. A similar observation could be made for the neolithization progress of Middle Europe, i.e. the spreading of the Linear Pottery culture.

106. Alpha-recoil-track dating of biotites from Quaternary volcanics

K. Gögen, G. A. Wagner

Forschungsstelle für Archäometrie der Heidelberger Akademie der Wissenschaften
Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Since its introduction by Huang and Walker in 1967, alpha-recoil track dating was sporadically applied to micas from samples of archaeological interest. So far the validity and feasibility of this technique has not yet sufficiently demonstrated.

The heavy recoil nuclei accompanying the a-decay leave short (10 - 20 nm) tracks in the crystal lattice. In biotite this radiation damage can be made visible by etching and phase contrast microscopy. Such alpha-recoil tracks are produced by ^{235}U, ^{238}U, ^{232}Th and their a-active daughter nuclides (radioactive chain).

In order to study their potential for dating young tephra layers, biotite samples were collected from the Eifel Quaternary volcanic area. For age calculation it is necessary to determine the track density and normalize it to the uranium- and thorium contents, determined by fission-tracks induced by separate slow and fast neutron irradiation. The latent alpha-recoil tracks are etched with 30% HF for ca. 20 min., reaching sizes of up to 1 mm. The primary advantage of the alpha-recoil track dating over the fission track method is a several thousand-fold increase in sensitivity. The applicable range of dating is ca. 103 to 106 years, depending on the uranium, thorium content (1 - 8 μg/g) and the limiting areal density of alpha-recoil tracks (104 tracks/mm^2).

Our investigations support this idea. The alpha-recoil track density grows linear with the known age of the samples. This relationship allows the calibration of the alpha-recoil track clock. Biotites even from distant tephra in the size range of 0.02 mm^2 seem to datable. In terms of archaeochronometry this may be important to date sections where archaeological layers are intercalated with tephra beds.

107. The analysis of dyeing technology of the 4th-8th CC. polychrome Coptic textiles from the Louvre Collection

V. Golikov, O. Nastichenko, Y. Pshenichnova, D. Voskresensky, D. Benazeth, M.-H. Rutshowskaya

Russian Research Institute for Cultural and Natural Heritage, Moscow, Russia
Louvre, Paris, France

In 1996-97 the present authors examined the specific traits of the dyeing technology of Coptic polychrome fabrics, including the famous *Chale de Sabine*, on the basis of 54 samples of threads from the Louvre collection. The study was aimed at:

a/ reconstructing the technology used for dyeing fibres of different colours and various tints of a particular colour

b/ estimating the possibilities of the applied research method for the dating and attribution of the relevant fabrics

c/ estimating the impact of water cleaning on the red dyestuff, i.e., madder.

With the aid of specially elaborated experimental methods both qualitative and quantitative analysis of dyes have been carried out. We have succeeded in reconstructing the mechanism of the attachment of dyes to wool fibres, in tracing the spatial distribution of dyes both on the surface and within the filaments and in estimating the technological quality of dyeing.

We have reconstructed the means of obtaining a given colour and making it pure - more vivid for red, yellow, green, blue, brown, black and white fibres from 14 textile samples. It appears that the applied method can be effectively used for solving historical and culturological problems. We have also established that even soft water cleaning may affect colour characteristics of the fibres dyed with madder.

108. The Muslim conquest and the routes of gold. A new approach

A. Gondonneau, C. Roux, M. F. Guerra, J.-N. Barrandon

Centre de Recherches Ernest-Babelon, C.N.R.S., 3D rue de la Férollerie, F-45071 Orléans cedex ; guerra@cnrs-orleans.fr

Several theories on the date of arrival of the gold of Sudan to the North of Africa were developed based on the Middle Ages literary sources.

Using 12 MeV proton activation analysis (PAA) and LA-ICP-MS we were able to show that the first gold struck in Ifriqyia under the Ummayyads had the same characteristics as Byzantine gold. Under the Aghlabids there was a change of the gold supply (characterised by high Ga and very low platinum group elements (PGE) contents).

Under the Fatimids another gold supply seems to appear in the Ifriqyia and in the Maghrib mints (lower Ga and higher PGE concentrations). This dynasty conquered the North of Africa in the 9th and 10th century and the Egypt and the Syria in the 10th century. Also in the 10th century they shared with the Spanish dynasties the Eastern and Western gold routes of Africa. We showed that after this separation the same gold (which is different from all the others) was struck in Al-Andalous and in Sidjilmasa.

Does the Aghlabid gold come from Sudan or from other African sources ? Where does the Fatimid gold comes from ? Are we able to distinguish the Sudanese gold from the gold of Nubia, Red Sea, ... ? Are we able to approach the Muslim gold provenance problem in the Orient ?

In order to understand the routes of gold, mainly under the Fatimids, coins struck during the 9th and 10th century in Misr and in Syria were analysed by PAA and LA-ICP-MS to follow, among others, the PGE and the Ga concentrations. Nuggets and samples from African excavations have also been considered when possible.

109. The gold and silver of the Persian Empire. From Cyros to Alexandre the Great

A. Gondonneau, H. Nicolet, M. F. Guerra

Centre de Recherches Ernest-Babelon, C.N.R.S., 3D rue de la Férollerie, F-45071 Orléans cedex ; guerra@cnrs-orleans.fr

It is under Darius I (522-486 BC) that the several Near East reigns of the Achaemenidae kings were organised and enlarged, forming an Empire from the Indus to the Aegean Sea and from Syr-Daria to the Persian Gulf and the first Nile cataract. In 334-330 BC all this Persian Empire was conquered by Alexander king of Macedonia.

In this Empire all the commercial transactions were made using gold and silver. It is so under Darius I that we assisted to the creation of the first silver (sicle) and gold (darique) coins struck in the Persian Empire. However, after its conquest by Alexandre the Great and even after his death (332 BC) staters of Alexander and (his father) Philip type (struck all over the Greek World) are also struck in the Persian mints (like, for example, in Babylon). In fact the stater was used all over the Mediteranean basin; we must notice that the first Gallish coin was a reproduction of the Philip stater.

Coins have always been struck in known mints (particular mint marks) during certain periods. The determination of their composition indicates the changes on gold and silver sources in time. Using 12 MeV proton activation analysis (PAA) and ICP-MS associated with laser ablation (LA) we determined the major, minor and trace elements of coins struck in the mints of Persia, Greece, Egypt, ... in order to follow the manufacture technologies and characterise the gold and silver minerals of these empires.

We present here the first results on the origin of several European, Near East and African precious metals used from the 5th to the 3rd century BC.

110. A Study of Hungarian medieval glass composition : preliminary results

Bernard Gratuze*, Imre Uzonyi, Zoltán Elekes**, Árpád Z. Kiss**, Edit Mester*****

*Centre de Recherces Ernest-Babelon, C.N.R.S., 3D rue de la Férollerie, F-45071 Orléans cedex, France; babelon@cnrs-orleans.fr

**Institute of Nuclear Research of the Hung. Acad. Sci., H-4001 Debrecen, P. O. Box 51, Hungary; azkiss@cseles.atomki.hu

***Hungarian National Museum, Mátyás Király Museum, H-2025 Visegrád, Fő str. 23

The study of colouring agents in glass finds from the glass workshop of Diósjenő, castles of Visegrád and Buda is the starting point of a co-operation project on glass analysis between the Centre Ernest Babelon in Orleans (France) and the Department of Electrostatic Accelerators of the Institute of Nuclear Research (ATOMKI) of the Hungarian Academy of Sciences in Debrecen (Hungary). Glass samples spread in date between the 14th and the 17th centuries from these archaeological sites were studied by the Centre Ernest Babelon using LA-ICP-MS and by the ATOMKI using (micro)-PIXE-PIGE methods. These preliminary results allowed to discriminate between the soda-lime glasses (importation from Venice) and the potash-lime glasses (made locally). The soda-lime glasses are dated from the 14th to the 16th century and in this group we find some bottles, cups and bracelets from the Palace, Buda Castle and Lower Castle. In the potash-lime group we find mainly 15th and 16th century glasses which are often heavily corroded due to their potassic composition. In this group we find mainly glass windows from the Palace and Buda Castle and one cup from the Lower Castle.

During the first part of the project we have mainly focused on the cobalt blue glasses. Our aim was to extend to Central Europe the systematic study of the Orleans group on the origin of cobalt blue pigments in French glass from the 13th to the 18th centuries. This study will allow the characterisation of the provenance of cobalt blue pigments used by glass craftsmen in Hungary in this period. Their former study — based on French objects found in medieval glass workshops, cathedrals and excavations — has shown for the first time that at least four different types of cobalt ores have been used during this period. For three of them the provenance are the mining districts of Freiberg and Schneeberg in Germany as it was shown on the base of geochemical evidence as well as studies of ancient texts. In the last group we find all the cobalt blue glasses made by the use of ancient Roman tessare. Different chemical association characterise these ores. For the German ores we can cite the Co-Zn-Pb-In association, the Co-Ni-Mo association and the Co-As-Ni-Bi-Mo-W-U one.

The period of use of these ores is also well established and ore determination can be used, in some cases, as a dating method. For example, one of the studied glasses, a glass window from Buda Castle dated from the 16th century is certainly older than supposed and the analytical results allow us to date this glass from the 14th-15th centuries. A systematic study of the trace elements, inclusions and local heterogeneity in other type of colouring agents like copper, and also in colourless glasses would lead us to the better understanding of used medieval glass manufacturing technology.

111. Evaluation and interpretation of archaeological resources using Non-Destructive Methodologies

M. Gucek, M.L. Stokin*, K.Oven, M. Piccolo*****

*Institute for the Conservation of Natural and Cultural Heritage Piran (SL)
**Institute of Geodesy and Photogrammetry Ljubljiana (SL)
***EURECOS s.a.s Portogruaro (I)

Three Case Studies

KOPER-Slovenia

To define the presence of archaeological structures in urban environment in Slovenia, a multidisciplinary approach was used.

Ground Penetrating Radar, Photogrammetry and Thermography were used to define the presence of buried structures below the stone pavement two squares.

The investigations permitted to detect a series of structures formed by voids, embankments and old pavements and tombs.

ALVISOLPOLI, (VE) ITALY

A small church was investigated by the G.P.R. methodology to map the presence of structures below the pavements.

A series of tombs and a masonry drainage system were detected.

The signal analyses permitted to distinguish the empty tombs.

PADOVA, ITALY

A G.P.R. test inside the Basilica of S. Antonio pointed out the presence of a series of tombs that were reconstructed with high detail.

The investigation showed also structural differences in the basement of the investigated areas.

112. The Application of Isotopic Analyses in the Study of Pacific Islander Population Dynamics

B.L. Gulson*, J. Jaric, P. Rainbird***, R.G. Thomas****

*Graduate school of the Environment, Macquarie University, North Ryde, Australia
**Archaeological Sciences, UWS Nepean, P.O. Box 10, Kingswood 2747, Australia
***School of Art and Cultural Heritage, Charles Sturt University, P.O. Box 86, South Broken Hill2880, Australia.

The aim of the project is, for the first time, to identify first generation migrants amongst archaeological populations of the Pacific. In order to decide whether any human individual was a migrant to a particular island and the direction of any migration, archaeologists have previously relied on a combination of stylistic and linguistic patterns together with oral tradition. This project pioneers the use of Thermal Ionisation Mass Spectrometry (TIMS) in the study of the movement of human populations across the Pacific, focusing on the problems associated with so-called Polynesian Outlier populations. Measurements have been made on the radiogenic isotopes of strontium and lead within the enamel layers of archaeologically-derived human dental remains. By comparison between these measurements and the database of geological measurements made on Polynesian Islands, it is possible to comment directly on the mobility of prehistoric island populations.

Of the three geo-cultural groups defined by Domeny de Rienzi, (Dumont-D'Urville 1832), the most cohesive and perhaps the most appropriate grouping, is that of the ‘distinct race’ of Polynesia (Thomas 1989). These peoples inhabit the islands of the Pacific within the near-triangle formed by Hawaii, Rapanui (Easter Island) and Aotearoa (NewZealand). The similarity of physical appearance and social customs across the region allow for the unambiguous identification of these people to geographic location. It is generally accepted that Polynesians settled their islands and started to become a distinct group after 3200 BP on the islands of Fiji, Tonga and Samoa. Their ancestors had travelled from Island Southeast Asia or Melanesia in the West (Smith 1995).

The Polynesian Outliers fall outside of the triangle formed by the Polynesian islands, but these island societies, eighteen in all, speak Polynesian languages. They have been variously considered as either relic populations left behind after their colonising friends and relatives moved east, or as representing a return west after most of the eastern Pacific islands had been settled. Recent studies suggest rather more complex histories, including cultural replacement, and highlight the need to consider each island individually rather than as a group (Bayard 1976, Kirch 1984, Davidson 1992). No matter what the case is for individual `Outliers', evidence is emerging from the middle of the second millennium AD for a major rise in Polynesian influence west of the `triangle' (Spriggs 1993). Some of the strongest evidence for this comes from the islands of Vanuatu, where burials (e.g. Granger 1982) and social systems (Spriggs 1986) are recognised as having Polynesian traits.

For archaeologists the frustration has been in the inability to identify whether this influence was due to actual migration of Polynesian communities into the islands, or through cultural transmission requiring contact rather than relocation of people. A third, but less likely possibility is independent development of traits similar to Polynesian due to a shared ancestry (Spriggs 1993). Archaeologists have recovered a number of human burials

in Vanuatu and the Solomons that have been said to represent the original Polynesian migrants to these islands. Result will be presented that provide a rigorous test for these claims.

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Instrumental Neutron Activation Analysis and Eastern Terra Sigillata-II Pottery Revisited

113. Instrumental Neutron Activation Analysis and Eastern Terra Sigillata - II. Pottery Revisited

Jan Gunneweg*, Márta Balla**

*Institute of Archaeology, Hebrew University, Jerusalem 91905, Israel
**Institute of Nuclear Techniques, Technical University of Budapest, H-1521 Budapest, Hungary

At the Mediterranean harbor town of Caesarea Maritima in Israel built by King Herod, hundreds of remains of Terra Sigillata-II vessels and pottery fragments of the Early Roman period (1st c. BC-AD 2nd c.) have come to light in recent excavations. This pottery is well stratified and can be well dated. Stylistic similar ware belonging to a much later period, Byzantine, was found in another area at Caesarea.

Roman Terra Sigillata wares may be considered as one of the more important indicators of trade items because they are easily distinguishable and readily available. It was, therefore thought useful to trace them to the manufacture site(s) in order to establish trade routes and/or inter-regional relations between Caesarea and remote lands.

Samples of 12 different types of this ware (Hayes' Sigillata B/1-2 ware) were submitted to Instrumental Neutron Activation Analysis at the Nuclear Reactor situated in the Institute of Nuclear Nuclear Techniques at University of Budapest in a collaboration program with the Hebrew University of Jerusalem in order to learn the provenience of the Sigillata wares.

Uni- as well as multivariate statistical analysis programs were employed to find the most likely chemical match for the Sigillatas and purported centers of pottery production in the Eastern Mediterranean.

This study showed that ETS-II is a conglomerate of various forms which has a unique chemical composition and which the archaeologist can easily distinguish by eye from other Sigillatas on the basis of its physical properties.

The much later Byzantine version of this ware, similar in "look" is of some importance because it was shown that the same pottery manufacture center continued to produce its output over a much longer period of time than was previously thought.

114. Instrumental Neutron Activation Analysis Used to Search Whether Late Bronze Cyprus was able to Imitate Greek Mainland Mycenaean IIIa-b Wares

J. Gunneweg*, F. Asaro, Helen V. Michel****

*Institute of Archaeology, The Hebrew University, 91905 Jerusalem, Israel
**Lawrence Berkeley National Laboratory, Berkeley, Ca 94720, U.S.A.

Mycenaean IIIA-B pottery has been manufactured in the mainland of Greece during the Late Bronze Period. It was exported to various regions in the Mediterranean basin. Among these regions is the island of Cyprus. It has

been suggested that Cyprus made its local imitation of Mycenaean pottery, stylistically indistinguishable from the Greek imported specimens.

Our objective was to see whether Mycenaean pottery found in Cyprus originated in Greece, or that Cyprus had been able to manufacture its own. For that purpose, samples of Mycenaean pottery found at Cyprus were subjected to Instrumental Neutron Activation Analysis at the Lawrence Berkeley National Laboratory and in the Hebrew University of Jerusalem to obtain a chemical composition of the wares, in order to show convincingly whether Cyprus had been able to reproduce this style of pottery.

INAA has satisfactorily proved to distinguish chemical compositions on the basis of 5 major and 25 trace elements, constituting the "chemical fingerprint" of a ceramic which is assumed to be characteristic for each source on earth from which clay was taken.

Uni- as well as multivariate statistical analyses were employed to separate and group the INAA data and to find a chemical match with purported pottery manufacturing centers.

The different chemical compositions at several regions in Cyprus, among which specifically Eastern Cyprus, suggest that there was an import of Mycenaean pottery from the main Argolid manufacture centers, whereas later, the local Cypriote Mycenaean pottery production superseded the imported version.

The importance of this study shows that the Cypriote clays gave the local potters the possibility to imitate Mycenaean IIIA-B wares since certain clays in Cyprus are of a highly similar "look" when fired into a ceramic. Furthermore, there was a search for a better chronology to be obtained from other Cypriote local wares in whose context the Mycenaean imitations had been found.

115. Chemical and Nutritional Analysis of Ancient Food Remains from Hungary/Central Europe

Ferenc Gyulai

Archaeological Institute of the Hungarian Academy of Sciences Budapest

The analysis of food remains poses a great challenge. This work requires simultaneous familiarity with botany and chemistry. In the analysis of food remains, additional opportunities are offered by chemical analyses. Results of such investigations shed light on the kind of food recovered, its ingredients and additives, nutritional value as well as the mode of preparation.

Modern analytical chemistry has made the analysis of the main components and trace elements in food remains possible.

Due to the previously mentioned moderate carbonization caused by charring, only a limited group of compounds may be expected to survive.

Nevertheless, results have contributed significant information on food consumption and subsistence culture of prehistoric people. Food remains are rarely encountered during the excavation of sites even cemeteries and settlements where food is clearly a major cultural component. The identification of these finds contributes to reconstruction of ancient ways of life and gastronomic history.

Under the climatic conditions prevalent in the Carpathian Basin, food remains, when found, are usually preserved in a carbonized form, probably as a result of exposure to relatively mild heat in an anaerobic or at least oxygen poor environment.

An increasing number of archaeological excavations have been accompanied by scientific analyses during the past few decades. As a result, prehistoric food remains have also been recovered. Remains of carbonized bread were found following the water-sieving of samples gathered on the floor level of burnt Ottomány (Middle Bronze Age) culture houses at the tell settlement of Túrkeve-Terehalom.

During study of the inside of another sherd from the Copper Age site of Zalaszentbalázs - Szőlőhegyi mező a small brownish-blackish spot of typical burnt food remains was discovered. The shape, color and thickness of this spot, on the other hand, is very similar to analogous remains found at lake dwellings in Switzerland and Southern Germany and to what was identified as simple flour soup.

Carbonized food remains recovered from a Tumulus (Late Bronze Age) culture refuse pit at the site of Balatonmagyaród-Hídvégpuszta. Macroscopical and microscopocal analysis, in addition to the instrumental analyses all indicated that remains of Bronze Age strawberry shortcake were here found.

During the course of excavations at Keszthely - Fenékpuszta in 1980 a 60 cm thick, ashy layer was found when a pit dated to the Celtic Period was excavated. The using methods all lead to the conclusion that the grayish-black ashy layer, rich in fish bones, were the remains of a fish soup.

116. The Analysis of Brass Samples from the Ball and Warminster sites in southern Ontario, Canada

R.G.V. Hancock*, L.A. Pavlish, R.M. Farquhar**, D. Knight*****

*SLOWPOKE Reactor Facility and Department of Chemical Engineering and Applied Chemistry, University of Toronto
**Department of Physics, University of Toronto
***Department of Anthropology, Wilfrid Laurier University

The Ball (circa. 1616 - circa. 1635 A.D.) and Warminster (circa. 1625 - circa. 1649 A.D.) sites are located 0.5 km apart in southern Ontario. The chemistries of 214 brass samples from the Ball site split into three major groupings: low tin (>0.1%); medium tin (0.7-2.3%); high tin (2.7-6.3%). Each of these groupings are sub-dividable into tighter chemical sub-groups, based on their trace elemental contents, forming more than a dozen sub-groups. As expected from the proximity of the two sites, most of the chemistries of the 100 brass samples from Warminster match the Ball sub-groups, confirming that there was major interaction between the peoples at each village. Both sites contain both red and yellow brasses. There is little evidence that specific brass chemistry sub-groupings appear at only one site lending credence to the assumption that the brass distributions represent the slow overlapping transition in occupation from Ball to Warminster.

117. Instrumental Neutron Activation Analysis of Siliceous Mudstone from the Birimi Site, Ghana

Hawkins, A.*, Casey, J., Pavlish, L. A.***, Hancock, R.G.V.******

*Department of Anthropology University of Toronto, Toronto, Ontario
**Department of Anthropology University of South Carolina Columbia, South Carolina
***Archaeometry Laboratory University of Toronto, Toronto, Ontario
****Slowpoke Reactor University of Toronto, Toronto, Ontario

Excavation and survey during the 1996 and 1997 field seasons has shown that there at least two components widely separated in time at the Birimi site in the Northern Region of Ghana. The Kintampo component dates to between 3000 and 4000 B.P. and the Middle Stone Age (MSA) component is estimated to date to 30 to 40,000 B.P.

During both the Kintampo and MSA occupations siliceous mudstone was used as a lithic raw material. Artifacts from the two occupations can be distinguished on the basis of lithic production technology as well as degree of patination. A possible raw material location has been located about 25 km from the site. INAA is used to examine the similarity between the artifacts and the siliceous mudstone from the raw material location. It is also used to examine the chemistry of the artifacts from the two components and to address the question of whether the same raw material resource was being used during different occupations of the site.

118. Deformation of burnt structures and archaeomagnetic error

Ian G. Hedley*, Yves Billaud**

*Dpt. de Minéralogie de l'Université, 13 rue des Maraîchers, 1211 Genčve 4, Switzerland
**DRASSM, 58bis rue des Marquisats, 74000 Annecy, France.

A surprising feature of compilations of archaeomagnetic results is the dispersion in the data points. Apart from the uncertainty in the age, given by the archaeologist and accepted as such, the reliability of the magnetic measurements must also be questioned. This is despite laboratory tests designed to eliminate poor quality magnetic data.

Various sources of error have been investigated over the years, including magnetic refraction, "kiln-wall fall-out" and magnetic anisotropy. Little attention has been given to possible movement due to subsidence or pressure from overburden. The deformation of a hearth or oven is difficult to assess as these structures could have been deformed by high temperatures whilst functioning in antiquity.

The recent discovery in the Rhone valley of a series of flat hearths dating from the late Bronze age (11th century B.C.) has enabled this to be tested. The site of Laprade, between Orange and Montélimar, was one of many recent rescue excavations carried out by AFAN along the future Valence to Marseille TGV line.

The habitat yielded three hearths, one of which was markedly dome-shaped, and these were the subject of an archaeomagnetic study. The latter hearth gives a poorer archaeomagnetic result than the others, but this is dramatically improved if the individual samples are "bedding corrected" into a horizontal position. Clearly the deformation occurred after the hearth was abandoned probably by subsidence of the poorly fired edges.

This result shows that archaeomagnetic analysis of apparently deformed structures should include a consideration of a tectonic correction.

119. Valuing Archaeometry versus Archaeological Values: A View from the Outside

Rob Hendricks

Senior Policy Analyst, International Programs in International Forestry, United States Department of Agriculture Forest Service, Washington, D.C., USA

We know the explosion into the work place of available and relatively inexpensive "high tech" science in Archaeology over the past decade is transforming how we analyze and view the past. It is also transforming how we do business. An increasingly larger segment of archaeometric and geoarcheology training and application, for example, is aimed at an interested leisure public anxious to learn and do technological applications in unravelling history and to pay for this opportunity. This paper will focus on the role and value of archeometry in the growing market place of citizen participation in historic and ecological conservation and eco-tourism.

120. Archaeological and Geophysical Survey for the Heptastadium in Alexandria: A New Hypothesis

A. Hesse, P*. Andrieux, M. Atya****, Ch. Benech**, Ch. Camerlynck**, M. Dabas*, Ch. Fechant**, A. Jolivet*, C. Kuntz*****, P. Mechler**, C. Panissod*,**, L. Pastor***, A. Tabbagh*,**, J. Tabbagh***

*C.N.R.S., Centre de Recherches Géophysiques, Garchy, 58150 POUILLY-SUR- LOIRE, France tel. : 33. 3 86 69 47 26 fax : 33. 3 86 69 47 33 E.mail : crg@garchy.cnrs.fr
**Paris 6 University
***Paris 7 University
****N.R.I.A.G., Cairo
*****C.E.A. Alexandria/Cairo

Strabo tells in his "Geography" that the two harbours in antique Alexandria were separated by an "embankment called the Heptastadium. The embankment forms a bridge extending from the mainland to the western portion of the island (of Pharos) and leaves open only two passages ... which are bridged over". Alluvium deposits, on which lies a large part of the city of Alexandria, have completely masked the traces of this embankment and its position in the large existing isthmus was, till now, entirely conjectural.

New studies have been undertaken since 1995 in order to establish a valid position of this significant feature of the antique city. This was done in co-operation between our team (Département de Géophysique Appliquée, Université de Paris 6 and C.N.R.S., Garchy), the Centre de Recherches Alexandrines (I.F.A.O., Cairo) and a colleague from the Helwan Observatory.

Several investigations were conducted in different ways: ancient documents and maps, old streets network, levelling survey, local information, metrology and various geophysical methods which could be worked out in the unfavourable (damp and salted ground) of the city, i.e. radar, electro-magnetic conductivity, electrostatic resistivity and seismics.

Despite the fact that the Heptastadium definitely does not appear as a geophysical marker, several original data concerning the structure of the isthmus could be gathered (existence of a resistant nucleus with sharp edges, contribution of a primitive islet to sedimentation, probable position of a passage, ...). Finally a new strong hypothesis for the position of the Heptastadium, consistent with the well-known street network of Alexandria, can now be ascertained.

121. Amphora sherds dating from the Middle to Late Roman Empire

Darren J. Hillegonds, M. E. Lipschutz

Purdue University, Department of Chemistry

We have begun a study of amphora sherds dating from the middle to late Roman Empire. The samples are from the Roman port town of Leptiminus, near modern Lamta, in the Sahel region of central Tunisia. They are primarily derived from surface survey, and represent a cross-section of the common rim types extant at the site. Approximately 50 samples have been analyzed via INAA, with the resulting data used as selection criteria for carbon isotope analysis, utilizing accelerator-based radiocarbon and stable isotope mass spectrometry.

Great quantities of Tunisian amphorae have been found all over the western empire, providing a tremendous opportunity to explore trade in the ancient world. Central Tunisian amphorae have been extensively studied topologically, but until the present study there has been no direct dating evidence for any of the middle or late Roman amphora forms at Leptiminus. We intend to combine INAA data with carbon isotope analysis in order to see how groupings assigned via trace elemental composition vary in time and carbon isotopic characteristics.

Preliminary results show agreement between presumed and measured manufacture dates. The stable isotope analysis shows a 10 per mille range in $\delta^{13}C$ values, which indicates that while the carbon extracted from the sample is contemporary to manufacture, it was derived from various sources. Groupings assigned on the basis of trace elemental concentrations are reflected in the radiocarbon data, while the stable isotope data shows no correlation with assigned elemental groupings.

122. Late Neolithic Ceramic Exchange Networks: New evidence from Northern Greece

Elissavet Hitsiou, Peter M. Day

Sheffield Centre for Aegean Archaeology, Department of Archaeology and Prehistory, University of Sheffield, Northgate House, West Street, Sheffield S1 4ET, UK.

The organisation of ceramic production and the extent to which households, and even communities, competed in the exchange of ceramics is of prime importance in investigating the development of society and economy in the Neolithic. Analytical studies which illuminate the technology of production and especially the provenance of early pottery groups, enable us to trace the distribution of different components of the ceramics assemblage, both within settlements and over long distances.

This paper summarises the results of a three year study of the 'Dimini' phase ceramics (early fifth millennium BC) from the large settlement at Makrygialos, in Northern Greece. A programme of petrographic analysis was conducted on 300 samples chosen from this extensive site. 150 samples of typologically similar vessels were also analysed from neighbouring sites in Central Macedonia, as well as Dimini in Thessaly.

The analytical programme has characterised the technology of different ware groups found within this chronological phase, enhancing our understanding of both utilitarian and high quality ceramics. Distinctive petrographic fabrics demonstrate extensive exchange of fine ware bowls and other non-utilitarian ceramics some of which appear to have been produced in the Plain of Thessaly, a distance of c.125 km. Such an extensive movement of different classes of pottery over long distances at this early time demonstrates an unexpected complexity in ceramic economy, previously only thought to pertain to comparatively rare materials such as obsidian. Ceramic analysis is therefore shown to be integral to a new understanding of economy and social stratification in the Late Neolithic.

123. The Origin Of The Tyrolean Iceman Documented By His Bone (Geo)Chemistry

Jurian Hoogewerff*,, Martin Kralik***, Margit Berner****, Pieter Vroon*****

*Marie Curie Fellow at Austrian Res. & Test. Centre ARSENAL, Faradaygasse 3, A-1031 Vienna, Austria.
**Dept. Health Risk Anal. & Tox., Univ. Maastricht, P.O. Box 616, NL-6200 MD, Maastricht, The Netherlands.
***Dept. Geol., Univ. Vienna and Federal Environment Agency, Althanstrasse. 14, A-1090 Vienna, Austria.
****Dept. Anthropology, Natural History Museum, Burgring 7, A-1014 Vienna Austria.
*****Fac. Earth Sciences, Free University, DeBoelelaan 1085 NL-1081 HV Amsterdam. The Netherlands.

Anthropological and botanical evidence presently available suggest that the Tyrolean Iceman („Ötzi“) has had its origin in the Vinschgau valley in South Tyrol. In a attempt to test this hypothesis we analysed the trace element and isotopic composition of skull bone fragments from pre-industrial North and South Tyrol together with two bone fragments from the Iceman. The Tyrolean bone material from 83 individuals from 19 different villages located on 5 different geological backgrounds was taken from the „Tappeiner collection“ at the National History Museum Vienna. Originally the skulls were collected from ossuaries in Tyrol at the end of the last century. We sampled soil, water and stream-sediment in order to trace the geochemical fingerprint („isotopic and trace-elemental“) obtained by the bones from local nutrition during the years before death or by possible contamination during burial.

The area encompassing North and South Tyrol has large geochemical compositional contrasts between Limestone's, both in the North and South, and the Central Gneiss zone in the middle. The skulls coming either from limestone ($^{87}Sr/^{86}Sr = 0.709 \pm 0.001$) or gneiss areas show large Sr-isotopic differences of $^{87}Sr/^{86}Sr = 0.709 \pm 0.001$ and $^{87}Sr/^{86}Sr = 0.712$-0.732 (range), respectively. The bone fragments from the Iceman have a $^{87}Sr/^{86}Sr = 0.7182 \pm 0.0005$ which is clearly within the values of the gneiss area. The gneiss area however encompasses both the Vinschgau, south, and the Oetztal, north of the last resting place of the Iceman. There are systematic differences in the trace element composition (e.g. Li, Mg, Sr, Mo, As, Ga, Cu, Ag, and Pb) of the skulls between these two valleys. In our presentation we will present statistical analysis of ratios of these trace-elements which allow us to determine the most likely region of origin for the Iceman on the basis of his bone (geo)chemistry.

124. About our symbol - Complex analysis of the Szeged-Szillér depot find

F. Horváth*, L. Költő, M. Balla***, K. Bruder****, G. Szabó, K. T. Biró****

*Móra Ferenc Museum, Szeged
**Somogy County Museum, Kaposvár
***Technical University of Budapest
****Hungarian National Museum

You might be interested in the symbol of Archaeometry '98 Symposium and how it relates to the subject.

The conference symbol is a copper age depot find from Szeged-Szillér, containing a heavily used prehistoric artisan's kit: a hammer-adze, different chisels and awl. This attractive kit was published by Ferencz Pulszky, former director of the Hungarian National Museum, distinguished archaeologist and politician of the last century. Pulszky published the basic monograph on Hungarian Copper Age - which is one of the rare instances when tools made of native copper are of real importance. This period of historical significance was established on the basis of the chemical analysis of the metals, also quoted in the same monograph by the author. The Szeged-Szillér depot finds therefore is symbolising several aspects of our conference - archaeology, analyses, technology and an appreciation of the past.

The find assemblage featured in several archaeometrical analyses in the past. Also, it is included in on-going comprehensive studies on early copper industry. Our studies are focused on this tool kit specially, from the respect of composition, provenance and technology.

Reference:

Pulszky, F., A rézkor Magyarországon. Budapest, 1881.

125. Investigation of stone tools from Earthwork at Százhalombatta, Hungary

T. Horváth*, M. Kozák, A. Pető****

*Hungarian National Museum
**KLTE, Debrecen

We should present our complex (petrological and archaeological) researches on the stone-materials of Százhalombatta. In the fortification Ildikó Poroszlai have been excavated for 1989 to 1993. She opened three sections, and she found the bequest of the Bronze Age People (Nagyrév culture from Szigetszentmiklós phase to Vatya culture to the Koszider period): houses, streets etc.

Among the available finds of the Bronze Age tell-settlements studied, high amount of rubbed or chipped flint implements, millstones, weights, moulds, stone axes, hooks and other microliths and stone implements used for manufacturing and building work have been turned up. In the archaeological part we made statistical, typological and microwear investigations.

In the part of petrological the stone findings about 435 samples were studied by the unconventional techniques of geological, geochemical material tests.

Among the millstones, besides the Carbonitic granites, varieties of Miocene andesite from the Visegrád mountains were identified, as well as sandstones and fine grained conglomerate have also been found.

The most characteristic materials of stone axes were the above mentioned andesites, but serpentinitised metadolerits (Picrite Formation at Budakeszi), as well as some siliceous shale and quartzite were also used.

The materials of chipped stones are mainly chert and hornstone, which can be found both in the Buda and Gerecse mountains.

The results of analysis have proved, that the stone implements originated from the neighbouring district within a distance 50 km from the Eastern part of Central Massive of Transdanubian region in Hungary.

The identification the places of origin has indicated that the most probable migration area of the manufacturers was the Dunazug Mountain Range and its immediate vicinity.

126. The warp weighted loom in the Carpathian Basin (Experiment in the Archaeological Park, Százhalombatta, Hungary)

Tünde Horváth, Erzsébet Marton

Hungarian National Museum, Budapest

In this poster the phases of the warp weighted loom's building from the excavation until the reconstruction of weaving in the Iron Age is presented.

Excavation evidence

Early, Late Neolithic Period

- Tiszajenő - Szárazérpart (Körös culture, 6-7. mil. B.C.)[1] **Pál Raczky** (1976): A Körös - kultúra leletei Tiszajenőn, Arch. Ért. 1976.)

- Öcsöd-Kovácshalom (excavated by P. Raczky, published in: **The Late Neolithic in the Tisza region**, Catalogue, Szolnok-Budapest, 1987.)

- Baláca (C 14 date: Deb-2509, 6030+-40BP cal 4921.in: J. Regenye: Fundorte der Sopot-Kultur auf dem Balatonhochland. ComArchHung 1996 pp. 23-42.)

- Parta (Romania. Published in: The Sanctuary from Parta. Muzeul Banatului, Timisoara. Foto&desing Artune, Timisoara)

[1] Selmeczy, 1969, Raczky, 1976

Early- Middle Bronze Age

- Százhalombatta - Földvár (excavated by I. Poroszlai)
- Bölcske (excavated by I. Poroszlai)
- Kakucs - Balladomb (excavated by I. Poroszlai)

Late Bronze Age

- Velem-St. Vid (material in the Savaria Museum from the last century)
- Kesellőhegy-Zöröghegy /near to Farkasgyepü/ (excavated by Gy. Nováki)
- Németbánya /near to Farkasgyepü/ (excavated by G. Ilon)

Excavation in the early, late Iron Age's fortifications:

- Százhalombatta among 1993-96. (Excavated by the author)
- Gór (Excavated by G. Ilon)
- Velem-St.Vid among 1988-1992 (excavated M.Szabó and a French-Hungarian joint)
- Sopron-Krautacker ("the weaving house" excavated by E. Jerem, E. Jerem's personal communication)
- Szentlőrinc (excavated by E. Jerem)

Material collecting - Hypothesis - Experiment

restoration, reconstruction, documentation

A constructed warp weighted loom

Slides of the textile

supposed rapport

the warp weighted loom in the Archaeological Park, Százhalombatta

127. Peculiar rock-types used by the Neolithic man of southern foothills of the Western Carpathians

D Hovorka*, L. Illásová**

*Faculty of Natural Sciences, Comenius University, Mlynská dolina, 842 15 Bratislava, Slovak Republic
**Archaeological Institute of the Slovak Academy of Sciences, Akademická 2, 949 21 Nitra, Slovak Republic

During field surveys and studies performed during last decades, concentrated on several tens archaeological sites spread over the whole state territory, several thousands of polished stony artefacts were collected. Among three hundreds of artefacts studied by means of thin sections, except of widespread greenschists, amphibolites, alkali basalts, andesites, blueschists, antigorite serpentinites and others, there were documented also peculiar rock-types.

From the site Nitriansky Hrádok axe made from eclogite was described. As eclogites are not known from the Western Carpathian territory, the provenience of this raw material type should be located to the Bohemian Massif.

In the western part of the Slovak Republic on several sites spinel-hornblende-anthophyllite (nephritoide) schists were studied by the use of electron microprobe in detail. The presence of green, Al-rich spinel, represents the most interesting aspect of the provenience of this rock-type in central Europe. No such rocks are described yet. Consultation with several colleagues from abroad prove this statement.

From the Sobotiste (near town Myjava - western Slovakia) axe made from jade (jadeite) was picked up in fields. So its exact position is not known. Emerald-green rock is very fine-grained with granoblastic fabric. Studies in detail are in progress.

Site Sarisské Micha'lany (eastern Slovakia) supplied several artefacts made from pelocarbonates (mixed rock composed of clay minerals and carbonates). This raw material represents typical local rock-type of the Paleogene strata in wider environment.

128. Slag Analysis on Kom el Adhem [The Hill of Bones,] Tel el-Rub'a, [Mendes], Egypt

S. Ierullo*, R.M. Farquhar, L.A. Pavlish**, R.G.V. Hancock**, D.B. Redford*****

*Archaeometry Laboratory, Dept. of Physics, University of Toronto,
**University of Toronto
***Near and Middle Eastern Civilizations, University of Toronto

The site of Mendes, Egypt (Tel el-Rub'a) is located approximately 90 miles north of Cairo, in the Nile delta. The site is characterized by the remains of several economic activities, including glass making, the production of lime plaster, ceramic firing and metallurgical work. Waste material, in the form of slag, is produced in addition to these finished products. A combination of Instrumental Neutron Activation Analysis (INAA), X-ray Fluorescence (XRF) and thin section visual microscopy was used in order to identify the activity that produced the slag at Kom el Adhem. The glass making activities which appear to date to a late occupation of the site (Hellenistic-Roman), represented by the slag, comprise one element of the local economy. The analysis of slag, in conjunction with other work, such as pottery analysis can help delineate the economic importance of Mendes; i.e. better understand the economy of the site and its role as a harbour town.

129. Copper plating on an iron artefacts from the early middle ages Peveragno site (Piemonte, north-west Italy)

G.M. Ingo*, E. Angelini, E. Micheletto, G. Chiozzini, G. Bultrini

*Consiglio Nazionale delle Ricerche, Istituto di Chimica dei Materiali, CP 10, 00016 Monterotondo Stazione, Roma, Italy
Dipartimento di Scienza dei Materiali et Ingegneria Chimica, Politecnico Torino, Italy
Consiglio Nazionale delle Riserche, Istituto per la Civilta Fenicia e Punica, CP 10, 000016 Monterotondo Scalo, Roma, Italy
Soprintendenza Archeologica del Piemonte, Torino, Italy

As prosecution of a work focused on the microchemical study of iron smelting slags from an early Middle Ages site found near Peveragno (Cuneo, Piemonte, north-western Italy), the characterisation of lead, iron and bronze artefacts, such as weapons, home life objects etc. has been carried out. The archaeological excavation, started in 1993., evidenced the presence of an inhabited place located on a terraced area obtained with a noteworthy rock levelling actions which caused the partial destruction of a village dating back to V-VI. century B.C. The more recent human presence was attributed to a peopled settling dating back from III. to VI century A.C. From the examination of the archaeological findings, there is no clear evidence of a metallurgical activity until V. century AD. From this time to the VI. century AD at Peveragno intense metallurgical activities were carried out as evidenced by the remains of furnaces with a noticeable amounts of slags and iron artefacts spread all over the site.

Among the iron objects, one sample attracted the attention of the researchers for the presence of a surviving copper plating on both the surfaces of an iron sheet. It is worth noting that even though the copper plating on iron was undertaken from the earliest use of iron, continuing through Roman and medieval times, the copper plated iron objects are quite rare and, to our best knowledge, the sample found at Peveragno is the first found in Italy. The object under study is quite flat, irregular shaped with the following dimensions 10 by 5 cm and 1 mm thick. The microchemical structure was studied by means of SEM + EDS and then, on the base of the microanalytical results, several experiments are carrying out in order to ascertain the copper layer is characterised by a thickness ranging from 100 to 200 micron, and it must be underlined that the copper is continuos on one side of the iron artefacts with a complex microchemical structure quite similar to that observed in the so called Ramo Secco bars and in the Aes Rude. Indeed, the presence of iron island dispersed in the copper layer was evidenced as in these latter materials characterised by iron-rich alpha spheroids (20-40 micron.) where are dispersed very small copper particles. On the contrary, the opposite copper layer is highly defective and is characterised by an entirely different microchemical structure with a very thin interdiffusion layer between iron and copper with a scarce presence of the iron rich () phases. On the base on these results, it can be ruled out a dipping technique and the first results of the copper plating experiments suggest a more sophisticated plating technique.

130. Determination of the iron ore source exploited for early iron smelting at Tell Afis (north-western Syria) through microchemical studies

G.M. Ingo*, G. Chiozzini, P. Tucci, U. Masi, G. Bultrini

*Consiglio Nazionale delle Ricerche, Istituto di Chimica dei Materiali, CP 10, 00016 Monterotondo Stazione, Roma, Italy

At Tell Afis (north-western Syria), during a stratigraphically related archaeological excavation, a large group of iron artefacts and iron smelting and smithing slags have been found. These materials are dating back from 1000 BC to 800 BC. The evidence for such an important technological breakthrough in this area, puts forward the question about the iron ore provenance. In order to gain a further insight into the development of the early iron metallurgy in this region and to locate the geographical sources of the iron ores exploited at that time, the iron ore outcrops of the north-western Syria have been sampled (Kurd Dagh mountains, Syrian Kurdistan). It is worth noting that historical sources indicate that this area classic Döliche "ubi ferrum nascitur", is supported to be located there.

The iron ores found in the Kurd Dagh mountains, in particular at Kerry and Alamdar, have been found mainly composed of hematite, whose content ranges from 37 to 73%, anatase with a small amount of arizonite and rutile. These iron ores have been subjected to micro chemical characterizations and to smelting processes carried out adopting experimental conditions similar, as soon as possible, to those used in an antique furnace. The attention has been focused on the micro chemical aspects involved during the smelting process and on the chemical composition of the slags that result from the process. The microchemical and microstructural studies have been carried out by means of the combined use of X-ray photoelectron spectroscopy (SA-XPS), small area X-ray induced Auger electron spectroscopy (SA-XAES), scanning electron microscopy (SEM) + energy dispersive spectroscopy (EDS), X-ray diffraction (XRD) and differential thermal analysis (DTA) + thermal gravimetry (TG). The micro chemical information have been compared with those obtained from the study of the archaeological iron smelting slags and from the inclusions entrapped in the iron metallurgy products could be proposed. Indeed, the presence of TiO_2 -rich phases have been found in the archaeological materials as well as in the iron ores and in the modern smelting slags.

131. Lead anchors and ingots from Is Piscinas (Montevecchio mine basin, south-western Sardinia, Italy)

G.M. Ingo*, R. Falciani, G. Chiozzini, G. Bultrini, M. Gucciardi, T. Agus, R. Ruggeri

*Consiglio Nazionale delle Ricerche, Istituto di Chimica dei Materiali, CP 10, 00016 Monterotondo Stazione, Roma, Italy

During a series of surveys along the coast of the Montevecchio mine basin, several Phoenician, Punic and Roman anchors from shipwrecks have been found at Is Piscinias. It is worth noting that some of these unfortunate ships are characterised by the presence of charges of lead ingots and further, other lead ingots have been found scattered along the coast. 12 Roman lead anchors of the 28 identified and some lead ingots have been retrieved from the sea and their chemical composition and microchemical structure have been studied. Some lead ingots are very similar in shape to the parallelepiped form found so frequently in the Mediterranean basin. They have an upper dimension of 34 by 10 cm, a base of about 37 by 15 cm with a weight of about 35 kg. The inscription on these ingots is IMP CAES HADR AUG and therefore, they have been manufactured during the time of the Emperor Hadrian (AD 117-138). Other lead ingots are characterised by a slightly different form and very similar to the Roman late Republican ingots found also in Sardinia at Mal di Ventre (first half of the 1st century BC). Other ingots have a very different form and unfortunately, nor marks and signs have observed on them, neither other materials have been found, that allow to precisely date the shipwreck. Only some of the smaller lead ingots and lead slabs are decorated with parallel notches, but these signs are not able to indicate the date or the people that have manufactured them. Concerning the form of these latter lead ingots, they are characterized by different shape, plano-convex and quite rectangular shaped slabs weighting 1 to 18 kg. The chemical composition of the lead ingots have shown that the tin content is ranging from 0.3 wt. % to 0.85 wt. %, zinc from 0.02 to 0.81%, antimonium from 0.30 to 0.80 %, silver copper, manganese, iron and bismuth are lower than 0.4 %. The microchemical structure of the lead ingots is characterized by the presence of high copper tin particles whose diameter is ranging from 1 to 4 micron. In order to localise the metal ore resources exploited for producing the lead ingots and anchors, lead isotope analysis has been carried out for these metal artefacts to compare with data of lead ore deposits of the Mediterranean basin. With this aim in mind, the most important lead deposits of Sardinia have been sampled and lead isotope ratios were determined.

From the comparison between the lead isotope ratios for the lead ores and the lead ingots and anchors it is possible to identify two main metal sources, that are some Spain lead mines and the Montevecchio basin, respectively. In particular, concerning this latter Sardinian lead ore source, the results show that is has been exploited for producing the lead ingots manufactured during the time of the Emperor Hadrian.

132. Processing Fishes with Obsidian Tools: A Description of the Experimental Microwear

Maria Rosa Iovino

Via F Mauceri 21, 96100 Siracusa, Sicily, Italy

The exploitation of fish, during Mesolithic and Neolithic period, also for a ever increasing nautical competence, was very important for people but often, if we have fish remains in an archaeological context, it is difficult to understand how people exploited this natural food resource. More even, in several sites near the sea fish bones not always are found for different reasons: it could depends on behaviour or it could depends on pH soil nature. Functional analysis can attempts to identify these lost data.

Few functional studies[1] have addressed the nature of the microwear resulting from processing fish with obsidian tools.

Making a reference to a well preserved Mesolithic-Neolithic fishing site (Uzzo's Cave, Trapani, Sicily; Franchthi's Cave, Argolide, Greece) we have conducted experimental activities to scaling and butchering a lot of different fishes (Thunnus, Epinephelus, Sparus aurata, Diplodus sargus, Dentex dentex, Mugil cephalus and Scorpaena scrofa). This case study attempted to observe the differences in microwear formation depending from the different kind of fish and from different quantity of fish worked. From this experimental work results that on obsidian implements it will be possible to recognize, very well, butchering fish. Scaling fishes reserves more problems, in fact not always this activity produces a well developed trace; but when it happens we could have a good collection comparison to identify the kind and the quantity of fish processed.

Reference

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133. The quantitative and statistical analyse of Late Bronze Age - Early Iron Age deposits in Serbia

Dragan Jacanovic, Dimitrije Madas

Zavod za zastitu spomenika kulture, YU-34000 KRAGUJEVAC, Krag. oktobra 184

Results of quantitative and statistical analyses of 101 depots from Serbia from the period between Late Bronze Age - Early Iron Age will be discussed . In these depots, 2965 metal objects were found. We divided them into 46 different sorts (weapons, tools, instruments, utensils, garment...). Quantitative analyse of objects give to us some precise conclusion about the nature of depots, i.e. about cult or prophanic character. Among the 2965 objects, nearly 70% are bracelets, 50% celts (axes), 30 sickles, lances, needles, buttons... But, the other kind of objects are present with less of 20%. The most numerous depots are those containing only one type of object and among them most frequently depots with bracelets. It is also evident that depots are more numerous in the period of Late Bronze Age / Hallstatt A1 and toward to the Hallstatt 2/Hallstatt C number is obviously less. Judging by damage of some tools we can recognise a cult character of certain depots.

134. Ashes to Ashes: Raw Material Variability and Medieval Glass Compositions

C.M. Jackson*, C.A. Booth*, J.W. Smedley**

*Department of Archaeology and Prehistory, University of Sheffield, Northgate House, West Street, Sheffield, S1 4ET, U.K.

**Department of Engineering Materials, PO Box 600, Sir Robert Hadfield Building, University of Sheffield, Sheffield S1 4DU, U.K.

Chemical analyses of ancient glasses show compositional groupings based primarily upon the type of alkali used in their manufacture. However, the final glass composition is dependent not only upon the nature of the alkali and its constituent salts, but also its manipulation through mixing, purification and melting. Therefore an analytical study of the nature of the raw materials used in glass manufacture, through to the production of experimentally produced glasses, may indicate the factors behind the final compositions. These include how composition is influenced by initial selection, by technological modification through ashing, solubility and volatilisation, and by the choice of glass recipe. This paper summarises the first results of a project which addresses the problems of working back from the chemical composition of Medieval glasses to the raw materials. The work focuses on composition and subsequent behaviour of glass making, alkali raw materials used in Medieval Northern Europe. To date, there are a number of significant results. The analyses of a number of different organic alkalis has been undertaken by energy dispersive X-ray spectrometry, X-ray diffraction and qualitative wet chemical techniques, to ascertain their constituent salts. These analyses have then been used to predict the final glass composition and tested against glasses produced under controlled laboratory conditions to a variety of different recipes. This project strengthens the scientific study of archaeological glasses and the use of glass making raw materials, as chemical composition forms the very basis for our interpretation of glass-making practices and their place in early societies.

135. The Complimentary Use of Bone Cholesterol and Collagen Stable Isotopes for Palaeodietary Reconstruction : Results from Animal Models

S. Jim*, A.W. Stott*, S.H. Ambrose, J.M. Rogers***, R.P. Evershed***

*Organic Geochemistry Unit, School of Chemistry, University of Bristol, Bristol BS8 1TS, UK;
**Department of Anthropology, University of Illinois,Urbana-Champaign, Urbana IL61801, USA;
***Rheumatology Unit, University Division of Medicine, Bristol Royal Infirmary, Bristol BS2 8HW, UK

The introduction of stable isotope analysis using carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) revolutionised palaeodietary research in the 1970s. This technique has been used to analyse both the collagen and apatite preserved in ancient skeletal remains and has been successful in assessing the consumption of protein vs. carbohydrates, C_3 vs. C_4 terrestrial resources and marine vs. terrestrial resources of ancient populations. The discovery that cholesterol is preserved in archaeological remains raised questions as to whether dietary information could also be derived from its isotopic signature (Evershed et al., 1995). Cholesterol is a single compound which can be unambiguously characterised, therefore ensuring its isotopic integrity. Preliminary research has shown that the dietary signal derived from cholesterol is different from that derived from collagen and apatite, and so its use in conjunction with these existing methods should give a fuller insight into palaeodiet. Cholesterol can be separated, characterised and its $\delta^{13}C$ value measured by using gas chromatography (GC), gas chromatography-mass spectrometry (GC-MS) and isotope ratio monitoring-gas chromatography mass spectrometry (irm-GCMS) (Stott and Evershed, 1996; Stott et al., 1997). Studies to date have demonstrated that the $\delta^{13}C$ value of cholesterol is almost homogenous within one skeletal type and highly consistent between different skeletal members. It has also been used successfully to distinguish subtle dietary differences between an English inland (Medieval, Abingdon Vineyard, Oxfordshire) and a coastal population (Saxon-Medieval, Barton-on-Humber, N. Lincolnshire) (Stott et al., in prep.).

Current research in our laboratory is concentrating on determining the effects of differing nutritional inputs, metabolism and turnover rate on the isotopic composition of bone cholesterol. Holtzmann albino rats were raised on a variety of isotopically controlled diets consisting of differing combinations and proportions of C_3, C_4 and marine protein, and C_3 and C_4 energy components. Bulk $\delta^{13}C$ values of the diet, bone collagen, apatite, hair and flesh of these samples have already been measured in a previous study (Ambrose and Norr, 1993). The aim of this work is to measure the $\delta^{13}C$ content of the rats tissue cholesterol and individual fatty acids as a function of each different diet with a view to determining how and which specific biochemical fraction (protein and/or energy) present in their formulated diets most influences their lipid isotopic composition. Comparisons of the cholesterol $\delta^{13}C$ values obtained from studies of this type with those measured on cholesterol recovered from ancient human bone should allow us to make more accurate interpretations as to the dietary preferences of past populations.

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136. SARM 69 Ceramic-1: a new pottery certified reference material for inter- and intra-laboratory calibration

L. Jacobson*, W.A. van der Westhuizen, J. Oosthuysen*****

*McGregor Museum, POB 316, 8300 Kimberley, South Africa. E-mail: jake@museumsnc.co.za
**Department of Geology, University of the OFS, P.O.Box 339, 9300 Bloemfontein, South Africa. E-mail: vdwestw@glg.nw.uovs.ac.za
***Reference Materials Section Mintek, 2125 Randburg, South Africa. E-mail: janeto@info.mintek.ac.za

The continually growing field of pottery provenance studies is beginning to present problems integrating databases derived from different laboratories and different analytical techniques although some labs have already taken the initiative to normalise their databases (Glasscock 1992). We are, therefore, pleased to announce the development of a certified multielemental reference material specifically for use by laboratories carrying out such compositional characterisation studies. Developed from an 80 kg sample of Late Iron Age pottery from a site in the Free State Province, South Africa, this reference material will carry a certificate by the South African Bureau of Standards guaranteeing that its preparation conformed to international standards. Sample preparation (milling, blending and homogeneity checking) has been carried out by Mintek and is currently being sent to a number of international laboratories for analysis. The results of these determinations will be statistically integrated into certified values which can then be used with confidence for comparative purposes.

It is recommended that all laboratories undertaking ceramic provenance analyses should regularly run CERAMIC-1 as an aid for normalising data from different runs and between different laboratories. In addition, a protocol should also be established between participating laboratories to govern usage and methods of reporting data.

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137. XRF Analysis of Pastoralist Pottery from the Riet River Area, Northern Cape, South Africa

L.Jacobson*, W.A.van der Westhuizen, D.Morris*, *****

*McGregor Museum, P.O.Box 316, 8300 Kimberley, South Africa. E-mail: jake@museumsnc.co.za
**Department of Geology, University of the OFS, P.O.Box 339, 9300 Bloemfontein, South Africa. E-mail: vdwestw@glg.nw.uovs.ac.za
***E-mail: dmorris@museumsnc.co.za

Archaeologists have recognised distinctive localised herding sites, referred to as Type R sites, along the Riet River. Provenance studies on a small suite of pottery from these sites were made in order to determine whether any imported vessels could be identified and from whence these might be derived.

138. Tiffany or Loetz ? Identification of Art Nouveau Iridescent Glass Artefacts

D. Jembrih*, **, M. Schreiner*, *, M. Peev**, P. Krejsa**, Ch. Clausen******

*Institute of Chemistry, Academy of Fine Arts, Schillerplatz 3, A-1010 Vienna, Austria
**Austrian Research Centre Seibersdorf, A-2444 Seibersdorf, Austria
***Institute of Analytical Chemistry, Vienna University of Technology, Getreidemarkt 9/151, A-1060 Vienna, Austria
****Schinzlgasse 3, A-2500 Baden, Austria

Art Nouveau iridescent glass has been highly estimated for its splendid, rainbow colour gleam. Iridescence itself is an interference effect occurring, whenever a reflecting material is coated by a very thin layer with a refractive index different from that of the bulk.

L.C. Tiffany was the first one to grant a patent for manufacturing glass with iridescent surfaces in 1881 followed by several centres in Europe, where the highest quality was achieved by J. Loetz Wwe. from Klostermuehle in Bohemia. After the Loetz-Patent in 1898 an intensive production of iridescent glass artefacts with exceptional quality started. Although influenced by objects of Tiffany Loetz artefacts were not the result of an imitation but rather of a parallel development due to alternative technological approaches.

In a project of Austrian research institutions with the Museum of Applied Arts Vienna a "recognition" procedure based on non-destructive analytical techniques supplemented with efficient experimental data processing, which allows quick and reliable identification of Art Nouveau iridescent glass provenience, was developed. More than 400 glass fragments and samples provided with the kind agreement of the Museum of Applied Arts in Vienna, the New York Historical Society, the Passauer Glasmuseum in Germany as well as private collectors have been analysed by FTIR (Fourier Transform Infrared Spectrometry) and XRF (X-ray Fluorescence Analysis) in a non-destructive way. Small glass splinters taken from special fragments could also be investigated by SEM/EDX (Scanning Electron Microscopy with Energy Dispersive X-ray Microanalysis) after embedding in resin. Although this method is not entirely non-destructive its application enables a better understanding of the chemical composition of the bulk glass and the iridescent layer.

The clusters obtained by the statistical evaluation of the FTIR spectra could be proved by XRF as well as by SEM/EDX. In general, the chemical composition of the bulk glass used by Tiffany differs profoundly from Loetz glass. Additionally, differences in the elements present in the iridescent surface layer could be detected due to the different technologies used for the production of the iridescent glass artefacts by Tiffany and Loetz.

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139. Anthracological investigations at Sopron-Krautacker

Jerem Erzsébet*, Rudner Zita Edina**

*Archaeological Institute of the HAS, H-1014 Budapest, Úri u. 49.
**JPTE Növénytani Tanszék, H-7624 Pécs, Ifjúság út 6.

The site lies in the valley between the Sopron hillside and the Rust mountain chain, on a low plateau formed by three rivers – the Zeisel-, the Ikva- and the Liget stream –, between 215-221 m above sea level. A surface of 20,000 square meters was excavated, which revealed a settlement with evidence of several phases of development and a nearby cemetery (Jerem 1981). The settlement was in the path of the ancient European trade route known as Amber Route. This excellent position explains why finds range in date from the Copper Age to the late Middle Ages, and also why there are traces of various stylistic influences. The golden era of this settlement can be dated from the sixth to the first century BC on the basis of items found in the cemetery, as is confirmed by radiocarbon dating (Jerem 1984; Jerem et al. 1984-85).

Charcoal samples were collected from graves of Urnfield culture, end of Hallstatt and early La Tène period, in addition to remains of bonfire, wooden grave-post or just remains of the nearby vegetation, and also from structures of coeval settlements, as rafter, joist, remains of fire-places, furnaces, kilns, etc., in order to find

botanical evidence concerning the natural arboreal vegetation, the different uses of members of this vegetation in architecture, in manufacturing, funerary practices and everyday life. Thus we can draw conclusions on the effects of man on its natural environment and how this selection can influence the vegetation. We can also make suggestions on the vegetational-climatological events. The applied methods in identification are stereo- and compound- microscopical investigations with the use of different tree-anatomical atlases (Schweingruber 1978).

In some cases we have carried out derivatographic analyses so as to find out what the origins of the charcoal can be, i. e. could it be from the nearby fire spot, or it is just a remain of a burnt or of a buried house, or just of the buried vegetation. So we can understand more precisely the events that could have affected the culture, or the life at the time. The basis of these suggestions is the separability of different charcoal types on the basis of the temperature they burnt. Although, botanical investigations have been carried out at this site, but they gave suggestions mainly on the cultivated vegetation (Badal et al. 1994; Rudner et al. 1997).

Results are unique in Hungary, as such a great area with the numerous material was not worked out for the development, composition and uses of arboreal vegetation from the Iron Age. It is also unique for Central Europe as well as for the previous and subsequent time periods.

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140. The impact of the Archaeometry on the recent prehistoric research in the Central Balkans

Borislav Jovanovic

The Institut Archéologique, 11000 Beograd, Knez Mihailova 35/IV, Yougoslavie

State of research of the technologies of prehitoric cultures will be examined, beginning with Lepenski Vir and Starcevo, till to La Téne period in the Central Balkans, with the special on the Danube region.

During last decades magy excavations of the important prehitoric sites in the South Pannonian plain /Vojvodina/ have been carried out by different domestic and foreign institutions. The excevations were often of a large size and long duration /Gomolava, Gradina Bosut, Zidovar, Rudna Glava, Vinca, Selevac, Divostin, Blagotin/.

Published separately for every single site, the analytical results have never been observed in common. A variety of analytical techniques were used, comprised all categories of relevant archaeological finds.

It would be useful to examine briefly present analytical results, with the intention to obtain first picture of the interaction between Archaeometry and prehistoric archaeology of the area.

141. Provenance Studies of Late Palaeo-Indian Quartzite Artifacts in the Great Lakes Region of North America Using Destructive and Non-destructive Techniques

P. J. Julig*, D.G.F. Long, R.G.V. Hancock***, L.A Pavlish******

*Department of Anthropology, Laurentian University, Sudbury, Ontario, Canada,
**Department of Earth Science, Laurentian University, Sudbury, Ontario, Canada
***SLOWPOKE Reactor Facility, Department of Chemical Engineering and Applied Chemistry, and Archaeometry Laboratory
****Department of Physics, University of Toronto, Toronto, Canada, M5S 1A7

Quartz rich lithic materials were widely used in the manufacture of stone artifacts by the Palaeo-Indian cultures in the Great Lakes region of North America. The Early Palaeo-Indians (ca. 12,000 - 10,000 YBP) used fine grained chert, silicified quartz arenite, orthoquartzite and some quartzite, while the Late Palaeo-Indian Plano culture (ca. 10,000 - 7,500 YBP) commonly used coarser grained materials, including quartzites, silicious quartz arenites and sandstones from bedrock quarry sources. As many of these quartzites and sandstones are visually similar, samples from several major quarry sources including the Lorrain, Bar River and Mesnard Formations, and the Agibik and Hixton quartzite quarries, were examined using both destructive and non-destructive techniques. Multivariate analysis of chemical data from X-ray fluorescence (XRF), Instrumental neutron activation analysis (INAA), and ICP-MS provides clear separation of several of these potential sources. While these methods are useful in identifying source materials they may involve partial destruction of samples, even in small quantities. The use of cathodoluminescence (CL) microscopy offer an additional non-destructive method which has no lasting effect on the artifact sample. Samples from Hixton quartzite can be clearly differentiated from older sandstones as the luminescence characteristics of the quartz grains, the early chalcedonic rim cements, and the late pore fill chert each have distinct luminescence characteristics.

142. Colluvial sediments near archaeological sites as a key to the past landscape evolution under human impact - a geoarchaeological case study from the Kraichgau-Hills in Southern Germany

Annette Kadereit, Andreas Lang, Günther A. Wagner

Forschungsstelle Archäometrie, Heidelberger Akademie der Wissenschaften, Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

In the loess covered Kraichgau-Hills in Southern Germany man has settled ever since Neolithic times. During that time the landscape has undergone enormous changes documented in cut soil profiles in areas prone to erosion and alluvial fillings in the depressions. Geoarchaeological studies in the vicinity of archaeological excavation sites shall help to answer the question, whether these changes are mainly the result of human impact or rather climatic variations. The colluvial and alluvial sediments represent an important archive for the reconstruction of the past landscape evolution and the correlation of the remnants of archaeological settlements with their time-equivalent sediments is of key importance. Therefore apart from archaeological and palaeoecological investigations well resolved time records for these sediment types are necessary. Recently achieved progress in the method of optically stimulated luminescence (OSL) makes it a powerful dating-tool to close the chronometric gaps for sediment layers free of archaeological finds or organic material, even for colluvial sediments with only short transportation distance. Infrared stimulated optically luminescence (IR-OSL) is considered the appropriate method to date the mainly fine grained loess derivates rich in feldspar.

The investigations are carried out in the study area of Bauerbach between an archaeological site with Neolithic and iron age settlement remnants on a hill top and an archaeological site with remnants of Roman buildings in the alluvial sediments of the river Kraichbach. Field studies reveal relief levelling with erosive lowering of ~1.5m on the hill top during the last 2.5 ka years and colluvial accumulation on the adjacent hill foot of ~5m during a yet unknown time span.

First results of the geoarchaeological investigations and their possible implications for the human impact on the past landscape evolution of the early settled Kraichgau-Hills will be presented at the meeting.

143. Determination of the Palaeolithic-Settlements' position on the territory of Serbia

Zvonimir Kaluderovic

Institut Archéologique, 11000. Beograd.

Palaeolithic period is the most unexplored prehistoric epoch in Serbia. Up to the eighties of this century, only two Palaeolithic sites, discovered by chance and already partly destroyed, were systematically explored. During the last decencies, thanks to the thematic field prospecting, more ten, mostly cave settlements were discovered. Parallel to the field research, a model of the Palaeolithic settlement was founded on the territory of the great ecological and geomorphologic diversity, in Serbia, i.e. the Central Balkan region.

Meanwhile, some regularities were noticed in this process, which could be valuable in discovering new sites, reducing the chance factor. This model reconstructs the optimal conditions for setting an area or a site in Palaeolithic period. Also, the elements of recent relief, pointing the Palaeolithic settlements were noticed. One of the most important climatic elements, during the Ice age, influencing the choice of the settlement, was the glacial and snow boundary at the definite height above sea level.

It is possible to determinate the optimal height above sea level of the Palaeolithic settlements by analysis of the glacial traces in recent relief of Serbia. Distinguishing the definite height above sea level and comparing it to other relief characteristics of Serbia, like existence of 1500 recorded caves and abrades, the way of discovering new Palaeolithic sites was made considerably easier.

144. Non-destructive analysis of European cobalt blue glass trade beads

K. Karklins*, M. Kapches, R.G.V. Hancock***, J. McKechnie***, M. Sempowski****, J.-F. Moreau*****, I. Kenyon******

*Department of Canadian Heritage, Parks Canada, Ottawa, Ontario, Canada, K1A 0M5
**Royal Ontario Museum, Toronto, Ontario, Canada M5S 2C6
***SLOWPOKE Reactor Facility and Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario, Canada, M5S 3E5
****Rochester Museum and Science Center, Rochester, New York 14603, U.S.A.,
*****Department des sciences humaines, Universit, du Quebec Chicoutimi, Chicoutimi, Qu,bec, Canada, G7H 2B1
******Ontario Heritage Foundation, Toronto, Ontario, Canada, M5C 1J3

Following successful attempts to establish that the chemistries of turquoise blue and white glass trade beads change over time, a preliminary study was begun to compare royal (cobalt) blue glass trade beads from early 17th century sites in southern Ontario with beads from a glass bead manufacturing house in Amsterdam. The bulk chemistries of these beads mirror their fine state of preservation. They are mixed alkali (mainly soda) - lime - silica beads with calcium contents usually above 4-5%. Their cobalt contents vary over a factor of six, and some were opacified with up to 4% tin. The arsenic/cobalt atomic ratio of ÷2 fits with the possible source of cobalt as a cobalt-arsenic ore (of common name smaltite) that was found in the Harz Mountains of Eastern Germany, a source not too far from either Amsterdam or Venice, both known glass trade bead making centres of the period.

145. Skeletal embalming and natronisation in the Old Kingdom conserves alkaline phosphatase

Y. Kaup*, H. Etspüler*, J. Koller, U. Baumer**, U. Weser***

*Anorganische Chemie, Physiologische Chemie Institut der Eberhard Karls Universität Hoppe-Seyler-Strasse 4, 72076 Tübingen Germany
**Doerner-Institut, Barer Strasse 29, 80799, Munich, Germany

Our knowledge on the conservation techniques used in the Old Kingdom of ancient Egypt is limited. In general mummification is observed after simple drying of the body. To improve this process embalming was increasingly performed from the Middle Kingdom onwards. The tomb of Idu II, the chairman of the pine wood office (2150+/- 50 BC) was discovered in 1914 at Gizah and its content was brought to the Pelizaeus Museum at Hildesheim. The mummy (Inv. No. 2639) essentially consisted of an unwrapped skeleton, the head was bandaged. It was soaked immediately after recovery with paraffin.

Extracts of a clavicle fragment were subjected to GC- and GC/MS-analyses and revealed a wealth of wood tar compounds including the antiseptic cedrol and gujacol. Acidified methanolic bone extracts yielded dehydroabietic acid and its oxidized forms. Further support of the suggested conservation of the skeleton was expected from sodium analyses. A 12-fold higher sodium content was seen by atomic emission spectrometry compared to sodium analyses of bones from modern autopsies. The embalming proved to be beneficial for the intactness of bone alkaline phosphatase. Clavicle fragments were employed to isolate the enzyme. During gel chromatography the elution profile was essentially the same to that observed for the extraction of a modern bone sample. The enzymic activity was allocated in either M (r) = 230+/- 30 kDa. The enzymic activity was improved after affinity chromatography where the specific activity rose to 200 mU/mg, some 20% of the activity obtained with a contemporary enzyme.

Proof of the unequivocal human origin of the ancient alkaline phosphatase was challenged in a specific ELISA using a monoclonal antibody directed to the human bone enzyme. There was an immunoreactivity of 23%

compared to that of the enzyme obtained from modern autopsy. Furthermore, no microbial contamination of the bones was detectable.

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146. From Palaeolithic tools to Mediaeval statues - precise identification of origin by microfacies analysis of limestone

M. Kázmér, Gy. Szakmány, J. Altmann, K. Török

Department of Palaeontology, Eötvös University, H-1083 Budapest, Ludovika tér 2, Hungary
Department of Petrology and Geochemistry, Eötvös University, H-1088 Budapest, Múzeum krt. 4a, Hungary
Budapest Historical Museum, Budapest, Hungary
Hungarian National Museum, Budapest, Hungary

Carbonate microfacies analysis is a sensitive method in identifying the geological age and depositional environment of sedimentary rocks (limestone, dolomite, chert, flint, etc.). The combined analysis of rock texture and fossil content, associated with a detailed knowledge of regional geology, makes possible to assign archaeological materials to precise locations, even to quarries.

The Palaeolithic tools of Bicske (Transdanubain Range, Hungary) were made of a fine-grained limestone, deposited in a 10 million years old Middle Miocene (Sarmatian) reef. We found the origin in an abandoned quarry at Páty, ca. 10 km away from the archaeological locality.

A Late Mediaeval statue found in the Buda Castle (Budapest, Hungary) is made of Late Tertiary limestone, rich in fossils. By identifying the components and the depositional environment we suggest a relatively small area within the Pannonian Basin as source of the stone.

Stone material both for tools and for statues have been carefully selected by their masters for resistance of wear and weathering. If the rock contains fossils, the inexpensive method of microfacies analysis provides good results in identifying the source of the material.

147. Finite Element Analysis for Failure Prediction of Archaeological Pottery

V. Kilikoglou, G. Vekinis

Laboratory of Archaeometry and Advanced Ceramics Laboratory, N.C.S.R. Demokritos, Aghia Paraskevi, 15310 Attiki, Greece.

Prediction of function of archaeological pottery has been a long-standing subject of discussion, as it is affected by many parameters, not always interpretable in a common sense. Mechanical behaviour is one of those parameters which have attracted a lot of attention and therefore its accurate determination is essential.

In this paper we present a quantitative model that was developed, based on the Finite Element Analysis (FEA) approach, for predicting the failure of vessels under almost any possible loading conditions, by taking into account the shape. The vessel is divided into a large number of virtual elements, on which the strains, under any type of loading, is calculated by the parametric solution of a large number of equations. The input needed for the analysis are the Young's modulus and the Poison's ratio of the material as well as the geometric characteristics of the vessel and the loading mode.

In order to evaluate the efficiency of the FEA approach, a series of ceramic pots were manufactured using a calcareous clay and different sizes and volume fractions of non-plastic inclusions. TRS, toughness and Young's modulus of the ceramic material were determined using standard techniques. The maximum strain experienced by the pots was then calculated by FEA, under different loading modes and loads. The actual pots were finally subjected to mechanical loading, where the load at failure was found to be within 10-20% of the calculated value. The results indicate, therefore, that the FEA method can be used to assess the failure behaviour of

ceramic vessels with sufficient accuracy. The model has also been applied to archaeological pottery with a view towards predicting their mechanical behaviour.

148. Chemical characterization of Roman brass and copper coins from Rome (Tiber), Italy

S. Klein*, G. Brey*, H.-M. von Kaenel, J. Riederer*****

*Institut für Mineralogie Abt. Petrologie und Geochimie Johann Wolfgang Goethe Universität Frankfurt am Main, Senckenberganlage 28, Pf 111932 60054 Frankfurt am Main, Germany
**Seminar für Griechische und Römische Geschichte, Universität Frankfurt, Gräfstr. 76, 60054 Frankfurt am Main, Germany
***Rathgen-Forschungslabor, Schlosstr. 1a, 14059 Berlin, Germany

A representative group of 500 selected brass and copper coins, all been found in the Tiber River, Rome, have been chosen for analysis. For the first time, sampling of such a large amount of Roman coin, dating to the reigns of the emperors Augustus to Claudius (27 BC to 54 AD), was possible ever. The concerning coins are filed and stored at the Museo Nazionale Romano at Rome. Drilling into the coin's thin side yielded filings, which were analyzed by electron microprobe (wavelength dispersive) for chemical composition. To the fore of our investigation was to determine a presumable quantitative shift of trace elements in chronological order during this time period. With the help of the analyses we strove for a better relative classification of some specific coin types and the clarification of the relative sequence of the emissions. In our presentation we will report about the first approach towards these goals of research. In the longer term of the project, we also wish to discuss the ratio between products of the official mint at Rome to either those of a supposed auxiliary mint or uncontrolled (illegal) imitations.

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149. INAA of pottery from Il Lokeridede and Jarigole, Koobi Fora region, Kenya

C. Koch*, L. Pavlish, R. M. Farquhar**, R.G.V. Hancock****

*African Studies Institute, Rutgers University, New Brunswick, New Jersey
**University of Toronto, Toronto, Canada

Instrumental Neutron Activation Analysis (INAA) was carried out on 52 samples recovered from the presumed Pastoral Neolithic sites of Il Lokeridede and Jarigole which are located in the Sibiloi National Park on the Koobi Fora Formation on the East shore of Lake Turkana near the Northern Kenyan borders with Ethiopia and the Sudan. The elemental data obtained from the SLOWPOKE Reactor Facility [University of Toronto], can be separated into two Groups (A & B). Group A samples represent both sites while group B samples come only from Jarigole. Group A samples suggest that sherd material recovered from these two sites may have come from a similar clay source. Since each of the sites contain samples of pottery ware that appear both physically and chemically similar, site contemporaneity may be inferred. A radiocarbon date obtained on charcoal from the IsoTrace Facility [University of Toronto] in connection with this project confirms the Pastoral Neolithic age (2910 - 2575 BC) for the site of Il Lokeridede. This is the first AMS date obtained from samples from the Koobi Fora Region. It is also the first date for any site in the Jarigole Mortuary Tradition.

150. The Invesitagion of Prehistoric Birch pitch Find by GC and GC/MS

Johann Koller, Ursula Baumer

Doerner-Institut, Barer Strasse 29, 80799, Munich, Germany

The tar obtained by smouldering birch bark represents the most important sealing and gluing material of past times. Its various uses can be traced back far into the prehistoric epoch of mankind.

Birch bark contains a concentrated form of the triterpenoid betulin which, next to lupeol may be considered a characteristic extractive of birch bark. Hence, the lupane derivatives betulin and lupeol are bio-markers which reveal the biological origin of archaeological pitches carbonised at low temperatures. While birch tar or the pitches formed thereof in the ageing process contain both betulin (lupendiol) and lupeol, the relative percentages of these substances depend greatly on the way the smouldering process had been carried out. In GC analyses only the gas chromatograms of birch tars obtained by gentle methods (smouldering temperature below 350 °C) show characteristic peak profiles, with a dominant betulin peak.

There are changes in the relative portions of the triterpenoid lupane derivatives as well as in the components themselves whenever birch tar had been produced at excessive temperatures (above 350 °C). Betulin, above all, is either reduced or absent altogether. The resultant peak profile of the birch tar shows considerable variations from the expected pattern and in this case is characterised by degradation and conversion products. Betulin and lupeol are degraded to give lupadienol and lupadien respectively, with a concomitant setting free of water. The bio-markers are thus replaced by degradation-markers which reveal the extent to which the pitch had been exposed to heat.

Generally, the role of betulin as a bio-marker in the identification of birch pitch is overrated, in particular in the case of pitch finds exposed to greater than normal heat either during production or in the course of their being used. Regardless of site and age of the prehistoric finds, both kinds of birch pitches were found, i. e. they either contained or lacked betulin.

151. An approach to dating based on the expert system technology The aim of this paper is to describe an application of the artificial intelligence (more precisely of the expert system technology) in archaeology

M. Korac*, Z. Ognjanovic, F. Dugandzic**

*Archaeological Institute, Kn. Mihailova 35/IV, 11000 Beograd Yugoslavia
** Mathematical Institute SANU, Kneza Mihaila 35, 11000 Beograd Yugoslavia

Expert system are computer programs that contain knowledge base, inference engine and user interface. Knowledge base consists of formalized knowledge, and partially, of intuition employed by an expert in his reasoning about particular problem. When this knowledge is acquired an expert system user can pose questions, while inference engine brings up conclusions that are presented in a multimedial manner through user interface. It is especially significant that an expert system should be capable to explain the way it reached answers, so that inferred conclusions could be confirmed, and a mode of reasoning could be illustrated.

Applications of an expert system depends on the contents of its knowledge base. We suggest that the archaeological knowledge is suitable for formalization, and that it is possible to produce useful expert systems for archaeology.

We represent an actual expert system called PANDORA through several examples, as well as the experiences acquired during its development. In our opinion PANDORA can be used as a consultant of explorers, as well as an education means by which an expert work could be represented to students.

152. Mapping of the archaeological facts

Kovalevskaia V.

Institute of Archaeology RAS, Dm Ulyanova 19 117036 Moscow, Russia

In pre-revolutionary Russian and international archaeology, interest in the systematization of materials was very closely interconnected and its streamlining in a time-space continuum was very significant. The 60s in our country marked the beginning of the mathematical analysis of the basis of source studies: namely at this time the question was placed of the necessity of mathematization, the introduction of objective criteria for the resolution of questions of similarity and difference, the creation of a generally accepted scientific language and rules of description, analysis and interpretation (V.B. Kovalevskaia (Deopick) 1961, 1965, I.S. Kamenetsky 1965, B.I. Marshak 1965, G.A. Fyodorov-Davydov 1965, Ya.A. Sher 1970, D.V. Deopick 1970). It's natural that in archaeology the temporal and territorial affixation of artifacts, monuments, and archeological cultures vary, the level of their complexity, heterogeneity, the rate of evolution of their components, and so forth, that is all the parameters in their endless variety. But the model and approaches are unified enough so that one general

procedure of investigation can be used for different material, taking into account all the possible variation of the applied methods. Time and space are a basic notions in archaeology while the definition and superimposition of distribution areas were hitherto the main techniques of spatial analysis in traditional archaeology. The introduction of computational genogeographic mapping, elaborated by prof. Ju. Rychkov, to archaeological materials has greatly enhanced the possibilities of archaeological researches. With the use of the continuous interpolation function (spline-interpolation, average weight interpolation) it became possible to create quantitative models for the distribution of a number of leading forms of mass archaeological materials and compare them. Early Iranian migrations, Hun invasions, "great migrations" of antic and early medieval time have been investigated with the aid of computational programs GGMAG, Datstat, Mapstat. The method allows one to create cartographic patterns of the distribution of the main types of artefacts throughout the archeological cultures under consideration (center/periphery, "diversity-in-unity"). In conjunction with historical, anthropological and genetic materials, a generalised maps show the movement of several groups of peoples in Europe (first mil. B.C. - first mil. A.D.) by aid of archaeological material.

153. Geophysical Survey and its Verification on Archaeological Sites in Bohemia

R.Krivanek

Institute of Archaeology of Czech Academy of Sciences, Letenska 4, CZ-118 01 Praha 1, Czech Republic, email: krivanek@arup.cas.cz

The most intensive and systematic co-operation between geophysics and archaeology including another non-destructive methods has been carried out in Bohemia since the 1990s when started the rapid increase of landscape changes and importance of rescue archaeological excavations. Geophysical methods were in the last years used not only for preliminary archaeological prospection of sites but some of them were used also in time of open excavation or for detailed survey of previous studied or excavated sites. The examples presented in this report shows comparison of results of magnetometry and archaeology or efficient use of combination of both methods on various types of archaeological sites. An example of systematic survey of hill-fort Cimburk by Bylany in Central Bohemia showed that by gradient magnetometric survey of area near the edge of previous excavated place we could identify continuing of different types of Eneolithic, Hallstatt and Early Mediaeval fortification. An example of detailed survey of North Bohemian glass-working High Mediaeval site Kyjov demonstrate that by different types and amplitudes of positive magnetic anomalies we can identify glass-furnances, glass-waste heaps and other features before archaeological excavations. Another example from North Bohemia shows application of detailed survey of prehistoric rectangular tomb near Cernoucek where various amplitudes of intensity of magnetic field separate dark soil filling inside of ditch and stony filling of central grave by massive neovolcanic blocks. Interesting results brought magnetometric survey of area near Central Bohemian Vinor where two very similar ditches documented during previous rescue archaeological excavations of pipe-line in distance 55m creates a Neolithic circular enclosure.

154. Provenance study of Iron Age amber from Bulgaria

I. Kuleff*, R. Djingova, M. Arnaudov, D. Gergova**

*University of Sofia Fac. of Chemistry, 1 James Bouchier Blvd. 1126 Sofia Bulgaria
**Bulgarian Acad.Sci. Institute of Archaeology, ul Saborua 2. 1000 Sofia Bulgaria

Using IR-spectrometry archaeometric investigation of 49 finds of archaeological amber has been performed. The finds originate from the region of West Rhodopes (26 samples), the valley of Vardar river (3 samples) and North Bulgaria (4 samples). All finds are dated 7th-6th century BC. Besides 16 finds from Roman time from the region of Varna (Northeastern Bulgaria) were additionally investigated.

The analysis of IR-spectra and comparison with reference spectra of amber from Baltic region (succinite), Switzerland and Austria (plaffeite) proved:

- the archaeological amber from West Thracia (West Rhodopes and Vardar river), and the majority of Roman amber 813 samples) have Baltic origin.

- all other investigated finds are not succinite

- the archaeological hypothesis that the amber ornament on a golden sheath of a Thracian warrior is of Swiss/Austrian origin was not confirmed.

155. Raw Material Sources and Ceramic Production in LBA Central Macedonia, Greece: A Comparative Analysis of Handmade and Wheel-made Pottery by Thin Section Petrography

E. Kyriatzi*, K. Kotsakis, Andreou, S. Dimitriadis*****

*British School at Athens, Odos Souedias 52 10676 Athens Greece
**Department of Archaeology Aristotle University of Thessaloniki, 54006 Thessaloniki Greece
***Aristotle University of Thessaloniki Dept. of Geology, 54006 Thessaloniki Greece

During the second half of the second millennium, two ceramic traditions, technologically and stylistically distinct, co-exist in Central Macedonia, Northern Greece. One relates to the manufacture of plain domestic, and some decorated, handmade wares and has a long history in the area. The other comprises a newcomer and its products, mainly wheel-made decorated table ware, appears with growing frequency after the 15th century BC and follows closely the Mycenaean style.

The present project aims to shed some light on the complex picture of pottery production in the area, focusing on the study of the ceramic assemblage from the site of Toumba Thessalonikis. Comprising a detailed typological and technological study combined with the thin section petrographic analysis of 300 pottery samples and the systematic research on the local clay sources aims to characterise the raw materials used and investigate their provenance, understand the technological processes and the organisation of ceramic production and, finally, relate them to the functional and typological characteristics of the pottery.

Three major "local" groups and some minor, not distinctively "local" ones, have been identified among the handmade vessels, on the basis of mineralogical composition and manufacturing technology. This distinction partly coincides with the main pottery functional groups: pithoi, cooking pots and table ware. Referring to the wheel-made pottery, despite limitations imposed by its technological characteristics and the fine quality its fabrics, macroscopic study and petrographic analysis have observed considerable variability in the materials used. The relationship of this variability to provenance, date, typological and technological differences is discussed.

The variable degree of internal homogeneity and standardisation within the various groups in terms of each potting tradition, seems to reflect different degrees of craft specialisation, indicating that different types of pottery were produced under different modes of production organisation, even within the same geographical area.

156. Prompt-Gamma Activation Analysis of Roman Brooches

Zsolt Kasztovszky*, Andrea Vaday**

*Department of Nuclear Research, Institute of Isotopes of the Hungarian Academy of Science, POB 77, H-1525 Budapest, Hungary
**Archeological Institute of the Hungarian Academy of Science, H-1250 Budapest, Úri u. 49.

Objectives

In 1996 a Roman cemetery (1st - end of 4th century) was uncovered near Hegyeshalom (north-west Hungary). Excavations were directed by András Figler, Mosonmagyaróvár Museum. Among the finds there were several bronze and silver brooches, exact composition of which had to be determined. Based on the PGAA measurements, archaeologists hope to get useful information about the findings (e.g. different manufacturing processes, different dates of origin). The lack of alternative non-destructive analytical methods emphasises the importance of PGAA.

Method and results

24 brooches were examined (both early and late types. Two of them made of silver, the rest made of bronze. The same part of the samples were irradiated for 1000 seconds. The sample chamber was not evacuated.

The main alloy components were identified by their prompt-gamma rays, originated from nuclear reaction. The Cu-, Zn- and Sn-ratios were determined with k0-method.

Three groups of bronze samples can be distinguished. Most of the samples contain 92-98 (10 % Cu and 2-8 (1 % Zn. The second group of samples contains also 4-6 (1 % Sn, and the third one contains Cu, Zn, and Sn.

We were also able to detect some trace-elements, like Mg, P, Cd and several rare-earth elements, which possibly originate from the soil, contaminating the surface. Further analysis of trace-elements may give more useful information.

157. Towards a Radiocarbon Chronology of the Romanian Prehistory

Attila László

"Al. I. Cuza" University, Iasi, Romania

Viewed, at the beginning, with doubt by archaeologists, starting with the 70's the radiocarbon dating gradually gains in importance also in the Romanian prehistory. For the time being, we have more than 200 radiocarbon dates, obtained from various European or American laboratories, Romania being one of the few European countries without a radiocarbon dating facility. Unfortunately, these dates unequally cover the various prehistoric periods and cultural areas. Thus, the almost 80 ^{14}C dates for the Palaeolithic and Epipalaeolithic regards exclusively the regions situated east or south of the Carpathians. Concerning the Neolithic and Eneolithic ages , with approximately 100 radiocarbon dates, we have the same situation: the Transylvanian cultures dispose of no more than few dates. The other about 20 ^{14}C dates refer to the so called transition period from the Eneolithic to the Bronze Age, and, to a smaller extent, to some of the Bronze Age cultures.

In the last decade, as regards the post-Palaeolithic civilisations, besides conventional ^{14}C dating, the usage of calibrated data was initiated too, working especially with the calibration program of M. Stuiver - P. Reimer.

The paper proposes a discussion of the radiocarbon dates regarding Romanian prehistory (Middle Palaeolithic - Bronze Age, ca 50000 BP-3100 BP/1435-1313 BC) in the context of the south-east European prehistoric chronology.

158. A method for the identification of copal resin in archaeological materials

Lazos Luz*, Pena Araceli, Barba Luis**

*Instituto de Investigaciones Antropologicas Universidad Nacional Autonoma de Mexico, Circuito Exterior s/n, Ciudad Universitaria 04510 Mexico D.F. Mexico

**Inst. Investigaciones Antropologicas UNAM Lab. de Prospeccion Arquelogicas, Ciudad Universitaria, Coyoacan Mexico D.F. 04510 Mexico

The copal resin has been widely used in Mesoamerica since Prehispanic time as a key element in ritual and domestic activities. Numerous historic and ethnographic References describe that the copal resin was employed not only in the ritual context, but also in the preparation of varnish and adhesives. However, the presence of copal residues in archaeological materials has been scarcely studied because of several methodological problems.

In this paper we present a method to identifying the copal resin from ancient objects by solvent extraction and gas chromatography/mass spectrometry (GC/MS). A method is described here that use a shorter extraction time and whose resulting yields are favourably compare with other methods. The method was applied both modern copal resin and Mexican archaeological materials such as copal figurines and ceramics. The results show that this method should be a useful tool for artifact-use determination.

159. Structural studies on the metallic artifacts of Phrygian period

Ercanli, Levent

PK 146, Maltepe, Ankara Turkey

The Phrygian metallic artifacts obtained from the excavations and tumuli in the vicinity of Ankara were initially examined from a purely archaeological point of view. Recently however, some of the metal findings were subjected to study through the application of physical and chemical analysis. The results have led to a re-examination of original conclusions drawn from the archaeological evidence.

In this study, we present some of the results which have been obtained through metallurgical analysis such as optical and scanning electron microscopy. Both techniques were used to reveal detailed structural analysis of artifacts which will give the production technologies of these objects. Also X-ray energy dispersive analyser was used to obtain microchemical analysis of the objects.

A characteristic feature of the external corrosion layer was the formation of a cuprite layer covered by a scale of malachite. From analytical evidence, the corrosion layer is practically devoid of tin. In the surface corrosion of tin bronze, copper is thus selectively attacked resulting in the formation of cuprite. As corrosion proceeded, the copper oxide was transformed from the outside into basic copper carbonate (malachite) through the action of CO_2 and H_2O present in the environment.

Most of the pieces investigated exhibit a recrystallized microstructure with annealing twins. This suggest that in processing of these artifacts, the deformation (hammering) of the starting material was followed by an annealing treatment above 550 °C.

The numerous precipitates and inclusions which occur in the metallic core were apparently already present in the starting material in the form of impurities.

160. Semifinished products for glass-making used in the Antiquity and the Middle Ages

Julia A. Likhter

Center of Archaeological Research, Pyatnitskaya Str. 19 113095 Moscow Russia

Written sources describing the Ancient glass-making are well known. But there are no answers to some questions: the structure and organisation of craft, the types of workshops. One of such questions refers to existence of workshops with an incomplete production cycle. Having no description of working methods used by craftsmen we have the results of their work - the artefacts they produced. An artefacts is a valuable source of information about its maker's know-how, and about the organisation.

From this point of view a great number of glass beads, vessels, armrings and fingerrings were investigated. We can connect same of them with different semifinished products - tubes, rods, halfspheric cakes.

Working with them characterises workshops of different levels. Insertion of glass sherds in non-glass artefacts is the first stage of working with the new material. It was the production of barbarian craftsmen. Next stage - working with simple semifinished products as cakes and rods. This is the first step in mastering the glass-making craft. Probably this refers to craftsmen, which were included in the sphere of influence of the Roman Empire. Working with tubes needs much wider knowledge in glass-making. Craftsmen having such knowledge were probably connected with classical regions of glass-making.

We can suppose also where semifinished products themselves were made. Mosaic strips came from Egypt, tubes from East Mediterranean and Northern Mesopotamian. Rods and cakes may be connected with these centres, but also with Rome, its European provinces, and afterwards with Byzantium as Rome's heir.

161. Application of digital spectrophotometry and geophysical prospecting to the analysis of archaeological activity areas

Karl F. Link

UNAM Lab. de Prospeccion Arquelogica Inst. de Investigaciones, Apartado Postal 21-964 Coyoacan, Mexico City DF 04000 Mexico

The detailed study of archaeological activity areas is now commonly carried out through advanced chemical and physical analysis. These techniques are designed to detect soil properties which have been enriched or altered by human activity. Soil color is a common descriptive property used to characterize and differentiate archaeological soils, but which lacks a clear relationship to the underlying chemical and physical composition.

The visual (and subjective) determination of observed color by comparison with the Munsell Soil Color Charts is subject to substantial errors due to several psychophysical and physical factors. Another limiting factor is that Munsell data derived from systematic sampling is not readily converted into quantitative data for spatial visualization. Soil color can be characterized by its spectral reflectance curve, and then converted into tristimulus values (CIE Lab) in a perceptually uniform color space. Small differences in soil color can then be used to identify and study differences in compositional properties and cross correlated with electrical and magnetic geophysical data. This analytical methodology will be illustrated through the analysis of the lime plaster floors from the post-classic period in the Hall of the Eagle Warriors, Templo Mayor of Mexico-Tenochtitlan.

162. Friesacher Pfennig: Non-destructive Examinations on Austrian Medieval Silver Coins by Energy Dispersive X-Ray Fluorescence Analysis

R. Linke*, M. Schreiner*, H. Winter, M. Alram****

*Institute of Chemistry, Academy of Fine Arts, Schillerplatz 3, A-1010 Vienna/Austria
**Numismatics Department, Kunsthistorisches Museum, Burgring 5, A-1010 Vienna/Austria

Increasing trade at the beginning of the 12th century AD in Europe implied new currencies with a wide range of validity. One of these new legal tenders in the area of Carinthia, a Southern part of Austria, was the Friesacher Pfennig. The first silver coins were struck by archbishop Konrad I. v. Abensberg (1106-1147) in the town of Friesach. Caused by its big financial success the area of circulation had spread from Carinthia to North-Italy, over Croatia and Hungary up to Slovakia. The big demand for this new currency yielded to a big number of mints and even copies were produced during this period.

Coins of the early period, which are very rare and of a high value, have no marks or punches, by which numismatists could classify the coin's mint. Therefore, non-destructive analysis by energy dispersive X-ray fluorescence analysis was carried out. The aim of these investigations was to set up a library of the chemical compositions of the alloys used for the production by the various mints. The silver coins, which were coated with a layer of wax for conservation reasons, were cleaned with white spirit and ethanol in an ultrasonic bath prior to analysis. The major elements silver and copper have been quantified by using silver-copper-standards, whereas the trace elements such as Fe, Au, Pb, Bi, and Hg were determined by their X-ray intensities. As most of the coins have been found in soil, where they have been buried for hundreds of years, leaching effects occurred and caused big problems during the interpretation of the results. However, calculating the ratios of Ag-Ka/Ag-L intensities decisions could be made, whether the coins were depleted especially on Cu on their surfaces or not. For the interpretation of the data multivariate statistical methods like cluster and factor analysis were carried out. Cluster diagrams and dendrograms enabled a clear and definite interpretation of the data.

The results showed that nearly each mint used its own technology or at least its silver ore for the production of the silver alloys. By comparing the data of unknown coins with the analytical results of objects of known origin it was possible to assign about 80% of these uncertain coins to one of five possible mints.

163. An industry in crisis? Changes in bronze composition bear the end of the Hungarian Bronze Age

D. Liversage*, E. Pernicka**

* National Museum Copenhagen, Marknesvej 26 2840 Holbe Denmark
**Max-Planck Institut für Kernphysik, Heidelberg

Changes in metal compositions at a late stage of the Central European Bronze Age are examined with a view to looking for trends in composition at the Jungbronzezeit/Spatbronzezeit transition (close before 1000 BC.) on the basis of a new series of 186 X-ray fluorescence analyses made at the Max Planck Institute. The objects are from the Hungarian National Museum and Nyíregyháza Museum. Comparison with the published Stuttgart analyses from the immediately foregoing period reveals several developments suggesting that the bronze industry was facing problems.

1. Tin was in shorter supply and a substantial proportion of the artefacts were suddenly of unalloyed copper. Occasionally the absent tin was replaced by large quantities of lead.

2. The impurity patterns suggest a tendency to breakup of the system of monopolistic metal production and supply that had prevailed since the Middle Bronze Age.

3. Some of the copper/bronze is very impure, with values of up to 11.7% arsenic, 13.3% nickel, 9% iron, etc. Such extremes are unusual and suggest problems in controlling the metallurgical processes.

It may be added that the ingots, furnace bottoms, slabs, drips etc. have usually been assumed to be melted down scrap metal, but as most were of unalloyed copper this is an error. They must show a hitherto unstudied intermediate stage in processing.

164. A Study of Antimony Bronze Alloys from the Late Bronze Age of the Carpathian Basin

P.I. Maclean, J.G. McDonnell

Department of Archaeological Sciences, University of Bradford, Bradford, West Yorkshire, BD7 1DP, UK,EMail: p.i.maclean@bradford.ac.uk

This work represents the conclusion of a long term study on a group of prehistoric metalwork comprised of exotic copper-based alloys from the Carpathian Basin, and most notably, Hungary. The project focuses on a previously little-studied area of archaeometallurgy, that of antimony bronze: copper - antimony alloys first discovered in the Hungarian archaeological record some 100 years ago. The current study considers known manufacturing centres, distribution, physical metallurgy and postulated reasons for its existence. The work is based on examination of a corpus of archaeological material in conjunction with a series of laboratory produced alloys. A suite of techniques have been used to illicit information on this select group of material, including optical metallography, Scanning Electron Microscopy, X-Ray Diffraction, X-Ray Fluorescence, Neutron Activation Analysis and mechanical testing. Conclusions drawn from the examination of high antimony objects (e.g. >1% wt. Sb) indicate that the properties of this material were known, understood and selected for during the Late Bronze Age, and that the predominant reason for the presence of elevated levels of antimony was due to its use as a colorant.

165. Analysis of high Antimony concentration finds with various methods XRF analysis of antimony bronzes

Paul Maclean,* László Költő, Miklós Kis Varga*****

*University of Bradford, Department of Archaeological Sciences (Bradford, UK)
**Directorate of Museums of County Somogy (Kaposvár, Hungary)
*** Institute of Nuclear research (Debrecen, Hungary)

Radioisotope excitation X-ray fluorescence analysis has been used to determine the composition of antimony bronze objects found near Velem in western Hungary. Earlier, the XRF technique with I-125 isotope source proved to be useful for analysis of late Avar bronzes where the amount of antimony was low or negligible. The problem of analysis of antimony with this method lies in the high spectral background caused by the incoherently scattered TeKa exciting radiation. Especially at low Sb level a not carefully performed spectrum evaluation procedure may lead to false results. Both the spectrum fitting method and the fundamental parameter method of concentration calculation have been tested by the analysis of the set of reference materials produced at the University of Bradford UK. The analyses of these samples have also been performed by a secondary target X-ray tube excitation system, where the antimony peaks can be measured without affecting by disturbing backgrounds. Acceptable agreement of the analytical results with the composition of ingots has been obtained. The composition of Velem findings are also given.

166. Provenance studies at Neolithic to Bronze Age pottery ware from the Castel Grande (Bellinzona, Ticino, Switzerland)

Andreas Mais

Department of Mineralogy and Petrography, University of Fribourg, 1700 Fribourg, Switzerland

The pottery which was found in the Castel Grande during excavations by P. DONATI in the years 1980-1984 provides a unique possibility to look into Early Middle European history. A very exact typological seriation by R. CARAZZETTI showed that the ware represents a complete sequence from the Early Neolithic period (~5300 B.C.) to the late Bronze Age (~1400 B.C.).This suggests a permanent settlement of the area around Bellinzona for a period of about 4000 years and makes it possible to study the development of pottery technology and changes in used raw materials.

For the provenance studies two different methods have been used.

The temper analysis was used to determine if the rock and mineral fragments in the sherds are of local origin. To do this, petrographical methods such as polarisation microscopy with quantitative mineral analysis have been used. The first results of these studies show a good correspondence between the rocks of the Castel Grande(gneisses, coarse amphibolites) and the materials which were found in the ware.

Chemical mineral analysis for main and trace elements of some typical minerals like amphiboles, feldspars and micas with the EMP (electron microprobe) and the SEM (scanning electron microscope) are used to verify this results.

The second method was a geochemical analysis of the sherds, local clays and rocks by XRF (X-ray fluorescence analysis) which was used to compare the ware of the different periods and the supposed local raw materials.

167. Geological-geochemical sourcing of prehistoric chert artifacts, north-western Alaska

N. Malyk-Selivanova*, G.M. Ashley, R. Gal, M.D. Glascock, H. Neff**

*Rutgers University Dept. of Geological Sciences, Busch Campus, Piscataway, NJ 08854 USA
**University of Missouri 223 Research Reactor, Columbia MO 65211 USA

In north-western Alaska chert artifacts are commonly the only surviving prehistoric relics. In this part of eastern Beringia chert sourcing is crucial for determining the routes of human expansion into the New World. We introduce the geological-geochemical approach to chert sourcing and illustrate it with the results of prehistoric chert sourcing in north-western Alaska.

The geochemical approach includes constructing a database of mineralogical and geochemical signatures of outcrops that can be then be compared with signatures of any artifact. The method is based on the idea that both the artifact and outcrop have identical geologic history: depositional environment, provenance and diagenesis, that are characterized with unique geochemical and mineralogical signatures. Analytical techniques involve instrumental neutron activation analysis for detection of trace element and electron microprobe analysis combined with X-ray diffraction for identification of mineral inclusions.

Four prehistoric chert quarries were identified in the western Brooks Range by comparison of 12 chert varieties sampled from 9 outcrops with 289 artifacts from 55 prehistoric sites (representing all known in the area prehistoric traditions dated from 10000 BP. to recent). Maps of distribution patterns of cherts mined in the western Brook Range and found as artifacts in north-western Alaska prehistoric sites delineate prehistoric group contacts and travel routes in the westernmost part of eastern Beringia. They show: 1/ direction and distance of transportation from to quarry for each chert variety, 2/ during which prehistoric culture each variety was mined and distributed, 3/ what chert varieties were preferred by different prehistoric groups.

The geological-geochemical approach to chert sourcing is generally applicable.

168. Provenance of White Marble with EPR Spectroscopy: Further Developments

Yannis Maniatis, Kyriaki Polykreti

Laboratory of Archaeometry, NCSR "Demokritos", Aghia Paraskevi, 153 10 Attiki, Greece

EPR spectroscopy has been proved to be a powerful tool for marble characterisation and provenance investigation since it was first applied in marble samples, in the early 80's. An extended databank has been created in the Laboratory of Archaeometry during the last ten years, with the EPR parameters for the most important ancient quarrying sites: Penteli, Hymettus, Naxos, Paros, Thassos Aliki, Ephessus, Afrodisias,

Proconnesus. The results of an attempt to discriminate between these quarrying regions are presented in this work.

The advantage of EPR spectroscopy over other analytical techniques, is that more than two parameters can be used for discriminating between different quarries. Except for Mn^{2+} concentration in the calcitic and dolomitic lattice, EPR gives many other parameters characterising the lattice structure and the presence of impurities.

In combination with EPR spectroscopy the Maximum Grain Size (MGS), determined easily with an optical microscope, proves very useful for quarry discrimination.

The method which is developed for provenance determination is based on a stepwise approach. A first discrimination is obtained using the Maximum Grain Size and the Mn^{2+} concentration of the samples. Overlapping areas occur between Naxos Melanes and Naxos Apollonas, Paros and Proconnesus and Paros and Hymettus quarries. A second discrimination stage follows, where overlapping areas are eliminated or at least decreased for the problematic quarries. Naxos Melanes and Naxos Apollonas are clearly discriminated using linear combinations of Maximum Grain Size, Mn^{2+} concentration and the intensities of the peaks at g=14.25 and 2.0044. Another successful discrimination is obtained between Hymettus and Paros, using a combination of Maximum Grain Size, Mn^{2+} concentration and the intensities of the peaks at g=1.9998 and 2.0044. The results are not so promising for the case of Paros and Proconnesus since most parameters overlap to a great extent. The famous Lychnites marble of Paros, quarried underground is however clearly distinguished.

169. A Technological Investigation of 12th Century Mosaic Icon tesserae from the Mount Athos, Greece

Y. Maniatis*, E. Malea, N. Minos****

*Laboratory of Archaeometry, NCSR Demokritos, 153 10 Aghia Paraskevi, Attiki, Greece
**Direction of Conservation of Antiquities, Ministry of Culture, Dioskouron 4, 105 55 Athens, Greece

A sequence of tesserae from two mosaic icons depicting St. George and St. Demitrios were investigated. The icons are kept in the Monastery of Xenofondas on Mount Athos at Halikidiki, Greece and are assumed to have been made in the 12th century AD.

The tesserae have a range of different colours such as, green, sky-blue, navy-blue, purple, black, red, brown, pink, yellowish and white. Also, there are tesserae with gold and silver colours. All different coloured tesserae were studied using, optical microscopy and scanning electron microscopy with energy dispersive microanalysis both at fractured and polished sections.

The results indicate that all the pieces apart of those with pink, yellowish and white colours are made of glass. The non-glass tesserae seem to be made of natural stones, like limestone or magnesium ores but they need further investigation for a full characterisation. The glass tesserae can be divided into two groups: 1) the lead glass ones, which have sky-blue and green colours, and whose colours are due to ions of Cu and Sn. The relative variation in the concentration of these two ions give the colour changes between light blue and green. 2) the non-lead glass ones, whose colours are dark-blue, black, purple and red with black striations are basically sodium glass. The dark-blue colour is due to Cobalt, the black is based on Mn-Fe minerals, and the purple is based on Fe-minerals as well as Mn-minerals, the intense red is a Cu based colour but the black striations are rich in Mn-Fe minerals. The gold and silver tesserae are made in a rather clear or slightly tinted glass by using gold and silver sheets of about 2 μm thickness and of very pure quality. The silver and gold sheet is covered by another layer of glass for translucency.

The work continues with more SEM analyses and selected XRD in order to clarify certain remaining questions.

170. Technical Investigation of Ptolemaic Egyptian Faience in the Collection of the Walters Art Galery

Yunhui Mao, A. Mellon Fellow

The Walters Art Gallery, Division of Conservation and Technical Research, 600 N. Charles St., Baltimore, MD 21201, U.S.A.

Pharaonic faience is familiar to many by its crude shape, thick walls, and deep turquoise blue color. Its manufacturing technique has well been established. However, stylistic and technological changes took place

with Egyptian faience produced in the Ptolemaic period (300 BC-30 BC). Ptolemaic faience is known to have been produced in the Delta region of lower Egypt, and has unusual features which distinguish it from pharaonic faience made in the earlier periods. These characteristics include: refined shape, thin walls, two toned glazes in contrasting colors, and detailed low relief surface decorations arranged in friezes. Very few faience samples of this period have been analyzed and their methods of manufacture have not yet been completely studied. The aim of this study was to characterize the materials and methods of manufacture of a group of this type of faience in the Walters Art Gallery. A total of twenty two fragments and vessels were studied. A number of analytical techniques were employed: stereomicroscopy, X-radiography, Xeroradiography, X-ray fluorescence spectroscopy, and scanning electron microscopy-energy dispersive spectrometry. The research results aided in the identification of body type and glazes used during production, and the explanation of fabrication techniques.

171. The Petrology of Iranian Safavid Ceramics

R. B. Mason, L. Golombek

Near East and Asian Civilizations, Royal Ontario Museum, 100 Queen's Park, Toronto, M5S 2C6, CANADA

During the Safavid period (1501-1732 AD) Iran saw the last of the great periods of ceramic production in the Islamic world. Wares were predominantly influenced by Chinese imports, particularly during the production of the "Kraak" wares widely traded from China in the seventeenth and early eighteenth century. Other important types included wares decorated with the traditional Islamic metallic overglaze lustre-paint, and polychrome underglaze-painted wares only distantly related to Chinese influence.

This is one of the last of the great periods of production of pottery in the Islamic world for which knowledge of the sites of production is not based on hard scientific evidence. Petrological studies of earlier wares of the Islamic world generally indicate very few highly specialised production centres for pottery of the highest quality (Mason 1995, 1996). This study is aimed at defining the characteristics of the Safavid wares, and eventually linking these characteristics to specific production centres.

Analysis of the available Safavid wares has produced four distinct petrographically-defined fabrics (petrofabrics) which generally relate to discrete stylistic groups. All are stonepastes, and so the criteria for characterising these quartz-rich ceramics has been applied (Mason 1995). None of the groups are identical to petrofabric groups defined for production centres identified in studies of earlier wares. No kiln evidence has been included in the samples, but there is historical evidence of production at a number of sites which can be related to the spatial distribution of the petrofabric groups. Hence two of the groups are tentatively attributed to Kerman and Mashhad.

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172. Beads from the North Caucasian Klin-Yar-III. cemetery (the 5th-8th cc. AD.). A chemical-technological analysis

Anna Mastykova

The Rescue Archaeology Dept. Institute of Archaeology, RAS, Moscow, Russia

The sites of the Kislodovsk hollow are of great importance for the study of North Caucasian archaeology. Among them the so-called Klin-Yar-III. cemetery stands out. The finds recovered from this site enable one to study a number of issues pertaining not only to the Kislodovsk area but to the whole of the North Caucasus. The present paper deals with the use of such a category of the archaeological record as excavated beads for the periodization of the site in question and for a more accurate dating of funerary complexes.

We have examined glass, jet, amber and carnelian beads recovered from 10 catacombs of the Klin-Yar-III. cemetery. Their morphological analysis has shown that a given time-span can be invariably associated with a certain technology of glass-making and a certain ratio of glass and stone beads.

A quantitative spectral analysis has shown the presence of the following types of alkaline glass:

a/ Si-Na(K)-Ca(Mg) being the main type

b/ Si-Na-Ca

Compounds of copper, manganese, iron and cobalt turn out to have been used for staining.

The study enables us to surmise that the glass beads under investigation are of Near-Eastern origin and their influx to the North Caucasus had been relatively stable, though in the mid-late 6th c. AD. then in the mid-late 7th c. Ad and in the first half of the 8th c. AD. new types of imported beads replaced the older ones. This fact can be accounted for by the establishment of new trading links indicative of changes in the economic priorities.

173. Strangers in a Strange Land? Renaissance Glass-making in Amsterdam

W. Patrick McCray

Dept. of Materials Science and Eng. College of Engineering, University of Arizona, Tucson, AZ 85721, USA

Based on archaeological excavations and archival material, glass was primarily a luxury item before about 1575 in Amsterdam. Within the next 50 years there was a shift with respect to the appearance of glass in different levels of society due to the changing role of Amsterdam in the world-economy. In the late 16th century, there are archival records which record the presence of Italian glass-makers at the first known glasshouses in Amsterdam. Eventually, it and other Dutch workshops employed many Italian workers including émigrés from Venice to make facon de Venise glass.

This work examines the transfer of glass-making technology from Italy to Amsterdam. There are many different sources of information that can be used to understand glass-making technology-written sources, pictorial representations, and studies of the glass itself. This paper integrates this information to provide a fuller picture of glass as it was made and used in Amsterdam.

Glass samples from several late 16th and early 17th century sites in Amsterdam were examined and analyzed. Chemical analyses were carried out with a variety of techniques including SEM-EDS, WDS, and ICP-AES. These results will be compared with analyses of Venetian glass from the same time period. In this manner, the adaptation of Italian/Venetian glass-making technology to local Dutch tastes, within the limitations of the available raw materials, will be examined. It will be shown that émigré glass-makers adjusted remarkably well to their new working circumstances in terms of making a glass that was aesthetically unique yet compositionally similar to that produced in Italy.

174. The complexity of copper mineral acqusition in the Aegean, Third Millenium BC.

Veronica McGeehan

The Open University, Eldon House, Newcastle upon Tyne NE3 3PW, UK

The objective of this paper is to analyse further the complex nature of copper mineral acquisition and exploitation in the Aegean during the Third Millennium BC. Particular emphasis will be given to the implications for the Helladic metal industry.

The initial problem which motivated this ongoing study was the need to identify which copper sources were exploited by the EBA mainland Greek industry in order to assess whether or not it developed autonomously.

In this paper, new data which helps us assess the copper sources available to, and in, the Aegean region is made available through an up to date evaluation of the latest geological data, lead isotope results, chemical analyses and typological data for mainland Greece, west Anatolia and the Aegean.

The results serve to further enhance our understanding of the nature of copper acquisition, the extent of trade and exchange and the impact this had on the development of mainland Greek metallurgy in the third millennium BC.

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175. The Traces of the Human Activity in the Pollen Diagrams of West Hungary

Medzihradszky Zsófia

Botanical Dept. of the Hungarian Natural History Museum, H-1088 Budapest, Könyves K. krt. 40., Hungary

West Hungary, especially the middle part of Transdanubia, the surroundings of the lake Balaton is one of the best investigated territory of Hungary from palynological and archaeological point of view.

In this work we collected the published pollen data of the last 50 years completed with very new analysis dated by C-14 method.

Our aim was

- to detect the changes in the pollen diagram caused by the human activity: forest clearance, animal husbandry, plant cultivation

- to observe the first occurrence of anthropogenic indicators (cereals and ruderals), the changes their quantity and quality compared with the cultural landscape development from the Neolithic Period until the Middle Ages.

- to compare the changes in the pollen diagrams with the settlement structure (number and character of the settlements) of the different archaeological periods.

- to compare the changes of the AP and NAP ratio and of the components of the pollen spectra comparable to different stages of the land-use history.

This paper is a part of a long term research, the first attempt to demonstrate by the pollen analytical record the development both of settlement and of land-use techniques in Hungary.

176. Estimating Age at Immigration: A Theoretical Model Using Strontium Isotope Ratios and Differential Bone Remodelling Rates in Various Skeletal Elements

William D. Middleton,T. Douglas Price

Laboratory for Archaeological Chemistry, University of Wisconsin-Madison, 1180 Observatory Drive, Madison Wi 53706

The use of strontium isotope ratios in calcified human tissues has become a powerful tool for identifying prehistoric residential mobility. Because tooth enamel forms during childhood and remains unchanged, while bone remodels throughout an individual's life, a difference in the $^{87}Sr/^{86}Sr$ ratio between tooth enamel and bone indicates a change of residence. Different skeletal elements, however, remodel at different rates throughout an individual's life span. After migration, skeletal elements will vary in their isotopic composition proportionate to the rate of bone turnover. These differences should make it possible to estimate the age at which an individual migrated. This was tested by computer simulation, modelling the effect of differential bone turnover on the isotopic composition in four skeletal elements (anterior and posterior iliac crest, rib, and mid-shaft femur). Two sets of 2000 simulated individuals, who moved and died at different ages, were generated. The first set was used to calculate a discriminant function for predicting the age at time of move, which was tested on the second set. The actual versus predicted age at time of move was correctly identified in 95% of the cases. The simulation, while still untested against empirical data, suggests an exciting new direction for the use of strontium isotope ratios in archaeometry.

177. Scientific Examination of Seventh Century Glass Fragments from Rome

Piero Mirti*, Lucia Sagui**

*Dipartimento di Chimica analitica, Universitŕ di Torino, Italy
**Dipartimento di Scienze storiche, archeologiche e antropologiche dell'antichitŕ, Universitŕ di Roma “La Sapienza”, Italy

Forty glass fragments were studied by scientific techniques of investigations. Most samples were fragments of chalices, lamps and window glass with colour ranging from blue to blue-green, green and yellow-green; other samples represented opaque decorative inlays coloured white, light-blue and red. The fragments, dated to the seventh century AD, had been found in the course of archaeological excavations carried out in the Crypta Balbi in Rome; their study aimed at obtaining information on the level of technological knowledge left in Rome and the regions trading with Rome after the fall of the western Roman Empire.

The composition of the fragments was obtained by ICP atomic emission spectroscopy, determining 22 elements, including major, minor and trace elements. In addition, reflectance spectroscopy was used to collect information on the presence of colouring agents, and X-ray powder diffraction to investigate the presence of opacifiers in the opaque inlays.

All the samples resulted to be soda-lime glasses, with low contents of potassium and magnesium; this would point to the use of a natural deposit of soda, rather than plant ash, as a source of flux. Cluster analysis and principal component analysis performed on the analytical data further indicated that several batches had been used to obtain the studied objects; this would result from the use of different raw ingredients or their mixing in different ratios, indicating various provenances or a technological differentiation within these glasses.

Iron(II) and iron(III) ions were found as the main colouring agents in the blue-green, green and yellow-green fragments, whose actual colour depends on the total iron to manganese ratio; total concentrations indicate deliberate addition of the two elements in about half the samples. Cobalt(II) was the main colourant in the blue glasses.

Copper was found as the colouring agent in the red and the light-blue opaque fragments; X-ray diffractograms suggest the presence of elemental copper rather than copper(I) oxide as the opacifier, besides colourant, in the red sample, and of calcium antimonate in the white and light-blue fragments. No evidence was gained on the use of tin compounds as opacifiers. However, the level of tin in the copper rich fragments suggests the introduction of the colouring agent through a copper alloy.

178. The Contribution of Colour Measurement in Studying Provenance and Technology of Ancient Pottery

Piero Mirti*, Patrizia Davit*, Enzo Ferrara**

*Dipartimento di Chimica analitica, Universitŕ di Torino, Italy
**Istituto Elettrotecnico Nazionale “Galileo Ferraris”, Torino, Italy

Colour measurement may be used to study provenance and technology of ancient pottery. In fact, colour co-ordinates of fired clays change with temperature, time and atmosphere of firing. This may allow to assess firing temperatures of ceramic materials fired under oxidant conditions, as the colour of refired sherds may not change until the equivalent temperature of firing (Te) has been exceeded. In addition, colour change after having surpassed Te depends on the clay used and may aid in tracing back provenance.

The method, previously tested on clay samples, was first used to study firing conditions of red gloss ware (Roman terra sigillata) from north-western Italy. Here, different temperatures of firing in the range 800-1000 °C were evaluated for wares of different provenance (Gaul, north and central Italy) and different quality; the obtained Te were in agreement with those inferred by X-ray diffraction.

Subsequently, colour measurement was used in the study of transport amphorae and black gloss ware (Campanian pottery) from ancient Calabria (southern Italy). Firing temperatures of about 600-700 °C were most frequently inferred for transport amphorae; this enabled to follow colour change with temperature in an upper range up to 1100 °C. It was found that amphorae of suspected local production could exhibit different behaviours, in agreement with the information provided by the chemical composition, which suggests grouping in different classes.

Colour graphs were more difficult to interpret in the case of Campanian pottery. However, an interesting result was obtained for sherds of Campana A, which displayed a similar behaviour. This would point to the use of the same clay and to a standardised working procedure, as was probably the case for pottery of this kind produced in the Naples region.

179. Provenance Study & Technological Approach of Late Samian Ware from Argonne, NW Gaul & Burgundy

Misonne, B.*, Laduron, D.*, Brulet, R.**

*Laboratoire de Géologie et Minéralogie, Université Catholique de Louvain, Place L. Pasteur, 3 - B1348 Louvain-la-Neuve (Belgium). e-mail: misonne@gem.ucl.ac.be
**Centre de Recherches d'Archéologie Nationale, Université Catholique de Louvain, Avenue du Marathon, 3 - B1348 Louvain-la-Neuve (Belgium).

Samian ware from Argonne has to be considered as a real 'guide fossil' in the knowledge of Late Roman time in North Gaul. This ceramic actually spread the market with a somewhat monopoly in Gaul. Its main diffusion area is located between the Seine and Rhin rivers from their springs to the sea. Moreover, a wider diffusion, even though more restricted, also occurred from the French Pyrenees to Hungary (Balaton Lake), and even in Ireland. Beside Argonne, other late Samian ware productions are also reported in Gaul, but their diffusion was less important. Furthermore, other local related productions known as Dérivées de terre sigillée, have been excavated in the Paris Basin and in the NW of Gaul.

The sampling of the research gathers wares from three workshops in Argonne, Domecy-sur-Cure workshop (Burgundy), Rues-des-Vignes workshop (NW of Gaul) in connection with three other groups of this area: Tournai, Bavay and Arras. Potsherds from Meuse valley settlements (Maastricht, Huy and Verdun) are also included.

The recognition of each of these productions without any confusion is a crucial archaeological problem which has to be coped by the means of mineralogy (thin sections, XRD) and chemical data (XRF) used for statistics. Our research points out the own features of each production and estimates likely origin of settlement sherds. Furthermore, microprobe analyses leads us to understand technological aspects of these wares pointing out the refractory nature of the clays used for the surface finish and the body which is, moreover, non-calcareous. This explains the bad quality of these ceramics.

180. Neutron Activation Results of Pottery from Boeotia including ten Linear B Inscribed Stirrup Jars of Thebes

H. Mommsen*, E. Andrikou, V. Aravantinos, J. Maran**

*Inst. für Strahlen und Kernphysik der Universität Bonn I., Germany
**Uni. Heidelberg, Germany

Chemical analysis of pottery is a well method to achieve a classification according to production methods in pottery workshops and provenance which in independent of archaeological classification parameters. As long as the ancient potters did not change their production procedure with respect to chemical composition, all pieces of such a production series will show the same elemental concentration profile and can be recognized by it.

As part of a project "Pottery production and distribution of Late Bronze Age (LBA) settlements of Greece and the Aegean ' further 200 neutron activation analyses (NAA) of LBA pottery from Boeotia have been added to our databank of already more than 2000 samples from different regions of Greece. The new samples stem mainly from Thebes and Orchomenos. Multivariate statistical grouping of the data reveals several hitherto unknown reference groups separable from groups of other regions of Greece and Crete. The results of the samples from 10 Linear B inscribed jars found at Thebes and formerly analysed by emission spectroscopy (OES) are of special interest. They form a statistically well defined group different from all the other groups known to us, but can be assigned to an unpublished reference group of pottery from Chania, Western Crete, in the LBA Perlman - Asaro databank of Greek Bronze Age pottery. The final results of the chemical classification and the archaeological implications will be presented.

181. Analysis of white beads of a late seventeenth century decorated bag from the Ashuapmuchuan site (Eastern Central Québec), Canada

J.-F. Moreau*, R.G.V. Hancock, S. Aufreiter, I. Kenyon*****

*Laboratoire d'archéologie et Département des sciences humaines, Université du Québec à Chicoutimi, Chicoutimi, Québec, Canada G7H2B1
**SLOWPOKE Reactor Facility and Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario, Canada M5S 3E5
***Ontario Heritage Foundation, Toronto, Ontario, Canada M5C 1J3

Previous INAA of 122 Cu/Co tinted blue glass trade beads from Ashuapmuchuan, combined with their archaeological site locations, led to two main hypotheses*:

1) From a comparison with the elemental compositions obtained for beads from sites in Ontario and Québec, these beads pertain to the late seventeenth century.

2) The sharp split into two chemical groups according to their elemental characteristics corresponds to the split observed between the beads of one of the chemical groups being spread over a surface as opposed to the beads of the other group that were found tightly packed together. The matching of the elemental groupings with the archaeological locations suggested that the group of beads that was spread widely corresponds to the blue beads of the decorative pattern sewn to a bag while the beads that were tightly packed together consisted of loose beads in the bottom of that bag. Together with these blue beads were found 344 European white glass beads. INAA of all these latter beads allows us to test both the hypothesis of the temporal assignment as well as that of the anthropological interpretation of these beads as pertaining to a decorative pattern of a bag, itself containing loose beads. Given a strong agreement of the results obtained for the white beads with those previously obtained for the blue beads, this study results in a strong case of reconstruction of an ethnoarchaeological behaviour pertaining to the field of cultural aesthetics, such an endeavour being among the most difficult to attain in archaeology.

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182. Toranagallu Mound: Observations of Unusual Glassy Materials

R. Nijagunappa*, G. C. Wilson,***, L. A. Pavlish***, ****,**

*Dept. of Mineral Exploration, Gulbarga University P.G. Centre, Krishnadevarayanagar campus, Sandur (Bellary district), Karnataka, INDIA 583119
**Turnstone Geological Services Ltd., P.O. Box 130, Station "B", Toronto, Ontario, CANADA M5T 2T3,
***IsoTrace Laboratory, University of Toronto, Toronto, Ontario, CANADA M5S 1A7,
****Archaeometry Laboratory, Department of
Physics, University of Toronto, 60 St. George Street, Toronto, Ontario, Canada M5S 1A7

Slag-like material from a mound of uncertain origin near the town of Toranagallu, Karnataka, India was analyzed with the purpose of determining its origin. The experimentally obtained temperature that was attained in the vitrified sample exceeds those obtainable in open fire conditions. Analytical results suggest that the material represents residue from a glass making operation. This result defines one use of the mound, but leaves open the possibility that a range of other activities may have contributed to the mound's development.

183. Archaeometrical studies of Neolithic stone tools from Tolna county, Hungary

Nikl, A.* , Szakmány, Gy., T. Biró, K.*****

*Eötvös L. University, Budapest, Hungary
**Eötvös L. University, Budapest, Hungary
***Hungarian National Museum, Budapest, Hungary

The subject of our study were stone tools mainly from the Lengyel culture. The samples were obtained from the Wosinszky Mór Museum, Szekszárd, Hungary.

The axes were found at the following localities: Lengyel, Mórágy, Dúzs, Szabaton, Tengelic, Nagydorog, Szekszárd. Our main goal was to characterize and describe the raw material of the stone tools and to determine the assumed origination place. We made detailed macroscopic and petrographic description on 21 axes.

The raw material of the instruments is very variable, among them there can be found magmatic, metamorphic and sedimentary rocks such as basalt, andesite, hornfels and different types of limestones. Additional investigation methods include powder diffraction analysis, neutron activation analysis, microprobe analysis and optical emission spectrography. By the agency of these methods we try to localise the origin of the raw material. Prehistoric men did not possess any means of communication or transport so long travels were hard for them if not impossible.

According to our investigations we believe that the major part of the used material is confined to the Alp-Carpathian region.

184. Age estimation of coral based on amino acid composition

J. Nyberg*, B. Malmgren*, A. Winter*, J. Csapó, Zs. Csapó-Kiss**, J. Csapó*** Jr.**

*University of Goeteborg, Geological Centre
**Pannon Agricultural University, Faculty of Animal Science, Kaposvár
***Janus Pannonius University, Faculty of Natural Sciences, Pécs

The amino acid (AA) composition of corals aged between 1 and 250 years, was analysed by ion exchange column chromatography. It was established that the concentration (g AA/100 g sample) of all AAs decreased with age; the greatest decrease was observed in those AAs which are particularly sensitive to environmental influences (Thr, Ser, Cys, Met, Tyr, Lys, Arg). The concentration of His, Asp, Glu, Pro, Gly, Ala, Val and Phe decreased with age, but the decrease in concentration of Ile and Leu was very small. These two amino acids are the least sensitive to environmental influences. In the protein of the coral (g AA/100 g protein) it may be asserted that the highest decrease can be observed in Thr, Ser and Tyr, which are very sensitive, and which decompose very easily. The decrease was also significant in the case of Met and Cys, the two sulphur-containing amino acids, which can be explained by the oxidation or conversion to other amino acids, or decomposition. The decrease was very slight in the case of Asp, Pro and Arg, and there were no changes in the concentration of Glu, Gly, Ala, Val, Phe and His in the course of 250 years. These AAs are not sensitive to environmental influences. There was a minor increase in the concentration of Ile and Leu during this time, which was surprising, but may be explained by the decomposition of other AAs, which caused relatively higher amounts of these two AAs in the protein. Plotting the concentration of the AAs as a function of time, calibration curves were obtained, which are useful for the age estimation of a coral sample of unknown age.

185. Characterization of Iznik Ceramics

Füsun Okyar

Marmara Research Institute Materials Dept., POB 21 41470 Gebze Kocael Turkey

In this study bulk compositional data on a group of Iznik ceramics is reported. Samples are selected from the materials excavated in 'Iznik Kiln Excavation' courses. The glaze, slip and body characteristics and the microstructures of the sherds are determined by optical and SEM work.

Slip painted and Miletus ware of Iznik ceramics are made from red earthenware clays and some lead rich inclusions are detected in their bodes. No trace of tin is detected in their alkali-lead type glaze layer.

The Iznik whiteware bodies are consist of ground quartz and a glassy matrix that bonds the angular quartz particles together. The glassy phase contains variable amounts of lead oxide. The glaze is of the lead- alkali type and have dissolved tin oxide in it.

186. On the population of the Aral and Caspian Region during the Early Iron Age

Olkhovsky, V.S., Veselovskaya, E.V.

Institute of Archaeology RAS, Dm Ulianova Str. 19, 117036 Moscow Russia

The greater part of the region between the Caspian and the Aral Seas is occupied by two plateaux, Usturt and Mangyshlak. Until recently this strategically important zone which connects the South Ural region and the Front Asia stayed practically uninvestigated by scholars. However during 1980-1990s numerous funeral and cult sites which date back to the 2nd half of the 1st millennium B.C. have been found there by Russian and Kazakh archaeological expeditions. Archaeological and paleoanthropological data which were obtained allows us to make the first conclusions about ethnical and cultural peculiarities of the Aral and Caspian region population during the Scytho-Sarmatian epoch. The characteristics of the burial constructions, funeral goods and "Sarmatian signs" are the most significant features of the Sarmato-Sako-Massgetae' s circle of cultures. But the round cult constructions and stone anthropomorphic statues which were discovered in the Usturt sanctuaries are the very interesting and unique objects.

The results of anthropological and osteological researches are important to solve the problem of ethnic origin of the region population. Three skulls from the burial sites of this époque were investigated in the Laboratory for

anthropological reconstruction of the Institute of Ethnology and Anthropology of RAS. Male skull (age 20-24) from the burial dated III.-II. cc. B.C. in the cult construction of the sanctuary Teren is large, dolichran at the limit of mesocran, the face is high and wide, nose protrudes considerably. Female skull (age 40-50) from the grave near Sarykamys village dated I.c. B.C. - I.c. A.C. is characterized as large, mezocran, middle high, the face part is wide, low, flat, mesoghnat. Male skull (age 55-60) from the Dykyl-tas cemetery dated II-III. cc. A.C. is mesocran at the limit of brachicran, the face is high and wide at every level, some flat at the upper part, altitude and the angle of nose protruziaon are great.

Three plastic sculptural portraits were reconstructed on the above mentioned skulls using the method of facial restoration at the basis of skull enriched by the soft facial tissues thickness dates, obtained by the ultrasonic technique on alive persons.

The restorated faces are characterized as europeoid with some mongoloid mixture which increases to our days. The representatives of studied East Caspian nomadic population more close to Sarmatians of Ural region and South Siberia than to East Aral region synchronic groups. That marks certain ethnogenetic contacts between the populations of the mentioned regions at the end of the 1st millennium B.C.

187. Minor Metallic Components Associated with Anatolian Copper and Bronze Artifacts: Indications of the Utilization of Polymetallic Ores

Hadi Özbal*, A. Mieke Adrieans, Bryan Earl*****

* Bogazici University, Department of Chemistry, 8085, Bebek, Istanbul, Turkey
**University of Antwerp, Department of Chemistry, Universiteitsplein 1, B-2610, Antwerpen, Belgium
***Heathercliffe, Sennen, Penzance, Cornwall, TR19 7AX, United Kingdom

Analysis of Anatolian copper and bronze artifacts show a wide range of minor metallic elements. Field research, examination of mines, orestuff and smelting debris along with experimental smelts in the laboratory demonstrate that polymetallic ores were smelted to win copper at widespread sites in Anatolia, using a one-step smelting technique on predominantly sulphide orestuff, followed by refining. Archaeometallurgical material recovered from the Merzifon region located in North central Turkey yielded results indicative of utilization of polymetallic ores in the production of copper. The tradition of exploitation of polymetallic ores extends back in to the Late Chalcolithic Period as is evident from a large number of such ores recovered from the Arslantepe excavation at Malatya. Similarly an ore sample from Pre Uruk HacÝnebi stretches the technology to Southeastern Turkey. Furnace design and smelting technology were critical to the success of smelting polymetallic ores. Application of extensive refining methods on the impure copper to obtain workable copper would also eliminate the critical arsenic which must be reincorporated into the copper at a later stage, for an arsenical bronze. Investigations by AA and SEM/EDS support the conclusions drawn from field evidence. The indications are that copper was sourced in Anatolia, using smelting technology radically different from that employed at more Southern sites in the Middle East.

188. Characterization of some medieval glazed building tiles in Anatolia

Özcilingir-Akgün, Serpil*, Caner-Saltik, Emine N., Bakirer, Ömür**

*Middle East Technical University Dept. of Physics, Graduate Program in Archaeometry, 06531 Ankara Turkey
**Dept. of Architecture, Materials Conservation Lab. Middle East technical University 06531 Ankara, Turkey

The medieval blue glazed building tiles from some 13th century Selcuk period monuments have been studied. These monuments are the Beysehir-Kubadabad Small Palace, Sivas Gok Medrese and Tokat Gok Medrese. Sample collected from these monuments have been analysed for raw materials properties and technological characteristics.

The study started with the visual analyses and the analyses of the basic physical properties of the tiles. Detailed analyses of the samples have been done by optical microscopy, scanning electron microscopy with energy dispersive analyzer and X-ray diffraction analyses.

Visual and microscopic observation showed that the bigger glazed tiles were prepared first, and then cut to desired shapes to form mosaic tiles.

The tiles are porous, the percent porosity values being 42 to 46. Bulk densities of the tile bodies are in the range of 1.48-1.60 gr./cm^3.

Combined interpretation of X-ray powder diffraction analyses and microscopic examination of thin sections reveal the presence of pyroxene, feldspar and quartz as the dominant minerals of the tile bodies.

The analyses show that the glazes have been directly applied without using a slip layer. The glazes have quite uniform thickness of 150 microns. The composition of the glaze layer is heterogeneous containing minerals rich in lead or tin, in the glaze matrix.

Heterogeneous nature of the glaze structure and its mineral content have been discussed with reference to X-ray diffraction analyses and scanning electron microscopic analyses coupled with energy dispersive unit.

Firing temperature of the tiles has been estimated to be around 800 C by considering the mineral composition of the bodies and their low degree of vitrification observed by the scanning microscope.

189. Some results of study of Cucuteni-Tripolye decoration techniques

I. Palaguta

Moscow State University Dept. of Archaeology, 23-4-185 Bashilovskaya St., 103287 Moscow, Russia

Present research deals with both relief and painted ornaments of Cucuteni-Tripolye culture in Carpathian-Dnieper region and changes of decoration techniques in the beginning of middle period of this culture (3650-3300 BC in uncalibrated dates).

According to the observations wooden sticks or tube bones were used for application of incised decoration and the implements with a flat terminal - for fluted ornaments. The main tendency in the developing of incised decoration during early and middle periods of Tripolye was revealed in changes of surface condition: dry (leather-hard) in early period and more plastic later.

Important innovation in ceramics decoration was the origin of polycolour painted ornaments. The researches on paintings were provided by laboratory of physical and chemical methods of State Institute of Conservation in Moscow (N. Podvigina, S. Pisareva, V. Kireeva, A. Levshtein, E. Malachevskaya, N. Travkina). In 1992-93 82 samples from 19 sites of Cucuteni-Tripolye culture were investigated. The technology of paintings looks reasonably complex. For paintings were used: red pigment of iron oxides and hydroxides, white - kaolin, black - compositions on the basis of a iron and manganese. The preparation of dyes was made o the basis of organic binding - proteins or carbohydrates. They were applied on a surface of vessels after firing. Paintings were covered with coating of wax or varnish.

As well as changes of ornaments the firing technology was also developed from reduction to oxidize firing. Such innovations in pottery technology can be interpreted as a reflection of ethnocultural changes.

190. Provenance studies of prehistoric flint from the Gargano mines (Puglia, Italy)

Palmieri A.M., Volterra E.

Istituto per le Tecnologie applicate ai Beni Culturali - C.N.R. -Roma -Italy

Given the peculiarity of the flint mine discovered in the Defensola area , near Vieste (its size and the presence of artifacts such as working tools, pottery, bone chisels and stone oil lamps) the number of mines in the Gargano to be analysed has increased in order to try to chemically separate each mine.

The characterization of different mines is the main aim of our study, the ultimate goal being the discovery of the chemical fingerprint of each type of flint which can be used to recognize the distribution of flint tools in the Tavoliere Neolithic and Bronze Age sites.

Chemical analysis was performed with a ICP- AES. A total of 13 elements were investigated 13. Factorial analysis (main component) reduced these elements to 9 (Al, Ba, Ca, Cr, Fe, Mg, K, Li, Ti) for the subsequent discriminant analysis. This statistical method allowed the separation between the mines and attribution of some artifacts.

This work represents the first attempt in Italy to distinguish different flint groups by means of chemical analysis.

The spatial and the chronological distribution of flint will allow us to build a model about the flint movements in the area and to find out exactly how far one type of flint travelled. It is clear that the archeological implications of this research work involve the structure of prehistoric society and its relationship with the territory.

191. Analysis of Sarcophagi Fillings of Egyptian Mummies from the Archeological Museum in Krakow.

Ewa Pańczyk, Maria Ligęza*, Lech Waliś

Institute of Nuclear Chemistry and Technology, Dorodna 16, 03-195 Warsaw, Poland
*Academy of Fine Arts, Smolensk 9, Krakow, Poland

Results of a study of materials from Ancient Egypt including mineral fillings of mummies deposited in the Archeological Museum in Krakow collection from the period of XXIth Dynasty as well as the Ptolomean and Roman periods has been reported.

The examinations of these materials has been realized in Institute of Nuclear Chemistry and Technology in Warsaw using instrumental neutron activation analysis, X-ray fluorescence spectroscopy and X-ray diffraction analysis. For the treatment of analytical data the cluster analysis has been used. The resulting data become a basis for objective archeological examination of the mineral fillings and further materials and for the conservation treatment of materials under study.

192. From Diagenesis to Fossilization of Buried Human Teeth

M. Papagrigorakis*, G. Panagiaris, A. Vossou***, Y. Bassiakos*****

*Dept. Of Orthodontics, Faculty of Dentistry, Univ. Of Athens, Thivon 2, 115 27 Athens, GREECE
**T.E.I of Athens, Department of Conservation of Antiquities and Works of Art, Ag.Spyridonos, 12210 Aigaleo, Athens, GREECE
***Lab. Of Archaeometry, NCSR «Demokritos», 15310 Ag. Paraskevi Attiki, GREECE

Structural and morphological changes occurring in individual components of ancient human teeth vary with increasing burial time, hence providing an ideal chance for investigating the interstadial between diagenesis and fossilization.

Among the main aims of the study was to define the elements which could be considered as indicators of the interactions between skeletal dental elements and the environment and create the frame for further research. Another aim was to investigate the diagenetic processes and even the beginning of fossilization of the material under study.

The analysed material consists of ancient teeth (Sample) of the Middle Helladic Period from the area of Delphi, dry modern teeth (Control I), teeth extracted recently (Control II), and soil from the excavation area.

The main methods followed were :

.Morphological study under the Optical Microscope and the Scanning Electron Microscope

.EDX Analysis

.ESR Spectroscopy (EPR)

.XRD analysis

The existing results show that:

- Molar ratio Ca/P in the Sample is steady in the dentine and it hasn't been affected by diagenetic processes, while the corresponding ratio in the outer surface of the root and the root canal, is dramatically increased, an indication that these areas of the ancient teeth are the areas from where the diagenetic processes start.

- The homogeneity and durability of the structure of cementum and dentine are remarkable, as well as the resistance of these two components to contamination by soluble minerals, or earthy admixtures.

Fission Track studies for U-microdistribution in different dental components as well as NAA for trace element concentration have finally enabled better assessment of the extent of diagenesis in human teeth, buried for some millennia.

193. Experiments with a Bow and Arrow

L. A. Pavlish

Archaeometry Laboratory, Isotrace, University of Toronto, Toronto, Canada

Experiments using reconstructed projectile points on modern shafts and employing a modern bow to create a "best of all worlds" condition are discussed. The experiments entail the use of a ballistics pendulum and high speed photography to ascertain the initial velocity of the arrow. In addition, distance tests, accuracy tests and a hunting simulation test were conducted. The amount of force required to break a projectile point is measured and implications for hunting are discussed.

194. Archaeological, Historical and Geochemical Analyses of Basket Handle Jars from Mendes, Egypt

L.A. Pavlish, R.M. Farquhar, D.B. Redford, J. B'Naity

University of Toronto,
Near and Middle Eastern Civilizations, University of Toronto

Large sea transport jars are evidence of commercial traffic in ancient times. Chemical analysis using Instrumental Neutron Activation Analysis (INAA) is carried out on Basket Handle Jars (BHJs) from the archaeological site of Mendes in the North-eastern Delta of Egypt. The Chemical analyses of BHJs shows that they probably derive from Nile alluvium and Western Delta clays. When these data are compared with control groups from Rhodes, Cyprus and Syro-Palestine, they give negative results. These observations lead to the rejection of the Hypothesis that BHJs found at Mendes are imports from non-Egyptian Eastern Mediterranean clay sources. Based on geochemical, historical and archaeological evidence, a new hypothesis may be formulated for testing: BHJs found at Mendes were manufactured from clay sources located in the vicinity of present day Alexandria.

195. Preliminary Geoarchaeological Report: Tel Kedwa, Sinai, Egypt

L. A. Pavlish, D. B. Redford

University of Toronto

A preliminary geoarchaeological survey was carried out at the site of Tel Kedwa during the 1997 field season. This survey had two major objectives:

1.) ascertain the depth of cultural remains on the site; and,

2.) measure relative elevations on the site and in the surrounding environs to calibrate the depth measurements for the excavation crews.

To accomplish these objectives a grid was set up using the inner corner of the north-west fortification wall. Measurements show that the transcendental beach to the south of the site is at an elevation of approximately 1 metre above sea level; and, that the transient lake bottom sediments are 10 to 20 cm below that of the beach in elevation. This lake bottom effectively separates Tel Kedwa from its rather better known neighbour to the south (two kilometers) Tel el Her or Migdol.

Sixty-three 10 cm diameter auger holes were dug with the objective of ascertaining water table depth, wall depths, sand foundation platform depths, moat locations and depths in addition to the spatially varying depth of cultural remains. Thirty-nine of the auger holes were dug along the 300 metre East-West grid line at 0N providing a reasonable cross-section through the site.

The 2.5 metre contour line describes a roughly rectilinear pattern that is angled at approximately 45 degrees with respect to the foundation complex representing the unbuilt fort. These results suggest that at least one earlier architectural manifestation at this site had a very different alignment. The two burn layers present at the site are consistent with such findings and probably date to the destructions of 587 and 525 BC.

196. Bone and Stone Breakage in White-Tailed Deer

L. A. Pavlish*, H. Savage**

*Archaeometry Laboratory, Isotrace, University of Toronto, Toronto, Canada
**Department of Anthropology, University of Toronto, Toronto, Canada (deceased)

Stone projectile points hafted on modern arrow shafts were shot into the left side of two white-tailed deer carcasses. The bow used in the experiment was calibrated using both a ballistic pendulum and high-speed photography. A 66 cm draw on the bow was used for the experimental shots, and it produced a range of velocities of between 35 meters and 42 meters per second. The bone damage done to the scapulae and the ribs was recorded. Bone and stone broke with forces of between 300 and 1000 lbs [1.3 x 105 nt and 4.4 x 105 nt]. The bones were cleaned and the damage was photographically catalogued. The observed damage to the white-tailed deer bones may provide a useful frame of reference for the interpretation of similar damage recovered from an archaeological context and insights into ancient hunting technologies.

197. Frozen Bone Breakage Experiments

L. A. Pavlish*, W. F. Bever, P. J. Sheppard****

*Archaeometry Laboratory, Isotrace, University of Toronto, Toronto, Canada
**Ministry of Finance, Government of Ontario, Canada
***Anthropology Department, University of Auckland, Auckland, New Zealand

Qualitative experiments are carried out on frozen animal femurs in an attempt to establish whether or not bone fracturing properties vary with the degree of freezing. Fracturing of samples cooled to -196 ^{o}C, -40 ^{o}C, -25 ^{o}C, 0 ^{o}C and room temperature (20 ^{o}C) is accomplished using a simple two-support beam configuration and a hammer. All sample specimens are broken by hammer with the exception of the -196 ^{o}C degree samples which are easily broken by hand. Although all bone samples fracture in approximately the same way, the ease of fracturing increases with decrease in temperature. The -40 ^{o}C samples are found to be capable of flaking in a manner analogous to that of cryptocrystalline materials. In addition, the -40 ^{o}C and -25 ^{o}C samples exhibit two fracture types: one which cuts across bone grain structure and one that follows bone grain structure boundaries. The uniform fracturing qualities are postulated to be the result of bone architecture which remains basically unaltered by cooling. It is suggested that the freezing of water in the bone is responsible for the increased ease of bone fracture.

198. The Heating Issue in Ancient Technologies

L. A. Pavlish

Archaeometry Laboratory, Isotrace, University of Toronto, Toronto, Canada

The issue of whether or not prehistoric peoples employed heat treatment of chert and flint as an integral part of their lithic tool production technology is a matter that has long been debated. While previous thermoluminescence (TL) investigations of the heating phenomenon concentrate for the most part on finished artifacts, this study investigates the TL stored in a number of artifacts representing a particular stage in a manufacturing sequence. While the single analysis approach will not provide the information necessary to identify purposeful heating, multiple samples (40-100) may provide this information. The examination of Arctic cores indicates that partial heating was taking place, but does not confirm that it need have been purposeful. The transition between two blade-flake cultures of Algeria is examined to ascertain whether or not the change in technology may have been facilitated in part through the agency of purposeful heating. The results suggest that heating was not a factor in the technology's transition. Finally, the bifacial retouch flakes from a Late Palaeoindian context are examined and compared with geological source material. Accidental heating does not explain satisfactorily the fact that the overwhelming majority of the flakes appear to have been heated. One can conclude that chert heating in this context was purposeful. These results are consistent with the heating model that is presented and the underlying philosophical principles upon which the model is constructed. The methodology developed for this work and the implications derived from the resultant data are combined with other appended archaeological experiments and are discussed. The overall conclusion reached through this work is that the heating issue will always have to be addressed on a case-by-case basis, and the conceptual tools employed to make the decisions will be phenomenological in their make-up.

199. Flume Experiments with Stone and Bone

L. A. Pavlish*, M. R. Kleindienst, P. J. Sheppard****

*Archaeometry Laboratory, Isotrace, University of Toronto, Toronto, Canada
**Department of Anthropology, Univeristy of Toronto, Toronto, Canada
***Anthropology Department, University of Auckland, Auckland, New Zealand

A recirculating laboratory flume was used to study the sorting and relative transport of stone and bone materials. Fifty-one flume runs were conducted with Froude Numbers between 0.06 and 1.71. Bone and stone movement was plotted as a function of their rate of movement in centimetres per second (cm/sec) with respect to their individual mobility numbers (U*).

Low, transition and upper energy flow regimes show a clear separation in the rate of movement of bone and stone. Settling velocity and drag coefficients are calculated for the material. These results have implications for understanding distributions of artifactual material on some archaeological sites, and may provide a key to interpreting the potential for movement on others. Results are applied to field problems.

200. Chemical Characterization of High-Lead Glazes on Islamic Decorated Ceramics, Produced in Northern Al-Andalus (Muslim Spain)

Josefina Pérez-Arantegui, Juan R. Castillo

Dept. Analytical Chemistry. Faculty of Sciences. University of Zaragoza. 50009 Zaragoza. Spain.

Glazed ceramics production was one of the most important industries developed during Islamic period in the Iberian Peninsula. Among the different centres who were making pottery at that time, Saragossa was one of the most important in the 11th century, in view of the significant group of kilns and quality and quantity of the objects found in this town: thousands of ceramic objects (jars, large plates, cooking pots, oil lamps, etc.), both non-glazed and glazed, and also potter's tools, associated with ten kilns.

A complete study of the different types of decorated (monochrome-glazed, two colours-glazed, cuerda seca, tin-glazed, etc.) and non-decorated ceramics was carried out, including glazes and bodies, by chemical analysis, Optical and Scanning Electron Microscopy, in order to know main characteristics and technology of this ceramic manufacture.

In this case, chemical characterization of coloured glazes by Scanning Electron Microscopy is presented. In several types of decoration high-lead glazes were used, with different features, chemical composition and colouring elements. These transparent glazes had some special characteristics in relation to tin-opacified glazes, produced in these workshops as well.

201. Ai Bunar and more: Multi-centered copper production in the south-east European Chalcolithic

Pernicka, E.*, Begemann, F., Schmitt-Strecker, S.**, Todorova, H.***, Kuleff, I****.**

*Max-Planck Institut für Kernphysik, Heidelberg
**Max-Planck Institut für Chemie, Mainz
***Archaeological Institute of the Bulgarian Academy, Sofia
****Faculty of Chemistry, University of Sofia

We have continued our earlier studies on the production and distribution of copper in the south-east European Chalcolitic by having analysed some 300 metal objects and some 70 copper ore samples from Bulgaria. Trace element concentrations and lead isotope ratios were determined as in a previous study in Serbia. The combined data lead to the following major conclusions:

- In contrast to previous assumptions, it seems that the majority of the Chalcolithic copper artefacts are not made of native copper but of smelted copper

- A considerable fraction (28 out of 192) of the Late Chalcolithic artefacts match ores from Ai Bunar in all parameters determined. Since among the ore deposits of the Balkans studied so far, the geochemical characteristics of Ai Bunar are unique, a positive assignment of these artefacts to this ore deposit with

contemporary mining evidence would appear to be well justified. It is noteworthy that some of the objects whose metal is assigned to Ai Bunar derive from Plocnik in Serbia.

- Another major group of artefacts resemble those from Serbia that we have previously related to the ore deposit of Majdanpek. Since most artefacts with such chemical and isotope fingerprints derive from western Bulgaria this assignment gains support. However, some such objects also have been found along the Lower Danube suggesting transport of this material towards the Black Sea. Trading of shells in the opposite direction has since long been proposed on the basis of carbon and oxygen isotope measurements.

- There is still not a single artefact among the suite of some 400 objects from the Balkans attributable to the Chalcolithic mine of Rudna Glava.

202. The Copper Metallurgy in the Condorhuasi-Alamito Culture of Argentine Northwest (200-400 A.D.)

Adrin Angel Pifferetti

CEMAT Universidad Tecnolgica Nacional, Castelli 501 - 2600 Venado Tuerto (Santa Fe) Argentina Tel. (54 - 462) 31013- Fax (54 - 462) 34800, E-mail apiffere@ipolitec.unr.edu.ar

Materials from the archeological place of Alamito, Catamarca, Argentine North West, obtained under A. R. Gonzlez and V. A. Nuez Regueiro' s direction have been studied. These materials allow to characterize the most ancient metallurgical culture of the Argentine North West, now considered as a cultural facies named Condorhuasi-Alamito. It belonged to the formative or earlier period and it was radiocarbonically dated between 200 and 400 AD The task of this work is to determine the obtaining processes, elaboration and transformation of copper alloys. It was in this place that manufactures, mineral, fluxes, crucibles, hammers, pottery tubes considered "huairas" or Indian vertical ovens have been found. Quality and quantitative analysis have been carried out using physical and chemical methods (estereomicroscopy, optical micrography, scanning electronic microscopy, Edax electronic microwave, X-ray and microhardness determinations). It was determined that all the cases were copper-lead alloys obtained from a partial fusion of cupriferous ore rich in lead , followed by a severe plastic deformation of purification and mechanical working by several metallurgical techniques as lateral hammering, repoussé and stretched applying multiple cold deformation treatments followed by recrystallization heating. Through this process flat sheets and circular section beams were obtained from quadrangular section beams.

203. Authenticating Ancient Marble Monuments with Thermoluminescence

Kyriaki Polykreti, Christodoulos Michael, Yannis Maniatis

Laboratory of Archaeometry, NCSR "Demokritos", Aghia Paraskevi, 153 10 Attiki, Greece

Crystal lattice defects on the surface of marble can be produced or annealed by mechanical treatment and natural irradiation such as sunlight, soil radioactivity and cosmic radiation. The application of Thermoluminescence (TL) is found particularly useful for a detailed study of such defects providing an essential step for developing a methodology for authenticating marble objects.

Exposure to sunlight reduces the intensity of the TL peaks to a certain low level. The bleaching rates were studied on polished and powdered marble samples of different origin and fabrics, and it was found that they have similar behavior. The reduction of TL peaks decreases with depth on samples exposed to sunlight for various time intervals. The combined dependence of TL intensity on time of exposure and depth from the surface was studied, on ancient pieces, continuously exposed to sunlight since antiquity and modern pieces recently exposed. An equation-model, describing the phenomenon was found. In particular, the model was tested in three cases of marble objects of known age from 10 to 1000 years old and found to have a very good approach to dating. This model could be modified to give us information on the exposure time of a marble monument and its history (burial-exposure to sunlight cycles).

Another potential application of the technique would be to authenticate or date buried objects. Soil radioactivity and cosmic radiation refill the electron traps that have been emptied by sunlight. A first attempt to date a sample buried since antiquity, was made. The resulting age is close to the archaeological one. Detailed study to investigate the potential of this technique for dating buried marble pieces is under way.

204. Experimental results from the Százhalombatta Archaeological Park

Ildikó Poroszlai*, Elisabeth Jerem**

*Matrica Múzeum Százhalombatta
**Archaeological Institute of the HAS

The Archaeological Park, as the first open air experimental archaeological museum in Hungary, represents a unique approach toward reconstructing the past.

Százhalombatta is very rich in archaeological sites and remains of which the most important ones are: a Bonze Age tell-settlement, an Iron Age earthwork with a huge rampart, an Iron Age tumulus cemetery covering 50 hectars, a Roman military fort and its vicus militaris, etc.

The park is situated in the southernmost part of the Hallstatt tumulus cemetery in an area of 6 hectars. The five best-preserved tumuli can be found here. One of them, tumulus No. 115 - excavated by Ms. Ágnes Holport - is unique in Europe because the wooden structure of the burial chamber has survived for 2700 years in its original form. It was decided to conserve and reconstruct the prehistoric grave in situ. The interior construction and the exterior presentation of the tumulus reconstruction reflect the original situation.

The tumulus reconstruction is divided by a fence from the so-called "living area", where reconstructions of houses from the Bronze- and Iron Age are being erected. The work began here in 1996, when two houses, some hearths and fire places were built and a prehistoric seed planting experiment started. Bronze casting, pottery making and firing took place together with the use of prehistoric tools.

In 1997, our work enlarged into environmental reconstruction. Our aim is to present the natural and cultural landscape of the Middle Bronze Age and Iron Age. Our present day climate is very similar to the subatlantic climate of both prehistoric periods. This means that oak forests advanced at the expense of beech. The replanted vegetation will thus be representative of the Bronze and Iron Age landscape.

The park is going to be a centre for experimental archaeology and education. The goal is not only to create a place for tourists but also an area where everything is authentic and constructed on the basis of the archaeological evidence. This will be a place where we will be able to present prehistoric lifestyles, handicrafts and agriculture. Archaeologists will be able to carry out various experiments as well as test their ideas and hypotheses derived from the results of different excavations and empirical observations.

205. Strontium Isotopes and the Bell Beaker Period: Evidence of Residential Mobility

T. Douglas Price

Laboratory for Archaeological Chemistry, Department of Anthropology, University of Wisconsin, Madison WI 53706-1393
email tdprice@facstaff.wisc.edu

One of the more important questions in European prehistory deals with the migration of prehistoric groups. Until recently evidence for such movement was largely based artifacts. A new archaeometric technique, utilizing strontium isotope ratios in human skeletal material, provides a means for assessing residential changes directly. Bone, which remodels at a known rate, has a $^{87}Sr/^{86}Sr$ ratio that reflects the geology of the residence before death; tooth enamel, which does not remodel, has a ratio reflecting the geology of the place of birth. In this case study, 66 skeletons from the Bell Beaker period in southern Bavaria were analyzed. Significant differences between $^{87}Sr/^{86}Sr$ in bone and tooth enamel indicate that at least 25% of these individuals changed residence during their lifetime. The overall direction of the migration, according to archaeological finds from the area, was toward the south-west. A relative surplus of migrating females and two cases of evidence for migration in children argue for the movement of small groups; exogamy might explain the higher numbers of immigrating females. This new method has great potential for resolving questions on migration, colonization, and residence change in the past.

206. Technical Aspects on Greek Mirrors from Southern Italy

Marianne Prohaszka

Göteborg University, Dept. of Classical Archaeology and Ancient History, 41298 Göteborg, Sweden

A number of bronze mirrors are known from Greek colonies in Southern Italy. The present paper deals with mirrors from the Greek colonial site of Metaponto. Looking at the technical aspects on the manufacturing technique of these mirrors, certain facts become obvious. First, the mirrors all have a disk which is slightly convex-concave. Some of them have a decorated 'front' side and a handle, some of them are just plain disks with or without handles, and lastly some are thick disks with concentrical circles on one side.

From the 5th century B.C. a number of large and elaborate bronze mirrors occur in mainly female burials. All of them have more or less the shape of a frying pan, with a high upraised rim on the concave, 'back' side of the disk. Here it is suggested that the often rough finish on the 'back' side originally was covered with a layer of tin giving an attractive and completely smooth surface. Another type of mirror turned up in burials from the late 4th to 3rd centuries B.C. These mirrors were called 'pocket' mirrors due to their miniature form, and are small and plain with no decoration, just around 5 cm in diameter. They are probably cast and thereafter forged and beaten. Some of these mirrors show a very hard corrosion, which may be traces of tin-plating. On some of them the reflecting surface is more or less preserved. Different hypotheses about the tinning technique have been suggested:

1) the tin was poured upon the cold bronze surface in a thin layer to give a more useful reflection, or

2) a possible hot-tin coating, a manufacturing technique consisting of heating the disks, thus melting tin directly on the surface to be treated.

Tin, with a rapid diffusion into the bronze surface, formed a thin coating of bronze alloy with a high content of tin and a silvery-white color, and with a very hard surface. Here it is suggested that the concave, 'back' side of the mirror was poured almost full with hot tin, creating a perfect plane mirror surface of a silvery (white) appearance, as seen on the vase-paintings. To test this idea small amounts of dirt and dust were mechanically removed from both surfaces of two of the mirrors and analyzed by Studsvik Material AB in Sweden. The analyses (BEI - backscatter electron image and SEI - secondary electron image) indicate that tin is present and give a clear picture of the amount of tin on the concave side.

207. New Data on the Tehnologies of Jeweller Products of Pastyrske Fortified Settlement

Prychodnyuk Oleg, Prychodnyuk Yuriy

Kiev, Ukraine

Pastyrske fortified settlement unique Slavic craft centre of end(!at the end of) VII - middle VIII century AD located in Average Dnieper region on border partially-wooded steppe and steppe near to the same village on area of Cherkass region of Ukraine.

Alongside with craft production of potters and smiths with Pastyrske fortified settlement there is the splendid collection of various ornaments from colour and noble metals, and also finds of jeweller tools. The study of these materials has allowed for the first time to recreate process of manufacture silver of bracelets with hollow by the ends and stamped pendants with the help of a pattern. The art style of the majority of metal products Pastyrske fortified settlement has Danube sources. The foreman from Pastyrske were remigrations from Danube region whence a part of the Slavs was compelled move after arrival there Bulgarians in 680 AD. The Slavic handicraftsmen have brought in Average Dnieper region advanced provincial Byzantine technology. They are not only copied the Danube prototypes but also creatively developed them.

208. Magnetic Prospecting in the Proximity of the Town. (Problems of data collection and processing.)

Sándor Puszta

ELTE Geofizikai Tanszék, 1083 Budapest, Ludovika tér 2., Tel. FAX: 2101083

A successful magnetic measuring in the environment of the city is hardly realizable. There is a strong electromagnetic noise in a board frequency band. The noise sources are for example the electricity in city traffic, the spark ignition of the cars, the industrial and civil electrivity consumption and radiocommunication. Spreaded iron objects are the source of the noise in field domain.

We present some methods of collection of the base data, in the case of different noisiness. Software pre-processing steps developed for these cases can be of help to noise reduction. Stochastic (for example Wiener type) filter as well as the deterministic one are used with good results for reducing the noise in field domain.

The illustration is based on real survey data.

209. Results of Archaeomagnetic Prospecting in Hungary.

Sándor Puszta

ELTE Geofizikai Tanszék, 1083 Budapest, Ludovika tér 2., Tel. FAX: 2101083

The poster presents the results of archaeomagnetic prospecting of the Geophysical Department of Eötvös Loránt University. It gives information on the applied measuring methods and the actual state of the appropriate processing.

The presentation compares the magnetic maps the excavating results.

210. Ceramic Micropalaeontology: Potentials and Limitations of Micro- and Nanno-fossil Analysis in Archaeological Ceramics

Patrick S. Quinn*, Peter M. Day*, Nicolette M. Hine**

*Sheffield Centre for Aegean Archaeology, Department of Archaeology and Prehistory, University of Sheffield, Northgate House, West Street, Sheffield S1 4ET, UK.
**Industrial Palynology Unit, Centre for Palynology, University of Sheffield, Sir Frederick Mappin Building, S1 3JD, Sheffield, UK.

Microfossils, the mineralised remains of various groups of single-celled marine and non-marine plants and animals, are a common and distinctive component of archaeological ceramics. The frequent occurrence of these minute structures in pottery of different periods and from varying geographical locations has often been noted, but only limited attention has been paid to their potential as a means of characterising and grouping ceramics.

After a brief review of previous work, this paper discusses the results of a project which has examined the potentials and limitations of the application of all groups of microfossils to archaeological ceramics. It details the way in which the highly specialised discipline of micropalaeontology might be applied to a variety of archaeological problems.

Case studies from the Southern Aegean are used to demonstrate how such techniques may be used to either confirm or question ceramic groups made by other methods, to investigate the mixing of clays, and how micropalaeontology may be useful in provenance studies. Its sourcing capability is considered on two levels: that of suggesting specific clay sources exploited near to known production centres and in distinguishing ceramic exchange over long distances.

The limitations of these techniques revolve around the difficulty of studying microfossils in thin sections, their ability to survive in a variety of firing conditions and the occurrence of similar aged sediments over large areas, such as on Crete. Micropalaeontological techniques and especially nannopalaeontology are shown to have potential in answering closely formulated archaeological questions, when combined with other techniques of ceramic analysis.

211. Chemical investigations of organic materials preserved in Neolithic ceramic vessels from lake-dwellings (Chalain lake, Jura, France)

Martine Regert*, Stephanie N. Dudd*, Pierre Pétrequin, Richard P. Evershed***

*School of Chemistry, University of Bristol, Bristol BS8 1TS, UK
**Laboratoire de chrono-écologie, UMR 6565 du CNRS, Besançon, France

At the lake-dwellings of Chalain the majority of the ceramic vessels are characterised by the presence of extensive charred surface residues which provide clear evidence for their functional role. These carbonised residues and the organic materials absorbed in the porous fabrics have been chemically investigated in order to

identify the commodities processed in the vessels (Horgen and Clairvaux cultures, respectively 3200-3100 BC and 3040-2950 BC, solar years).

Gas chromatography (GC) and GC/mass spectrometry (GC/MS) analyses of the solvent soluble fraction revealed the presence of high quantities of lipid. The pattern of the different homologous compounds (free fatty acids, mono-, di- and triacylglycerols) is characteristic of the presence of animal fats in all the vessels investigated. Detailed assignments of odd carbon numbered fatty acids, close study of triacylglycerol distributions and the results of $\delta^{13}C$ measurements of the major fatty acids from the neutral fraction (GC-combustion-isotope ratio-mass spectrometry analyses) provided evidence for the use of ruminant fats. One vessel, characterised by a more complex GC profile, is thought to have contained beeswax as it has already been reported in association with other archaeological vessels (Charters et al., 1995).

Protein markers such as indole, pyrrole and diketopiperazine derivatives have been identified by pyrolysis-GC (Py-GC) and Py-GC/MS, highlighting the preservation of proteinaceous materials in the vessels.

Comparison of these data with the information recorded from faunal remains (Arbogast, 1997), are of great importance for the understanding of procurement, management and wide use of animal fats during Final Neolithic at the Chalain lake-dwellings.

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212. A Late Neolithic Production Site For Axe Flakes Near Kottenheim, Kr. Mayen-Koblenz, Germany

K. Rehn

Oppelner Strasse 17, 53119 Bonn Germany

Volcanic rock such as pumice, lava and basalt are predominant for the area of the Middle-Rhine and the eastern part of the Eifel. They are still part of mining- industry of present Germany. The Prehistoric people, however, used this raw material, too.

In between the villages of Mayen and Kottenheim, is the torrent of lava of the „Bellberg" with the so called „Winnfeld". Four ground- plans of prehistoric huts, averaging 3x3.5 meters in size, where excavated here by the Provincial Museum of Bonn in 1916. Two of Which overlapped each other, so that they obviously did not exist at the same time. According to the ceramic finds, all four huts can be dated to the late- Neolithic.

The rock made artifacts from the site deserve special attention. Approximately 80 pieces allow the assumption that axe flakes were produced on a larger scale here. Rough- outs, blanks, flakes and waste material reflect all stages of manufacture from the raw material to the finished product.

Hammerstones(quartz) served as universal tools. They were being used to carve rough-outs. By secondary flaking, blanks with distinct edge and neck portions where then produced. The hammerstones were also used to give the blanks a regular scarred surface by picking. A final shaping followed by grinding and polishing. For the letter special sandstones (Bundsandstein) were being used, which had to be imported to this place.

Mostly the axe flakes were made of quartzite, which is available in the area. There are no indications of quarry activities. In any case rubble was selected.

213. Prehistoric tin metallurgy in the Bohemian/Saxon Erzgebirge

Th. Rehren*, M. Bartelheim, E. Niederschlag

*Deutsches Bergbau-Museum Bochum,
Saechsisches Landesamt für Archaeologie, Dresden

The search for tin resources is a long-standing issue in Bronze Age archaeometallurgy, but only during the recent past, increasing scientific evidence appeared for early tin metallurgy. The Erzgebirge is among the major potential tin sources of antiquity in Europe, with evidence for tin mining well into the Middle Ages, and a

suspiciously rich Bronze Age culture. A recent survey program in this area produced a couple of finds related to tin metallurgy. These range from slagged furnace material to crucible fragments with repeated layers of tin-dominated dross. The furnace fragment indicates smelting of mixed copper-tin ores, using predominantly tin mineral, forming a fayalitic slag. The crucibles contain much more tin oxide than copper oxides, and residual intermetallic phases from the tin-rich end of the copper-tin system. In one case, the melting vessel was used at least four times for similar successive operations. The finds will be presented in detail and the analytical results (optical microscopy, microprobe analysis, chemical analysis) interpreted in view of their archaeological background and early tin metallurgy in general. The discussion will include comparative material from a Middle Bronze Age site in the Alps. Due to the survey character of the archaeological program, the finds studied so far are from different sites. Therefore, the interpretation can be done only on a preliminary level. The clear evidence for tin metallurgy in the Erzgebirge region and in particular the identification of tin smelting, however, appears as a highly promising incentive for further field work here.

214. The development of analytical cupellation in the Middle Ages

Th. Rehren*, K. Eckstein**

*Deutsches Bergbau-Museum Bochum,
**TU Bergakademie Freiberg

From the Renaissance onwards, we have plenty of physical and documentary evidence for the use of cupellation as an analytical tool for noble metal determinations. The roots of this technique are evidently the full scale cupellation of argentiferous lead, used from the Bronze Age onwards. The origins of cupellation as an analytical tool, that is for the treatment of a sample representing the total, are still unclear. This development most probably took place during the Middle Ages. The presentation will include microscopic and analytical data from two extremely well preserved Central European finds, dated to the 11th and 14th century AD, which illustrate the change from the full scale procedure to the small size, analytical process. This reduction in size goes along with the development of the bone-ash cupel as a free standing vessel, as opposed to the traditional cupellation hearth build into the ground. Then, these data will be put into relation to better known early Modern Period material from Austria, allowing to establish different recipes for the making of cupels. Additionally, relevant written sources will be cited to illustrate the background of this development that ultimately leads to the establishing of analytical chemistry as a merger of metallurgical fire assay and alchemical experimental practice.

215. Reconstructing Human Diet in the Neolithic of North-West Europe using Bone Stable Isotopes

Mike Richards, R.E.M. Hedges

Research Laboratory for Archaeology and the History of Art, 6 Keble Road, Oxford, OX1 3QJ, U.K.

The Neolithic of North-West Europe is a period of great social upheaval. Along with new innovations like pottery and monumental architecture, there is the first use of domesticated plants and animals. However, the artifactual evidence for subsistence during this important period of prehistory is inconclusive, and there are questions about how rapidly the change in diet occurred, and even what form Neolithic subsistence took. Bone stable isotope analysis can provide us with new information about subsistence that may help to fill in the gaps left by the archaeology. We will report on a large scale study of human bone stable isotopes from a number of Neolithic sites, mostly in Britain, which shed new light on the nature of Neolithic subsistence, and by implication, Neolithic society.

216. Determination of heavy metals in human and animal bones from Holocene Period

Prócoro Quevedo Robles

ESIA Earth Sciences, IPN-Mexico

This paper forms part of a preliminary study focused on the determination of feeding habits on two human samples and four different mammal species recollected during a field trip on the valley of Chalco on the state of

Oaxaca, Mexico. Another objective was to find its relation with the process of fossilization in order to complement the studies made in sight to establish a tentative chronology of those found on archeological and paleontological recollections. This work forms part of an agreement made with the Musée de L'Homme from Paris, France.

The first human sample (SFI001-I) and those animal (SFI008-III) were found in a sotomonte on the Mixteca sierra, Oaxaca, close to a village with the name of San Felipe Ixtapa. This region presents three levels of settlement clearly established, even though some are altered by rockslides. The levels are, from the most recent to the oldest, from the Colonial period, Prehispanic (postclasic and preclasic) and from the Pleistocene - Holocene transition (confirmed by lithic material).

The SFI001-I sample belongs to a female subject of about 45 years old found on a burial made with basaltic rock flagstones. The mammal remains belonged to a bison, coyote and deer.

The second human sample (LCH045-I) belongs to a male of about 22 years old found on the surroundings from Chalco ex-lake, Mexico state. He was found near the surface and is associated to some sherds.

The studies were made using a thermic absorption dispositive PEKIN ELDER MOD 370 with the right kind of lamp used on each case in order to make an interpolation of curves for the each metal.

The results on the content of Ca, Ba, Pb, Cd, Zn and Mg on every sample does not show any insight about their feeding habits; however, since there is no relation in the way the samples were found, it cannot be stabilised one. A palynological study is required in order to shed more light about it. Nevertheless the studies gave some interesting lectures, especially on sample SFI001-I as it is the contamination by volcanism which can modify the studies about migration routes.

217. Large Scale Paleoecology Using Opal Phytolith Analysis in Small Scale Sites

Irwin Rovner

North Carolina State University Raleigh, NC, 27695-8107,USA, (IRV@worldnet.att.net)

Recent developments in plant opal phytolith analysis provide many new avenues of archaeobotanic and paleoecological data in a broad variety of contexts. Several recent phytoliths-studies in small Late Pleistocene and Holocene sites generated patterns of data that cast the potential application of phytolith analysis in a new light. Phytolith data is not merely a redundant or impoverished substitute for pollen data. The sites studied were small scale causing very little impact on the natural ecology. Yet, small scale microenvironmental change caused by human activity invited phytolith evidence for large scale climate change. Such evidence not readily available in the pollen record in terms of identified flora, level of floristic scale and many rather more subtle ethnobotanic activities exposing aspects of the local environment and human activity within it. This occurred in a forest zone where pollen data is expected to be strong and phytolith data, normally considered applicable to paleo environments dominated by grasses, is thought to be weak. Phytolith data contributes significant data that is independent, and often unique. Results both enhance and are enhanced by parallel studies of pollen or, indeed, any method of paleoenvironmental analysis and interpretation.

218. Viking- and Middle Age Tars from Norwegian Ships

Klaus Ruthenberg*, Inger Marie Egenberg **, Carl Heron***

*Fachhochschule Coburg, Labor für Physikalische Chemie, 96406 Coburg, Germany (2) NIKU, Norwegian Institute for Cultural Heritage,
**PB 736 Sentrum, 0105 Oslo, Norway (3) University of Bradford,
***Department of Archaeological Sciences, BD7 1DP, United Kingdom

Modern organic archaeometry, at least modern archaeometrical tar analysis, literally began with the investigation of residues found on ships [1, 2]. Pine tar origin was confirmed for samples found on or in ships from antiquity [3, 4], the Middle Ages [1,5], and the 18th century [6]. Research on Norwegian tars from ships is quite rare [5,7]. However, there are some recent investigations on tar production and application in Norway [8].Cultural context. Organic material from two mediaeval Norwegian ships, one mediaeval and one Viking age, was analysed. These are the Sjoevollen ship (1210 AD, [9]) and the Gokstad ship (895 AD, [10]),now held at the Viking Ship Museum in Oslo. Research objectives. Main objective is the identification or the

characterization of the organic material. Additionally, a comparison of these samples and the results reported by other groups is performed. Analytical techniques. Samples were analyzed using gas chromatography and combined gas chromatography / mass spectrometry. Results significance. Both historical samples are pine tars, which is confirmed by the similarity of their compound pattern to that of authentic pine tar. A comparison of results of the analyses of recently kiln-produced pine tars with results of other investigations shows significant differences for most of the tars analyzed so far including the Sjoevollen sample on the one hand, and the Gokstad tar on the other. These differences are discussed in more detail referring to the compound patterns. It is argued that the so-called Stockholm tar is not restricted to Stockholm respectively Sweden. This kind of tar probably was manufactured all over Sweden, Norway, and Finland as well. As for the Gokstad sample, the first chemical analysis of a Norwegian Viking age tar is presented.

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219. On Casting Mould of the Northern-East Balkan Eneolithic

Natalja Ryndina

Archaeological Department, Moscow State University,119899 Moscow,Russia

The most impressive Eneolithic metal objects come from the sites within the area of Gumelnitsa, Varna, Vinca-Ploenic, Cucuteni-Tripolje and Tiszapolgar-Bodrogkeresztur cultures in SE Europe dated to the IV millennium BC. Now there are over 4000 objects in the collection and among them nearly 1500 are large tools of striking function (axe-adzes, axe-hammers, adze-chisels etc.). In spite of huge concentrations of large cast items in the Balkan-Carpathian region, Eneolithic casting moulds are still practically unknown. Discussion on what these moulds might have been made of and their construction is still among the matters of top interest for archaeologists. 242 samples obtained from Bulgarian museum collections have been investigated in the metallographical laboratory of the Archaeological Department of Moscow State University. They were extracted from metal objects found on the sites of Gumelnitsa and Varna cultures located in the Northern Balkans. Thorough microstuctural and micro X-ray spectral analysis revealed the fact that casting moulds would be often made of graphite. Graphite dissolves in the outer layers of copper castings enriched with oxygen. As carbon diffuses into copper, copper-oxygen reaction starts, which, because of the slow kinetics of the process, occurs only on the surface between the casting mould and metal. As a result a deoxidized zone is being formed. Similar zones were observed in microstructures of a variety of objects: axe-hammers of Vidra, Codor, Coka-Varna types, adze-chisels of Gumelnitsa and Salkuta types. Graphite stands temperatures up to 2500[C in the reducing medium

220. Site Evolution at Tafi Valley, Northwest Argentina. A Geoarchaeological Approach

María Marta Sampietro*, José Manuel Sayago**

*Instituto de Geociencias y Medio Ambiente (INGEMA). Facultad de Ciencias Naturales. National University of Tucumán. Argentina.
**Instituto de Geociencias y Medio Ambiente (INGEMA). Facultad de Ciencias Naturales. National University of Tucumán. Argentina.

Tafí valley is an intermontane valley located at Tucumán in the Northwest Argentina that typifies Holocene environmental evolution.

From the archaeological point of view, it was determined that the most important occupation was during Formative period (300 BC to 800 AC). They were identified many different kind of prehispanic constructions, most of them destined to agricultural works (they are some of the most earlier structures purpose-built to this works in Northwest Argentina). after this period the valley was practical abandoned by unknown reasons according to previous studies. Towards the moment some typical features were identified but environmental processes or sites evolution were never studied.

On this paper we used environmental data from nearest areas together with archaeological digs, photo interpretation and radiocarbon data from agricultural structures presents on the valley.

Our results are very significant, we determined an edaphic sequence composed by three cycles. One of them (the central one) was intensively cultivated and it present some outstanding features of soil degradation (absence of phosphorous, present on the other edaphic cycles) and erosion (absence of A horizons) probably a product of agricultural practice but influenced by a regional environmental aridisation process.

This is an important approach to the understanding of the poblacional dynamic of the valley that according to previous studies was practically abandoned after this period.

221. Qualitative and quantitative analysis of silver coins struck under the rule of Mathias by EDXRF

Sándor, Zsuzsanna*, Tölgyesi, Sándor*, Tóth, Csaba**

*Technical University of Budapest
**Hungarian National Museum, Budapest

Energy - Dispersive X - Ray Fluorescence technique was applied for analysis of silver coins to determine the elemental composition in a fast and non-destructive way. The non-destructivity of the analysis is very important when it is not possible to destroy the structure of the ancient, precious coins.

In this present work we have developed a quantitative method for samples with different size and geometry. This method was employed for coins with two components, Ag and Cu, where the content of the trace elements is under 0,1 %. All the coins and standards were exposed to an annular 1-125 source: the X - ray radiation was collected by a Si(Li) detector with associated electronics and a multichannel analyser which was coupled to a computer.

The usefulness of the method has been confirmed by analysing certificate silver alloys. The agreement between the measured and true values is good. The precision that is indicated by the relative standard deviation (RSD %) is under +- 4 %.

Silver coins were analysed from the collection of the Hungarian National Museum and the Hungarian National Bank, struck in Hungary during the reign of Mathias (1458-1490) and Nicholas Újlaky, king of Bosnia (1464-1476).

Before the far reaching monetary reform of Mathias in 1467, the fineness and the weight of the silver coins fluctuated year by year and the written sources are very sporadic. After 1467 the standard of coinage officially remained the same, but the analysis indicates that it is not sure. We are in the same situation with the denars of Újlaky, who struck his coins as the king of Bosnia, the same type as Mathias did.

In our poster we present the concentration values of the main components and a list of trace elements, comparing the results of the EDXRF analysis with the data of contemporary written sources.

222. A Geophysical Campaign at the Neolithic Settlement of Kantou - Koufovounos (Cyprus).

A. Sarris*, S. Ball, K. Georgila***, E. Kokkinou***, E. Karimali****, E. Matzourani*****

*Laboratory of Geophysical - Satellite Remote Sensing & Archaeoenvironment, Institute of Mediterranean Studies, Foundation of Research & Technology - Hellas, PO. Box. 119, Rethymnon 74100, Crete, Greece (asaris@rdt.forthnet.gr)

**Glenn G. Black Laboratory of Archaeology, University of Indiana, Bloomington, IN 47405, (sball@ucs.indiana.edu).
***Laboratory of Applied Geophysics, Dept. of Mineral Resources Engineering, Technical University of Crete, Chania, Crete, Greece.

****Foundation of Hellenic World, Akademias 15, Athens, Greece.
*****Department of Archaeology, University of Athens, Zografou, Athens, Greece.

The geophysical mapping of the Neolithic Settlement of Kantou-Koufovounos, in Cyprus, was conducted as part of the continuing archaeological research program in the specific area. The goals of the project included the mapping of the shallow depth architectural remains of the site in order to assess the limits of the settlement and plan the future excavations of the site. Magnetic surveying was successfully applied, together with soil resistivity prospecting. Both techniques resulted to a number of features that have been correlated to the existence of architectural features. The electromagnetic survey (EM38) encountered various problems related to the balancing of the instrument due to the extreme high temperatures, the high resistivity of the shallow bedrock and the lack of contact with the surface due to the dense vegetation islets and bedrock outcrops that were scattered in the area. The magnetic susceptibility maps, covering an area with existing architectural relics, resulted to a detail mapping of their inner details, in close correlation to the other techniques.

Subsequent excavations in the following year revealed a number of architectural features which were located by the use of geophysical prospection techniques. The geophysical maps indicate that the site extends in the north and east directions with no evidence of a surrounding defensive structure. Further geophysical work is planned to map the relics on the slope of the hill. The final product will consist of the superposition of the excavated regions on the geophysical maps to provide a tool for the management and preservation of the site and its environmental settings.

223. The Island of Amorgos: Micro-scale & Macro-scale Remote Sensing

A. Sarris*, L. Maragou A. Gkiourou***, Ch. Karathanasis***, M. Stefouli****, Th. Mavroidis*****, E. Karimali******, E. Giannouli*******, G. Gavalas**, G. Asvestas***, K. Georgila***, D. Ioannou***, E. Vrontaki*****

*Laboratory of Geophysical - Satellite Remote Sensing & Archaeoenvironment, Institute of Mediterranean Studies, Foundation of Research & Technology - Hellas, PO. Box. 119, Rethymnon 74100, Crete, Greece (asaris@ret.forthnet.gr)
**Dept. of Archaeology, University of Ioannina, Ioannina 45110, Greece
***Geophysical Laboratory, Dept. of Mineral Resources Engineering, Technical University of Crete, Chania, Crete, Greece.
****Institute of Geological & Mineral Exploration, Mesogeion 70, Athens115 27, Greece.
*****Dept. of Mineral Resources Engineering, Metsoveio Technical University of Athens, Zografou, Athens, Greece.
******Foundation of Hellenic World, Akademias 15, Athens, Greece.
*******Orfeos 27, Dafni, Athens 17236, Greece

The island of Amorgos has become the target of micro-scale geophysical prospecting and macro-scale satellite remote sensing investigations. The goal of the project was the formulation of a general strategy for applying a wide spectrum of remote sensing techniques and integrating the corresponding results to the general framework of archaeological research.

The geophysical survey was conducted in two remote areas, accessible only by foot, a coastal Roman site and a hilly site dated from the Early Cycladic period. Magnetic and soil resistance surveys were carried out at the particular sites for mapping the subsurface relics. A systematic surface survey was applied on the same grids. The correlation of the geophysical maps and the surface sherd concentration has drawn specific results about the boundaries of the E.C. site. Geophysical surveying was also able to detect architectural remains of the Roman site, most of which are either covered completely by alluvium deposits, or are submerged within the sea due to the past seismic activity.

Aerial photographs were used for creating the aerial mosaic of the wider region. The geophysical grids were registered to the aerial images and both layers were superimposed on the DEM of the region. Two Landsat TM images were combined to produce the satellite mosaic of the whole island. Processing of the different bands was used for creating a number of thematic maps. The satellite image was also superimposed on the DEM of the whole island and other layers such as the digitized geological maps were added for producing a GIS. Digitization processes and Sub-centimetre accuracy Global Positioning Systems were used specifically for the registration of the known archaeological sites and Ground Truthing procedures of the environmental and cultural variables. Supervised classification techniques have been used for modelling the settlement patterns of the island.

The island of Amorgos has been used as a pilot study for the application of large and small scale investigations of the archaeological sites of Greece, proposing a model of archaeological site assessment and the creation of an electronic archaeological and monument record through the use of Geographic Information Systems.

224. Ancient Itanos (Erimoupolis, Lasithi): Creating an Archaeological Site to a Remote Sensing Laboratory

A.Sarris*, A. Vafeidis, St. Mertikas**, M. Guy***, E. Vrontaki**, M. Manakou****, Th. Kalpaxis***

*Laboratory of Geophysical - Satellite Remote Sensing & Archaeoenvironment, Institute of Mediterranean Studies, Foundation of Research & Technology - Hellas, PO. Box. 119, Rethymnon 74100, Crete, Greece (asaris@ret.forthnet.gr)

**Applied Geophysics Laboratory, Dept. of Mineral Engineering Resources, , Technical University of Crete, Chania, Crete, Greece (vafidis@mred.tuc.gr)

***28 Montcalm, Ramonville, France 31520.

****Geophysical Laboratory, University of Thessaloniki, PO. Box. 352-1, Thessaloniki, Greece.

For the last 4 years, a coalition of European researchers is studying the archaeological site of Itanos (E. Crete, Greece) from various archaeological, environmental and geophysical aspects. The program, supervised by the Institute of Mediterranean Studies and the French School of Archaeological Sciences, has integrated a number of techniques for accessing the archaeological and environmental parameters of the wider archaeological region.

The purpose of the geophysical survey was to map the buried archaeological relics, including remnants of buildings, streets and walls in the extended area of the archaeological site. Furthermore, the site has been used for testing a number of high resolution conventional and non-conventional techniques.

Seismic refraction and reflection techniques were used for detecting the ancient port of the site and mapping the bedrock of the area which is covered by alluvium deposits. The ancient port was also the target of GPR and electrical tomography prospecting, which encountered serious problems due to the shallow depth of the water table.

The results of the geophysical, topography and archaeological survey are superimposed on the aerial mosaic of the region. The general assessment of archaeological sites is proceeded through the use of Landsat and SPOT imagery (the last of which has been re-sampled to 5m accuracy, through pixel-mixing techniques). Sub-centimeter accuracy Global Positioning Systems were used specifically for the above registration of archaeological, environmental and geophysical features.

The archaeological site of Itanos has been developed to an actual remote sensing lab, where different approaches are applied in order to maximize the information context of the site.

225. Identification and characterisation of local pottery production sites in Southern Italy by a combination of thin-section and heavy mineral analyses

Sauer, R.*, Gassner, V., Haiden, H.*****

*Institut für Archäometrie und Silikatchemie, Hochschule für Angewandte Kunst Wien, Salzgries 14 A - 1010 Wien, Tel. +431/ 53 56 830

**Institut für Klassische Archäologie, Universität Wien, Franz Klein - Gasse 1 A - 1190 Wien, Tel. +431/31352 - 249, e-mail: Verena.Gassner@univie.ac.at

***Hochschule für Angewandte Kunst in Wien Lehrkazel für Technische Chemie, Salzgries 14/1 1013 Vienna Austria

In a project funded by the Austrian research fund (FWF), on identification and characterization of local pottery production sites in Southern Italy, various pottery products from different cities of Magna Grecia were studied using the combination of thin section and heavy mineral analyses and comparing them with their local clay raw materials.

Samples from the following sites were included in this study: Puteoli, Surrentum, Poseidonia, Hipponion, Velia, Rhegion, Locri, Caulonia, Croton, Sibari, Messina, Naxos. This project was performed in addition to an archeometric study of the archaic pottery of Velia.

The information from this study are used as an aid to improve the identification of the provenance of possible import ceramics at Velia and especially to get a better understanding of the origin of the various transport amphorae found at Velia.

For this project mainly common ware and bricks, where a domestic production could be assumed, have been used. Subordinate samples of amphorae and fine wares were also available. Potential clay deposits and raw-materials were collected near the archaeological sites and studied. Additionally some quality tests with selected raw-material samples were performed (various clay preparations, burning at variable burning temperatures, etc.).

The results of this study show that a combination of thin section and heavy mineral analyses enables identification and characterisation of local pottery production in most of the studied sites. In many cases the clay raw materials used for the pottery could be directly linked with the collected samples. Results from significant examples and analyses are presented.

Typically in almost all studies cases more one local raw material was used simultaneously. This should be kept in mind especially during interpretations of chemical analyses (especially for provenance analyses of common ware).

Furthermore, it is necessary to do a direct study from and around the archaeological sites. Geological literature is often only of very limited value in characterising pottery raw materials. Proper mineralogical information in literature on potential clay deposits and their natural impurities are very scarce and should always be checked by reference samples. Using volcanic material as an argument for provenance information, especially if based on published geological information only, sometimes could be very misleading.

226. Diagenetic processes in fossil wood ash deposits in Kebara and Hayonim Caves (Israel)

Solveig Schiegl

Forschungsstelle Archäometrie der Heidelberger Akademie der Wissenschaften am Max-Planck-Institut für Kernphysik, Postfach 103980 69029 Heidelberg Germany

A series of ash-derived sediments of Mousterian age in Kebara and Hayonim caves (Israel) was studied for their mineral composition and postburial alteration processes (diagenesis). The mineral composition of experimental and fossil ashes was determined by means of Fourier Transform Infrared Spectroscopy (FTIR), X-ray diffraction techniques, Scanning Electron Microscopy linked with an Energy Dispersive X-ray Analytical System (SEM-EDAX), Electron Probe Microanalytical techniques, and by Optical Microscopy. Modern plant ashes as well as extraordinarily well preserved fossil ash consist predominantly of calcite. In addition, fresh ash and very well preserved fossil ash contain about 3 vol. % siliceous aggregates which are by far less soluble than the ash calcite. In the course of diagnoses ash may undergo a continuous change in composition. By percolating phosphate bearing solutions the initially dominant calcite component may be dissolved or replaced by a sequence of secondary phosphate minerals (appetite, montgomeryite, taranakite, crandallite, leucophosphate). Consequently, during diagenesis the ash becomes enriched in the more stable siliceous aggregates and undergoes a reduction in volume of 20 to 50 times.

The archaeological implications of these investigations are:

a/ Areas with well preserved sediment context are reflected by calcitic or apatitic ash deposits.

b/ The presence of siliceous aggregates in these cave sediments in indicative of the original presence of ash deposits in those areas in which ash lenses are no more recognizable.

c/ The volume reduction caused by diagenetic alterations in ash deposits may result in vertical displacement of the enclosed lithics.

d/ In both caves the ash diagenesis is connected to increases in potassium content of the sediments. Due to alterations in the content of radioactive K(40) the representativity of environmental gamma-dosimetry is not ascertained. Consequently, TL-dating of burnt lithics enclosed in diagenetically altered sediments is problematic and the lithics should be sampled from unaltered calcitic or slightly altered calcitic to apatitic hearths.

227. Petrographical Studies of Neolithic Stone Tools

Schléder Zsolt*, T. Biró Katalin, Szakmány György***

*Eötvös L. University Budapest, Hungary
**Hungarian National Museum, Budapest

With geological studies of Neolithic stone tools we can obtain many pieces of archaeological information such as sites of Neolithic workshops and trade-routes. Parallel to the studies of the tools it is necessary to investigate the potential raw materials, too. Unfortunately, the provenance of some rock types can be determined only with rough estimations, sometimes it is not possible at all. Such rock types are for example the sedimentary rocks. It is a consequence of the relative small variability and great distribution of these rocks. Concerning tools made of metamorphic and igneous rocks the determination of the provenance can be more exact.

Investigation of tools and potential raw materials begins with studying the macroscopic features. From these results we can not draw far-reaching conclusions, because the surface of the tools may be altered considerably by the persistent burial near the surface. More details can be obtained by studying thin sections of the tools. If the mineral composition and textural features of the supposed raw material are very similar to those of the stone tool, it is probable that they are of the same origin.

Decisive evidence can be given by the analysis of microelements and mineral chemistry. We use the following analytical methods: NAA, microanalysis, X-ray diffraction. Should the data obtained from the analysis of the tool and the supposed raw material correspond even at this level, the provenance of the stone tool is in all probability found.

Using the above outlined method we investigate 18 stone tools of the Zengővárkony findings owned by the Janus Pannonius Museum, Pécs.

228. A Chemical Study of Roman Pottery and Lamps from Aquincum

Gerwulf Schneider*, Paula Zsidi**

*Arbeitsgruppe Archäometrie, Freie Universität Berlin, Fabeckstr. 34/36, D-14195 Berlin, Germany
**Aquincum Museum, Szentendrei ut 139, 1031 Budapest, Hungary

Roman pottery production in Aquincum and in other parts of modern Budapest is well known from excavations of various kiln sites. Selected finds from those were used for a chemical study to get some answers on questions of Roman pottery and lamp production in Pannonia. How many distinguishable raw materials were used in Aquincum to produce coarse wares, fine wares and lamps? Are moulds, also those with stamps of names known from other sites, all made locally? From finds of moulds it is evident that Firmalampen, the most common type of Roman lamps in Pannonia and in the northern Roman provinces after the middle of the 1st century AD, were made in Aquincum but for the imported Firmalampen it is not known how many and which lamp-making centres play a significant role and, also, if lamp-makers in Aquincum produced for large scale export. Analyses of 80 samples from Aquincum by WD-XRF are compared to analysed pottery and lamps from Intercisa, Poetovio and Carnuntum and used to demonstrate the possibilities and limits of chemical analysis for provenancing.

229. Non-Destructive Pixel-by-Pixel analysis of elements with low atomic numbers using X-ray fluorescence analysis

M. Schreiner*, M. Mantler, Ch. Neelmeijer***, M. Maeder*****

*Institute of Chemistry, Academy of Fine Arts, Schillerplatz 3, A-1010 Vienna, Austria
**Institute of Applied and Technical Physics, Vienna Tniversity of Technology, Wiedner Hauptstr. 4-6, A-1040 Vienna, Austria
***Research Centre Rossendorf, Postfach 510119, D-01314 Dresden, Germany

An increasing number of instrumental analytical techniques has been applied for studying the material composition of objects of art and archaeology. Among these techniques X-ray fluorescence analysis (XRF) using x- or g-ray for the excitation have gained growing interest. A major advantage of such systems is their non-destructive applicability, which means that no sample material has to be gained from the object for the examination. However, a big disadvantage is that such systems described in the literature have used a x- or g-ray beam of several millimetres or even centimetres in diameter and the characteristic radiation of the elements with low atomic numbers (Na - S) is absorbed due to the fact that these instruments are air-path systems.

A new spectrometer was designed for pixel-by-pixel analysis along lines or within selected areas. The technical details of this instrument are already described in the literature [1-3]. It consists of a spectroscopic X-ray tube of max. 60 kV/2.8 kW and an energy dispersive Si/Li-detector and enables both the analysis of points selected

prior to analysis as well as the imaging of the elemental distributions along lines or within selected areas. Several collimators and a shutter unit define an effective beam diameter of 1 mm and below. X-ray tube, detector and laser pointing device for selecting the points of analysis are mounted on a platform, which can be moved by 3 DC-motors in horizontal and vertical direction in front of the object as well as towards or away from the artefact. Optically encoded glass scales with a resolution of 10 mm are employed for the determination of the exact position of the tube/detector assembly.

Additionally, a He-flush system was developed in order to solve the problem of absorption of the characteristic X-ray radiation of the elements Na - S. This project was carried out within the frame of the COST G1-Action "Application of Ion Beam Analysis in Art and Archaeology" supported by the European Union. Examples for the identification of pigments such as blue ultramarine (Na, Al, Si, S, Ca, Fe) or cobalt blue (Co-glass) as well as objects made of glass and ceramics are presented.

References:

1) M. Schreiner, M. Mantler, F. Weber, R. Ebner, F. Mairinger: *A New Instrument for the Energy Dispersive XRF-Analysis of Objects of Art and Archaeology*. Advances in X-Ray Analysis 35 (1992) 1157-1163
2) M. Mantler, M. Schreiner, F. Weber, R. Ebner, F. Mairinger: *An X-Ray Spectrometer for PIXEL Analysis of Art Objects*. Advances in X-Ray Analysis 35 (1992) 987-993
3) M. Schreiner, M. Mantler: *A New Instrument for Non-Destructive Pixel-by-Pixel Analysis of Art Objects*. 4th International Conference Non-Destructive Testing of Works of Art, 3.-8.10.1994, Berlin/D, Berichtsband der Deutschen Gesellschaft für zerstörungsfreie Prüfung, Band 45, Teil 1, p.221-230

230. IMMACO: Improvement of Means of Measurements on Archaeological Copper Alloys for Characterization and Conservation within a European Research Project

Manfred Schreiner

Institute of Analytical Chemistry, Vienna University of Technology, Getreidemarkt 9, A-1060 Vienna/Austria

During the last decades an increasing number of instrumental analytical methods has been applied for studying metallic archaeological artefacts. Within these techniques spectroscopic methods have provided a great number of elemental analyses of such artefacts and have enabled a statistical evaluation of the data as well as a correlation of the chemical composition of the objects with the raw materials used for their manufacturing. However, due to the lack of reference materials, especially with regard to the elemental composition of archaeological copper alloys, a comparison of the results published in the literature and any historical interpretation is rather difficult. Therefore, an international co-operation has been built up in order to make reliable tools for scientists working in the field of archaeology and conservation. These tools are:

- Certified Reference Materials (CRMs) for the calibration of bulk elemental analysis of ternary and quaternary copper alloys,
- an analytical practice guide for the use of energy dispersive x-ray fluorescence analysis for the study of the bulk composition of archaeological metallic artefacts,
- an analytical practice guide for the study of the surface of artefacts in cases where the investigation should be non-destructive,
- assessment of the limits of the correlation between outer (corroded surface) and inner (bulk) composition,
- improvement and optimization of the electrochemical methods available for monitoring the corrosion behavior.

In this project supported by the European Union, DG XII, within the Standards, Measurements and Testing (SMT) research programme the following institutes are involved:

- Institut Francais d'Archéologie Orientale, Cairo/Egypt (M.Wuttmann) - Coordinator
- Electricité de France, Group des Laboratoires - VALECTRA, Paris/France (J.-M. Barache, N.Lacoudre, T.Beldjoudi)
- Ecole Nationale Supérieure de Chimie de Paris, Laboratoire de Corrosion, Paris/France (Ch.Fiaud, J.-P.Labbé, L.Robbiola)
- Universitaire Instelling Antwerpen, Micro- and Trace Analysis Center, Antwerp/Belgium (F.Adams, K.Janssens, A.Adriaens, I.Constantinides, G.Vittiglio)
- Technische Universität Wien, Institute of Analytical Chemistry, Vienna/Austria (M.Schreiner, M.Wadsak, J.Rendl, R.Allabashi, E.Eitenberger)

- Institute for Reference Materials and Measurements, Joint Research Center, European Commission, Geel/Belgium (Ch.Ingelbrecht)
- Stiftung Europäischer Kulturpark Bliesbruck-Reinheim/Germany (J.Schaub, P.Brunella, H.Boecking)

The IMMACO-Project started in October 1996 and first results concerning the Certified Reference Materials will be presented in the poster.

231. The geophysical image of a part of the Respublica Municipii Septimi Porolissensium in Dacia

Florin Scurtu

Geological Survey Romania, Str. Sibiu Nr. 10, bl OS1, ap. 138, 77317 Bucharest 66 Romania

The old Porolissium was a piece of the long chain of forts built up by the Romans along the north limes of the Roman empire.

The ruins of the fort show that it was about 300 m long and about 200 m wide. About 5000-7000 soldiers stayed permanently in the fort. At a small distance of the fort walls a Roman amphitheatre was found.

Around the military fort a civil settlement of about 20,000 inhabitants (Forni, 1976) was built up during the time. Few (5-6) buildings were found by the archaeological works east of the fort, but no trace of buildings is visible in the area geophysically studied by us, south of the fort.

The walls of the aedificia are built essentially in blocks of andesite (magnetic susceptibility of about 2000 μuCGS). The electrical resistivity of the sediments of Quaternary age is of about 20 ohmmeters, much less than that of underlying sandstones and conglomerats.

In a first step a magnetic survey in a very dense grid was used in order to check the possibilities of the method. The results obtained in a small area of 20 m by about 90 m showed that the method works very well, walls and rooms being clearly represented in the image (see the figure), after all the geophysical corrections (diurnal variation, geographical variation and geological variation) and the needed mathematical filtering were applied.

In a second step, a larger area, of about 2.2 Ha, was studied using the same methodology. The results are spectacular: a Roman road of about 7 m wide and 150 m long (including its change of direction at 90^o), a lot of buildings between 6 m by 6 m and 40 m by 40 m in dimensions, streets, fountains and platforms of monuments appear very clearly on the old town left by the Romans 17 centuries ago. The resistivity measurements (most of them vertical electrical soundings) show that the people living there could have the necessary groundwater under their feet.

Reference:

Forni, G. 1976, L'indagine demografica e gli amfiteatrei in Dacia. Apulum 13, pp. 141-151.

232. A Study of the Metallurgical Remains from Ashkelon - Afridar, Israel

Irina Segal*, Ludwik Halicz*, Andrei Kamenski**

*Geological Survey of Israel, 30 Malkhe Israel Street, Jerusalem 95501, Israel.
**Israel Antiquities Authority, P.O. Box 586, Jerusalem 91004, Israel.

Recent excavations at Ashkelon - Afridar Areas E, G and H have revealed numerous remains of metallurgical activity. The occupational remains uncovered in these excavation areas have been dated by the excavators to a very early stage of the Early Bronze period (EB Ia).

In order to reconstruct the ancient metallurgical technology at the site, to define the provenance of the copper and to assess the skill of the ancient craftsmen, the chemical, isotopic and mineralogical composition, as well as the metallographic structure of slags, prills and metal artifacts was determined and analyzed. ICP-AES, ICP-MS, XRD and SEM-EDS were used for these analyses.

From our present research, it is clear that there are no significant changes both in the composition of slags and production technology of metal between the Chalcolithic and the EB I periods. The chemical and mineralogical composition and isotope ratios of slags and pure copper objects point to Feinan region as source of the ore. The raw (black) copper has been delivered from Feinan region. Objects made of pure copper were produced at the

site. The technology at EB I Ashkelon - Afridar included use of open casting, the possible use of the "lost-wax" casting technique, hot and cold forging and annealing. The small dagger/amulet made of arsenical copper and two plates (convex and tube) made of leaded copper were probably imported to the site.

233. On the transition from tin-rich to antimony-rich European white glass trade beads

M. Sempowski*, R.G.V. Hancock, S. Aufreiter**, J.-F. Moreau***, K. Karklins****, I. Kenyon*****

*Rochester Museum and Science Center, Rochester, New York 14603, U.S.A.
**SLOWPOKE Reactor Facility and Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario, Canada, M5S 3E5
***Department des sciences humaines, Université du Quebec Chicoutimi, Chicoutimi, Québec, Canada, G7H 2B1
****Department of Canadian Heritage, Parks Canada, Ottawa,Ontario, Canada, K1A 0M5
*****Ontario Heritage Foundation, Toronto, Ontario, Canada, M5C 1J3

It has been shown that European white glass trade beads in north-eastern North America start the 17th century with beads opacified by tin, finish the 17th century with antimony opacification and end the 18th century with arsenic opacified beads. In an attempt to define more closely the transition from tin-rich to antimony-rich white beads, we analyzed an additional 129 white glass beads from a number of archaeological sites in western New York State that covered the 17th century. Chemical analysis shows that the arrival of antimony-white glass trade beads occurs at about 1650 C.E.

234. The calculation of the iron production based on the chemical balance between ore and slags.

Serneels, Vincent

Centre d'Analyse Minérale, Earth Sciences Department, University of Lausanne, Switzerland.

The early medieval bloomery of Boécourt - Les Boulies (Jura / Switzerland) has been excavated in 1989 (Eschenlohr and Serneels 1991). The mineralogical and chemical study of the metallurgical wastes leads to the development of a method for the calculation of the iron production based on bulk chemical analyses (mainly XRF). In this case very accurate data were available, due to the good preservation of the archaeological remains and the particular chemical composition of the ore.

This method has been applied, with more or less success, to several other examples based on archaeological, experimental and ethnographical data. Results, sources of error and related problems are discussed. In areas where ancient slag-heaps are preserved, this method is a very useful tool to quantify the iron production and understand the importance of the iron industry.

Reference

Eschenlohr, L. and Serneels, V., 1991, *Les bas fourneaux mérovingiens de Boécourt, Les Boulies (JU / Suisse)*, Cahiers d'archéologie jurassienne, n° 3, Porrentruy.

235. Precision Versus Accuracy in the XRF Analysis of Archaeological Obsidian: Some Lessons in Archaeometry and Archaeology

M. Steven Shackley

Archaeological XRF Laboratory, Phoebe Hearst Museum of Anthropology, 103 Kroeber Hall University of California Berkeley, CA 94720-3712 USA, shackley@qal.berkeley.edu

In the last decade, the analysis of archaeological obsidian using wavelength and energy-dispersive X-ray fluorescence spectrometry has become increasingly common. As in most cases where a relatively new application is embraced by archaeologists and supplied by the physical sciences, the understanding between the two groups is not necessarily very fluid. An emphasis by the physical scientists on the precision of the measurement without an understanding of the silicic melt reactions that produced the glass is in opposition to the ignorance many archaeologists possess in understanding either instrumental precision or accuracy in assigning an artifact to source. This lack of mutual understanding presents a number of problems for both

archaeometrists and archaeologists, and can undermine the use of this important analytical method in the service of interpreting issues of exchange, group interaction and raw material procurement. Using data from the Berkeley XRF lab and obsidian from the American Southwest, these issues will be explored, and solutions proposed in the hope of bridging the gap between the archaeometrist and archaeologist.

236. The experimental study of the tools on the fragments of the pottery

Shamanaev Andrey

Urals State University, 51 Lenina Prosp. 620083 Ekaterinburg, Russia

The fragments of the vessels with the traces of the re-using were determined in course of investigation of the pottery of the settlements Eneolithic-Early Bronze Age of the Middle Trans-Urals. The majority of such instruments had the working traces on the edges in form of the linear features, polish, rounding. Prof. G.F. Korobkova investigated the similar scrapers for a wood and a hide processing in collections of Eneolithic sites of the Middle Asia and Caucasus. The series of the experiments was made for determination of the functions of the tools from the Urals monuments. The use-wear analysis of the experimental and the archaeological implements was made through the stereo microscope. The magnification up to 100(x) was used. The fragments of the pottery were not effective for the scraping dry or fresh wood. The good result was attained for the production of the grooves and cavities after the scorching of the wood. Probably, the main part of the archaeological tools was connected with the hide-processing. The best results were achieved for the scraping a hide dried a little (the worked-material was placed on a soft ground or a thigh) and for the hair-removing. The fragments of the pottery were used as the grinder for the metal tools. Besides, the ceramics implements are effective for scaling of a fish. Probably, the using of the tools on the fragments of the pottery saved time and labour for the raw material extraction. The releasing industrial potential could be directed in the more important branches of a economy.

237. ESR Dating of flint: Problems with the E' Centre

Anne R. Skinner*, W. Jack Rink**

*Chemistry Dept., Williams College, Williamstown, MA 01267, USA
**School of Geography and Geology, McMaster Univ. Hamilton, Ontario L8S 4M1, Canada

Dating flint artifacts by electron spin resonance (ESR) should be possible if the artifact was heated during manufacture, annealing any signal accumulated over geological time. It has been previously reported (Skinner and Rudolph, 1996), based on several New World flint types, that heat-treatment of flint does not anneal the signal completely. The investigation has been extended to Old World material, which also exhibits a residual signal after heating that would affect the accuracy and precision of reported ages. In this paper we present evidence that the residual signal is probably due to the presence of an amorphous silica component in the flint matrix, which appears to carry an E' signal that is difficult to anneal completely. We also have found one type of flint which does not have a significant amorphous component, and in which the E' ESR signal does reduce essentially to zero on heating. We conclude that X-ray analysis may prove to be a useful screening test to determine if ESR dating with the E' signal is likely to be problematic.

Reference:

Skinner, A. R. and Rudolph, M. N. 1996, The use of the E' signal in flint for ESR dating, Appl. Rad. Isot., 47, 1399-1404.

238. Pedological studies as a means of reconstructing patterns of Alanian terrace agriculture in the north Caucasus (late 1st mil. BC - AD 1st mil.)

M. Skripnikova*, I. Arzhantseva, S. Sedov**

*Dokuchaev Soil Science Institute, Pyzhevski Str. 7, Moscow, Russia
**University of Moscow Fac. of History, Archaeological Dept. 1 Tverskoi Iamskoi Pereulok 14-19 125047 Moscow, Russia

A great deal of scholarly studies have been devoted to the integration of the Alans into the North Caucasian population, the formation and evolution of their settlements, culture and daily life . Yet, subsistence patterns of Alanian settlements, particularly those of highland exploitation, have evaded the attention of researchers.

The exploration of the elevated areas along the Alikonovka river valley in the Kislodovsk hollow has shown that mountain slopes were habitually turned into arable land through their artificial terracing. Before the joint pedagogical-archaeological expeditions of 1995-1997 the terraced mountain slopes had never been subjected to scientific examination, and the local geologists believed them to be swarded terraced outcrops of the armouring layers of sand- and limestone.

Man-made terraces were levelled or slightly concave stepped shelves ca. 10-30 m wide and 20-300 m long. The dirt for terracing was either brought from another slope or cut from the upper part of the same slope and patterned into steps further down the hill. In the area under investigation one could encounter from one to seven man-made terraces on a single slope.

The study of the terraced soil morphology and its comparison with that of standard virgin soils enabled us to establish their artificial origin implied by the following traits:

a/ the thickness of modern humic horizons varies considerably within the levelled terraces areas, increasing away from the overlying slope,

b/ the medium area as well as that transitional into the underlying slope often display buried horizons,

c/ the borderlines between the soil horizons within the terraces including their edges are frequently both clear-cut and rectilinear, while those of virgin non-terraced soils on hill slopes are indistinct and wavy,

d/ in the upper soil horizons and on the surface of buried soil profiles one often encounters fragments of pottery,

e/ edges of certain terraces are either reinforced with stones or show traces of reinforcing constructions.

The slopes of the northern and western aspects were most meticulously ameliorated and cultivated owing to their greater natural humidity, which was especially urgent under the arid conditions of the period in question.

The variety of terrace patterns and their wide distribution in the North Caucasus enable one to postulate the existence of an original well-developed tradition of terrace agriculture among the Alanian tribes.

239. Lipids in Ancient Ceramics: Patterns and Processes

R.J.Stacey*, C.P.Heron*, O.E.Craig, M.J.Collins****

*Department of Archaeological Sciences, University of Bradford, Richmond Road, Bradford, West Yorkshire. BD7 1DP
**Fossil Fuels and Environmental Geochemistry (Postgraduate Institute); NRG, Drummond Building, University of Newcastle upon Tyne. NE1 7RU

The exceptional yield of lipid molecules absorbed in sherds of Iron Age date (Easingwold, North Yorkshire, U.K.) offers a range of approaches to understand their origin, including:

- localised examination of sherd lipid content
- application of novel extraction regimes
- comprehensive lipid fractionation techniques (isolation of sterols, purification of acyl lipids, etc.)
- a survey of the survival of other biomolecules.

These techniques have been applied with the aim of examining patterns and processes of lipid absorption and the contribution of soil organic matter, exterior soots and original contents to the extracted lipid. A series of simulation experiments have been designed to test specific processes. These involved reconstruction of cooking events using experimental pots hand made from authentic raw materials.

The results of this study contribute to a better understanding of the relationships between absorbed organic matter and archaeological ceramics. Clarification of some of these processes may guide future interpretation of the often complex mixtures of lipids that survive in archaeological pottery.

240. Statistical Analysis Concerning the Determination of Some Probably Measuring Units Utilised in the Ancient Dacian Buildings (1st c. B.C.-1st. c. A.D.) in the Orastie Mountains (Romania)

Florin Stanescu*, Alexandru Sonoc**

The great civilizations of the Antiquity knew and used different measuring units and building modules, among some length units like the Sumerian -Babilonian cubit (0,4953 m) on the Greek-Roman cubit ("cubitus" =0,4436 m). The first part of the work is a presentation of the most known ancient measuring units, especially of them which were utilised in the constructions of the of the temples and sanctuaries. There are presented , afterwards, some elements of the Dacian civilisation in the research area of this paper, a territory which is situated in the region of the Dacian Kingdom's capital, Sarmisegetuza Regia, in the Orastie Mountains (Southern Carpathians, Romania), as well as some evident Greek influences. The try to determine some length units used by the ancient builders of the Dacian fortresses and sanctuaries - either North- Mediteranean, or Central or West- European units didn't lead to the expected results. Therefore, the authors tried to proof the existence of some length units and buildings modules at the Dacians. Mathematically the existence of an length element which could be a common divisor for an ~ensemble, which is formated by an as much big number of routes (lengths) of sanctuaries' interiors, doesn't solve the problem. It is obviously that a such common divisor exists for every possible lengths' ensembles-from the Antiquity to today. As a result , the author's research method consists of a selection of the components of lengths' ensembles, principally on the existence criterion of a pillar demarcation, of the exactly division (without rest), as well as on the existence of a signification for the wanted module. It was determined a length unity or building of 0,436 m, used probably in the building of the Great Round Sanctuary, of the Little round Sanctuary, of the Small Rectangular Sanctuary, as well of the as "The Andesite Sun" known sundial-altar. This size , respectively 0,436m, has some properties which recommends it as length modular unity:

1. It is the single common divisor for which the division quotient of the sanctuary's dimension at the module's length is equal with the number of the sanctuary's border pillar; otherwise said to each border pillars on the sanctuary's length or circumference correspond an unity-module.

2. The division of a dimensions' series of another sanctuaries of the Dacian capital's sacred zone to the calculated module gives however whole numbers, too.

3. The size of this length unity or building module is very nearly to the Greek -Roman cubit (0,436m-0,4436m in our actual units). Current researches on another sanctuary of the Orastie Mountains' region, at Costesti and Fetele Albe, will confirm or infirm this hypothesis.

241. Interpretation of $\delta^{18}O$ values in fossil animal bones as a function of preservation of hydroxiapatite, species, environment and climate

E. Stephan

Institut für Mineralogie, Petrologie und Geochemie, Univ. Tübingen, Wilhelmstrasse 56 72074 Tuebingen, Germany

Oxygen isotope compositions of bone phosphate (hydroxiapatite) mainly depend on the $\delta^{18}O$ values of the drinking water (meteoric) of the animals. This in turn correlates with the mean annual temperature allowing $\delta^{18}O$ of both recent and fossil animal bones to be related to temperature.

X-ray diffraction measurements of Pleistocene herbivore bones from sites in Germany and France demonstrate, that the state of preservation of hydroxiapatite influences the hydroxiapatite. The standard deviation of hydroxiapatite of well preserved fossil reindeer bones is as low as that of fresh bones from recent populations. The hydroxiapatite values of poor preserved horse bones originating from the same archaeological horizon have more scatter, although the arithmetic means of the two species are almost the same. The higher variations in hydroxiapatite appear to be caused by recrystallisation of the hydroxiapatite during diagenesis. Preservation of the hydroxiapatite should thus be taken into consideration when interpreting hydroxiapatite in fossil bones.

Hydroxiapatite can also be influenced by the uptake of drinking water and/or dietary water with higher ^{18}O content compared to the meteoric water. The hydroxiapatite of Pleistocene animal bones are often higher than expected, because hydroxiapatite values reflect not only the $\delta^{18}O$ of the meteoric water, but also depend on the humidity. Leaf-water as well as water from small puddles and ponds which have experienced significant evaporation, is commonly enriched in ^{18}O relative to the precipitation. Furthermore differences in the diet and water sources horses and reindeers from one archaeological unit may also lead to differences in their hydroxiapatite values.

242. Multi Element Analysis Of Uruk Ceramics - Provenance and Distribution

Fiona M. K Stephen

University of Edinburgh, Old High School Dept. of Archaeology, Infirmary Street Edinburgh, Scotland United Kingdom

Research is currently underway on a selection of fourth millennium BC Uruk and Uruk related ceramics from North Syria to shed light on the Uruk phenomenon and its cumulative effect on the Upper Euphrates River Valley area. The main aim is to distinguish locally made ceramics from those which might be imported from other areas in North Syria or South Mesopotamia. Much of the evidence for this expansive transformation is ceramic. Yet in Syria, studies of what is referred to as Uruk and Uruk related pottery have been limited to stylistic considerations. Central to this project is the identification of the sources of the clay minerals used in the manufacture of Uruk style ceramics. Then it should be possible to determine the chronology, spatial extent and nature of Uruk expansion to the west and its interaction with local cultures.

Sites of different status have been chosen to assess whether there was a hierarchy of full-fledged colonies with exclusive Uruk ceramics, enclaves with mixed ceramics and stations with discrete concentrations of Uruk ceramics amongst essentially local traditions. Selected sites include, Jerablus-Tahtani, Jebel Aruda, Habuba Kabira South, Sheikh Hassan and others. The sample set comprises several hundred examples of corresponding styles from each site as well as clay samples when possible. Techniques applied included INAA, ICP-MS, XRF, XRD and petrographic analysis. Also under consideration was a comparison of the techniques themselves and the accuracy and efficiency of each was carefully assessed.

243. New approaches to the analysis of resin and oil residues from Canaanite amphorae transported to Egypt in the Late Bronze Age

Ben Stern*, Carl Heron*, Margaret Serpico, Janine Bourriau*****

*Department of Archaeological Sciences, University of Bradford
**University College, London
***McDonald Institute for Archaeological Research, Cambridge.

Canaanite amphorae, believed to have been manufactured in Syria/Palestine, were widely exported throughout the Mediterranean and are important indicators of the trade in bulk commodities during the Late Bronze Age (c. 1500-1050 BC). Sherds analysed in this study are from Egypt (Tell el-Amarna and Memphis). Based on inscriptions the likely compositions are fatty acids and triglycerides (oils), diterpenoids (pine, cedar and/or fir) and triterpenoids (Pistacia spp) resins, as well as the gum-resins frankincense (Boswellia spp.) and myrrh (Commiphora spp.).

This project applies innovative extraction and derivatization methodologies for the identification of 'archaeological-invisible' organic commodities. Protocols have been developed for the extraction of both visible (ca. 1 mg) and ceramic-absorbed (ca. 0.1 g) residues. TMTFTH, (m-trifluoro-methylphenyl) trimethylammonium hydroxide, a reagent for the hydrolysis and methylation of esters and methylation of carboxylic acids, is compared to diazomethane and analysis without derivatization. In comparison to conventional extraction these smaller sample sizes and fewer stages results in a less time-consuming methodology which decreases the possibility of introducing laboratory contaminants, lends itself to multiple sampling of individual sherds and increases the number of analyses.

Fatty acids from oils and triterpenes from Pistacia have been recovered in archaeological material. A concentration gradient of absorbed organic matter through the ceramic matrix has been established, further reducing the sample size needed for analysis. Samples from the dry Amarna site exhibit excellent preservation whilst those from the wet-dry site of Memphis show little or no preservation, even for ceramic-absorbed material. Products of degradation have also been investigated. A comparison is made between residues and the ceramic fabric.

The contribution of molecular information to our understanding of the movement of oils and resins is producing valuable new data.

244. The characterisation, by lead isotopes and trace elements, of the ore deposits of Cyprus & Sardinia, and its bearing on the possibility of the lead isotope provenancing of copper alloys

Z.A. Stos-Gale, N.H. Gale

Research Laboratory for Archaeology, University of Oxford.

Cyprus has long been held to have been a very important ancient source of copper for the whole of the eastern Mediterranean world, from the Bronze Age down to Roman times. For the Bronze Age there was little or no direct evidence for this belief; nevertheless Mediterranean and Aegean archaeologists held this belief with some passion, rarely admitting any other copper ore source into the discussion. Since 1982, lead isotope analysis has held out the hope that such questions can be answered by this field of archaeological science, and that it could in particular solve the long standing problem of the source(s) of copper for the Late Bronze Age copper ox-hide ingots. However, from 1992 to 1996 there has been much controversial discussion of lead isotope provenancing, including one paper in 1995 which claimed that lead isotope provenancing was not possible, even for the copper ox-hide ingots.

Amongst the arguments advanced in 1995, perhaps the most telling one was that the isotopically analysed copper ox-hide ingots did not, as had been claimed by Stos-Gale & Gale in 1994, match the 'lead isotope field' for Cypriot ores, even for ox-hide ingots excavated in Cyprus itself. A further argument was that the lead isotope compositions of Cypriot ores could not be distinguished from those of Sardinian ores. Whatever the truth of these arguments, the advent of new ideas about the metallogenesis of Cypriot ores made it clear that the lead isotope compositions of Cypriot ores might well be more complex than the relative paucity of analysed ore samples from Cyprus had yet revealed.

Here we present new analyses of Cypriot and Sardinian ores which are discussed, in ways not so far published, in terms of the geology and geophysics of the ore deposits. The ore analyses, in combination with those of relevant artefacts, are applied to a thorough discussion of a number of critical aspects of the fundamental hypotheses which underlie the concept of lead isotope provenancing of metals, in an attempt further to clarify matters which have received much recent discussion. Finally it will be shown that lead isotope analysis is indeed a viable way to provenance the copper in prehistoric copper alloy objects, and that at last a solution is at hand to the long-standing problem of the source of the copper used to make the LBA copper ox-hide ingots which are found in many Mediterranean sites.

245. C-14 Dating of Archaeological Pottery: A Compound Specific Approach using Individual Lipids

A.W. Stott*, R. P. Evershed*, R.E.M. Hedges,C.B. Ramsey****

*Organic Geochemistry Unit, School of Chemistry, University of Bristol, Cantock's Close, Bristol BS8 1TS U.K.
**Research Laboratory for Archaeology and the History of Art, University of Oxford, 6 Keble Road, Oxford OX1 3QJ

Extensive studies of pottery recovered from archaeological sites have resulted in empirically derived sequences representing changes in pottery types or characteristics through time. Termed seriation, this process is widely used as a system of relative dating. Absolute dates, used to fix points in chronologies, are often derived from radiocarbon dating of associated finds at the excavation (e.g. bone, carbonised seeds) or by dendrochronology. Accelerator mass spectrometry (AMS) C-14 dating is regarded as a routine technique in archaeology and is applicable to a wide range of biogenic materials e.g. wood, shell, teeth, bone, seeds, charred organics, etc. One of the major problems in radiocarbon dating arises from contamination of samples during burial by absorption of exogenous carbon containing components from the burial environment. The problem of contamination may be overcome by purification of the organics into components that can be directly linked to the sample itself e.g. cellulose from wood, or collagen from bone. Accurate C-14 dating of archaeological pottery remains an ongoing area of research to the archaeologist; the ideal method would be to date carbon deposits directly associated with or incorporated within the pottery itself.

It is well established that a wide range of lipids are detectable in appreciable concentrations in unglazed archaeological ceramics. These derive largely from the processing, procurement and storage of foodstuffs during vessel usage. The porous nature of the ceramic allows entrapment and affords considerable protection to otherwise readily degradable compounds (Evershed, 1993). Recently, AMS has been successfully applied to the

dating of individual lipids from sedimentary organic matter (Eglinton et al, 1996). We are currently applying a similar approach to date individual lipids preserved in archaeological pottery. Lipids possess several important properties that make them favourable candidates for radiocarbon analysis:

1) their structures, distributions and ^{13}C content are can be well characterised;

2) contaminants can be readily detected using gas chromatography mass spectrometry (GC/MS);

3) their hydrophobicity makes them relatively immobile in the burial environment, and

4) they possess young ages at the time of deposition.

Using automated preparative gas chromatography (PCGC), individual lipids can be isolated from extracts in high purity and in sufficient concentrations (>200 mg) for high precision AMS dating. In this paper we will discuss the methodology of compound specific radiocarbon analysis and present results obtained from studies

undertaken towards confirming relative chronologies and establishing secure sequences for selected British pottery using the single compound approach.

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246. Environmental Change and Human Adaptation in the Carpathian Basin at Late Glacial/Postglacial Transition

Sümegi P.*, Kertész R., Hertelendi E.*****

*4010 Debrecen P.O.B. 4
**5001 Szolnok P.O.B. 128
***4001 Debrecen P.O.B.51. Hungary.

Reconstruction of past environment and society interactions is one of the most difficult problems for archeologists and paleoenvironmentalists. According to the paleoecological data some global climatic and environmental changes developed and they transformed the habitats of the different human populations and chances for their economy from the Last Glacial to Postglacial time. The global climatic and environmental changes can be also detected in paleoecological and geoarcheological sites in the Carpathian Basin. This region (including Hungary) is an important intermediate zone between Balkan peninsula and the western, eastern and northern parts of Europe thus it occupies an important geographical position for understanding the interaction of population infiltration, spreading of cultures and settling process and environmental changes in Europe. Quartergeological, quarterpaleontological and recent climatological data suggest the Carpathian Basin has been situated at a meeting point of different ecological and climatological zones from the Pleistocene up to the present. From this ecological/paleoecological sticking point it follows that a mosaic-like environment and some area-separating paleoecological barriers developed in the Carpathian Basin during the Late Quaternary. The paleoecological and geoarcheological data suggest that the ancient geographical distribution of plants, animals, soil-types and cultures with economy-types could be modified and limited by factors of these paleoenvironmental mosaics and paleoecological barriers. According to the paleoecological data the most important paleoecological/ paleoclimatological barrier was formed in the central part of the Carpathian Basin. This paleoclimatic/paleoecological change-line with the fluvial valleys could transform migration directions of the game animal herds and hunters following them in the analysed region before the Neolitization process. There seems to be a contact between this paleoenvironment-line and the settling process Early Neolithic people in the Carpathian Basin. Based on soil base rock types and submediterranean climatic effects, we can state this environment change-line could stop the spreading of the Early Neolithic people northwards, who had mainly Mediterranean growing experiences, because it limited the breeding of Mediterranean type domestic animal and cultivation of Mediterranean type crops. Thus this paleoenvironment change-line formed an agroecological barrier for Early Neolithic Mediterranean base agrotechnic and economy in the Carpathian Basin.

247. Archaometallurgical investigation of the LBA bronze objects in the Carpathian Basin

Géza Szabó

Szekszárd, Hungary

Archaeometallurgical studies of objects from Late Bronze Age Studies of the Urnfield Cultures resulted in many reports dealing with the tool set and products of metal processing, and general problems of the production of bronze articles, basically from historical, typological points of view. However there has been less opportunity and less attention paid to the study and evaluation of bronze articles within an interdisciplinary background. The paper is aimed at approaching the subject from this less studied aspect.

In addition to the existing research results, the new methods, used scarcely or not at all, in the Central European archaeological practice, offer broader understanding of earlier data. For instance, during the investigation of the material not only the composition (in percentage) but also the microstructure, the type of the appliances, the way of their use, etc. were assessed together, and the solutions guessed on the basis of observations, were modelled in a foundry workshop. Moreover they were tested in the experimental archaeological camps under

conditions essentially analogous to the original ones. For demonstrating the serviceability of articles, in addition to the practical tests, hardness studies also were performed firstly in the domestic practice of Bronze Age studies. An additional problem is the high tin content revealed in the investigations of the last decades, considerably exceeding the European average. This fact renders more difficult the integration of the domestic data into the international system of archaeometallurgical research.

The exact determination of alloying metals and impurities, and the hardness value, shows the level of a particular workshop and its serviceability characteristics, thus allowing evaluation of technological characteristics in cases where the traditional methods fail. All this could facilitate outlining particular workshops and workshop regions and could contribute to the solution of historical and chronological problems, as well.

248. Data and experiments to trade of the raw material in Central-Europe of Late Bronze Age

Géza Szabó*, Miklós Szónoky**

*Szekszárd, Hungary
**Attila József University, Department of Geology and Paleontology H-6722 Szeged, Egyetem ut. 2-6.

Data of researches performed so far demonstrate that within the today's country border natural geographical factors necessary for bronze manufacturing were available in the Bronze Age. Among the geological factors the native copper and its ores along with tin, antimony and lead ores were present as well. The archaeological data - absence of considerable number of mining tools, absence of large waste rocks and ash heaps - prove that no significant ore mining and metallurgy on industrial scale was developed in our country. A part of the archaeological data, however, indicate, that in some areas for example in the Mátra Mountains we should take into consideration the processing of native copper or even a smaller amount of ore.

Above the simplest loaf, tongue, and bar-shaped raw material pieces, in the domestic find sets one can find pieces of particular forms and destinations. For archaeological investigation pieces with easily traceable territorial occurrence (due to their ornaments for which special manufacturing knowledge was needed) are of particular importance.

Along with the special raw-materials, the source and transportation route of stone materials used during the process of bronze production can also be well-traced. These materials of the casting moulds display a great variety.

Then the Upper Permian-Lower Triassic sandstone, which in all likelihood has a similar facies with the red beds of the same age occurring in the Carpathian Basin as well. Rocks similar to this fine grained, well-workable material used for making the casting moulds can also be found in Hungary in the western part of the Mecsek Mountains and the Upplands near Lake Balaton and North and West Europa. They have always enjoyed a great preference among the stone materials used for architectural and sculptural purposes since the Ancient Times. Among the casting moulds there is one made from light-colored, thin bedded sandstone, which compared to the other rocks was deposited later during the history of the earth in the Miocene or Pliocene eras. Rocks of this age are very common in the Carpathian Basin.

One of the moulds has a very typical Miocene material: fossil-bearing calcitic tuff, which in all likelihood comes from the Tokaj Mts. It can also easily be recognised that the sand used for thinning the clay in case of the clay casting moulds also comes from domestic localities. The examined cannelura rock used in the foundries were also made from rocks, which are present in the Carpathian Basin.

The stone axe found at the Bölcske island locality and which might have been used in the foundry as well has a very peculiar stone material: garnet gneiss. The material of the polished stone also from this locality is a typically. Alpine-type rock which also occurs in Burgenland: micaceous quarzite.

249. Petrographical analysis of polished stone tools from some Neolithic sites of Hungary

Szakmány, Gy., Starnini, E.

*Eötvös L. University Budapest, Hungary

**Soprintendenza Archaeologica Della Lombardia, Italy

During the last years a research project for determining of the provenance of raw materials employed for the manufacture of prehistoric polished and ground stone tools in Hungary was conducted by the writers. Actually thanks to the kind permission of the excavator, namely Dr. János Makkay, we have investigated samples from the Neolithic sites of Méhtelek-Nádas in NE Hungary, Endrőd 39, 119, Szarvas 8, 23 in the Great Hungarian Plain and Bicske-Galagonyás in Transdanubia.

The aim of the research was both to determine and describe the raw materials from which the prehistoric tools were made and to establish a possible source, for a better understanding of the prehistoric exchange system and the raw material procurement pattern.

Up to now almost 50 samples have been analysed in thin section and a few with X-ray diffraction. Different raw materials have been determined, however most of them can be grouped into two basic categories:

Resistant and hard, fine grained and metamorphic rocks, employed for cutting-edged tools (axes, adzes and chisels) and hammerstones, such as greenschists, hornfels, basalt, amaphitic andesite.

Siliceous and sedimentary rocks such as fine grained sandstone, metasandstone, siliceous magmatite and quartzite for grinding tools.

The original locality of the studied rocks could be identified quite exactly for some samples. For the others, a possible source can be suggested, In some cases the rock is available not far from the sites, in the form either of raw material outcrops or in secondary, alluvial deposits. In other cases, the identified rocks do not occur in the surroundings of the sites, thus they might have been acquired through an exchange system or a long distance procurement pattern.

This study revealed the existence of a wide network of stone procurement since the Early Neolithic period and the good, although empirical, knowledge which the prehistoric populations had of the basic characteristics of the rocks they needed for specific tools.

250. Paleodietary applications of strontium and zinc in animal bones from Teotihuacan site

S. Tejeda, L. Manzanilla, R. Valadez, G. Zarazúa

Instituto Nacional de Investigaciones Nucleares Centro Nuclear Dr. Nabor Carillo Carratera, Mexico-Toluca Km 36,5 Ocoyoacac, Estado de Mexico, Mexico

The analysis of faunal remains from Teotihuacan site (Mexico) is important because there is no comparable method for determining the significance of animals to the Teotihuacan population. The amount of strontium, calcium and zinc deposited in the body parts of the animal depends on the rate of Sr, Ca and Zn passage through biological membranes, and on the amount of these elements in their diet.

Samples of archaeological animal bones from Teotihuacan site were analysed for zinc, strontium and calcium. Diagenetic contamination from the burial soil were considered to remove anortite and calcite particles from the bone structures. The elemental analysis and diagenetic contamination was carried out by X-ray fluorescence, X-ray diffractometry and scanning electronic microscopy. Analysis of the archaeological animal bones indicate that identification of diagenetic contamination is critical in order to obtain useful paleonutrition information. The results of trace element analysis indicate that Sr/Ca and Zn/Ca ratios are different between carnivorous, herbivorous, omnivores and domestical animals from the Teotihuacan valley.

251. Macroscopical, Mineralogical and chemical characterization of pottery from an early La Tène settlement at Alle (Noir Bois), Jura, Switzerland: An example for the combination of "low-" and "high-tech" Methods

G. Thierrin-Michael*,, G. Galetti*, C. Masserey****

*Institute for Mineralogy, University of Fribourg, Pérolles, CH-1700 Fribourg, Switzerland
**Office du patrimoine historique du Canton du Jura, Section of archaeology, CH-2900 Porrentruy, Switzerland

Excavations of an early La Tène settlement (450 to 300 BC) in NW Switzerland brought to light about 20'000 sherds belonging to more than 1500 vessels. Analyses by Polarisation Microscopy, X-ray Fluorescence and X-ray Powder Diffractometry were carried out in two phases on 50 sherds. First, 25 sherds were selected among three macroscopically defined wares (fine, medium, coarse). A second lot of 25 sherds was selected on the basis of macroscopical resemblance to the groups defined among the first lot by mineralogical-chemical criteria. Does the macroscopical and the mineralogical-chemical classification of the second lot lead to the same subdivisions? Could macroscopical analyses reliably complete the classification of all the 1500 vessels? The first survey revealed the presence of one predominant group (n=19)showing sufficient similarities to clays sampled around the site to suggest a local origin. Differences among these sherds mainly in the grain-size and frequency of inclusions indicate several subgroups (variety of local clays). The six samples which are clearly not part of the predominant group are characterized by a particular fabric type and/or a different chemical composition, each quite distinct. The second series confirmed the predominance of wares produced with locally available raw materials. The predominant group, as well as foreign samples were identified by macroscopical and mineralogical-chemical methods likewise. For this “coarse" classification macroscopical fabric analyses proved reliable and could be applied to the totality of vessels and thus supply the basis for a statistical evaluation. However, subgroups determined in the sample by macroscopical fabric analyses differ from those determined by mineralogical-chemical analyses. The extrapolation therefore was not carried further.

252. The Technology and Development of 12th Century Ad Islamic Polychrome Ceramics

M. S. Tite*, R. B. Mason**

* Research Laboratory for Archaeology and the History of Art, 6 Keble Road,Oxford, OX1 3QJ, U.K.
** Near East and Asian, Royal Ontario Museum, 100 Queen's Park, Toronto, M5S 2C6, CANADA.

During the twelfth century AD two techniques of polychrome decoration of glazed ceramics were developed in the Islamic world. In Syria potters began to paint under an alkali glaze using metal-oxide pigments. This was the beginning of the "underglaze-painting" technique that was also used in Iran for bichrome wares, and would later become the predominant decorative technique in the Islamic World and in China. In Iran potters began to paint over a tin-opacified glaze, again using metal-oxide pigments. This technique is often called minai (Arabic for "enamelled") or haft rang (Persian for "many-coloured"), and was traditionally considered to be a low-temperature enamelling technique.

Examination of contemporary Syrian and Iranian underglaze-painted wares has shown that while the Syrian polychrome wares represent the true underglaze pigment-painting technique, the Iranian wares are actually a more conservative slip-painting technique. This establishes precedence for the Syrian wares, although traditionally the reverse has been thought to be the case. It is hypothesized that the Syrian technique derived from an earlier splash-painting technique in lead-alkali glazes known as laqabi ware.

Examination of the Iranian overglaze-painted wares appears to indicate that they are not typical low-temperature enamels at all, but in fact would have a higher maturation temperature than that of the glazes. The pigments are generally not matured, so may have been fired at a low temperature, but this means that it is not easily related to contemporary and earlier glass-enamelling techniques. It is hypothesized that this is an independently developed technique perhaps derived from the lustre-painting technique. The prohibitive costs would make this a short-lived ceramic technology.

253. The First Pottery in Europe: Technology, Production and Consumption in Early Neolithic Knossos, Crete

Peter Tomkins*, Peter M. Day*, Vassilis Kilikoglou**

*Sheffield Centre for Aegean Archaeology, Department of Archaeology and Prehistory, University of Sheffield, Northgate House, West Street, Sheffield S1 4ET, UK.
** Archaeometry Laboratory, Institute of Materials Science, NCSR Demokritos, Aghia Paraskevi 153 10, Greece.

Recently, interest has been generated in the development of the earliest ceramic technologies in both the Old and New World, producing a welcome influx of new ideas and explanatory models (e.g. Barnett and Hoopes 1995). In the case of Greece, Vitelli's influential work has proposed that pottery production was restricted and specialised from its very introduction (Vitelli 1995): the opposite of that expected from a evolutionary

viewpoint. Such important issues may only be clarified by looking beyond relative ceramic chronologies and simple models of change, to a detailed analysis of pottery production and consumption.

In this effort, analytical work on ceramics has a major role to play. This paper presents the first results of the study of perhaps the earliest known pottery in Europe, that from the Early Neolithic (EN) of Knossos (mid seventh millennium BC). The analytical programme includes thin section petrography and scanning electron microscopy of ceramics chosen through macroscopic examination of fabric and form. The pottery assemblage has been characterised in terms of its mineralogy, paste preparation and its decorative and firing technology.

From the results of this extensive analytical programme, new information has been produced on whether production was specialised at this early stage, to what extent the technology was 'developed', whether different production traditions existed within the assemblage and finally on the existence of imported vessels. With no known earlier occupation in Crete, the rich EN sequence at Knossos provides an ideal opportunity for archaeometric work to investigate the introduction and development of an influential technology.

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254. Alternate methods of EPMA characterisation of gilt silver metal threads

Attila L. Tóth*, Márta Járó**

*Res. Inst. for Tech. Phys. of the Hung. Acad. Sci. POB 76. Budapest H-1325
**Hungarian National Museum, POB 124. Budapest, H-1450

Textiles had been decorated with gold threads for several thousand years. Pure gold or gold alloys were replaced by about the 13-14th centuries A.D. by gilt silver threads made in different ways. One and both side gilt narrow, thin silver strips and gilt silver wires were the basic constituents of these metal threads.

Gilding was carried out by hammering thin gold leaves onto the surface of a silver foil or the joint of the metals was obtained by a soldering material. Mercury gilding and from the 19th century onward, galvanoplating were also used. The determination of layer structure of the strips and wires can reveal the manufacturing technique which is characteristic to the period of use.

The average width of the metal strips used in metal thread making is about 250-400 μm, their thickness is about 6-30 μm. The diameter of the wires varies between 50 and 100 μm . The width of the coatings rarely exceeds 2 μm.

From the early 90's attempts have been made for distinguishing the different metal coating techniques by measuring the concentration of the different elements present in the metal - conducting a set of step by step EPMA point analyses on the cross-section of the strip or wire, resulting in depth profiles. This method can handle multicomponent and multilayer structures, but as the sample has to be embedded in a synthetic resin and polished, problems of sampling and non-destructivity arise. Furthermore in the case of submicrometer coating thickness the depth profiles reflects the lateral spread of exciting electron beam rather than the chemical distribution of constituent concentrations.

These inconveniences can be avoided by utilising the fact, that the penetration of the exciting beam in the range of the typical coating thickness. Analysing the gilt surface of the samples, decreasing the beam energy, the apparent concentrations will be more and more characteristic to the composition of the layer. From the rate of change of these concentration values the layer thickness can be deduced. In the case of pure layers the problem can be treated using calibration curves, while the evaluation of multielement or graded layers requires a data reduction program. As the method needs no special sample preparation, it is quick and non–destructive for the sample.

In order to explore the possibilities and limitations of the methods gilt silver strips of metal thread samples taken from textiles dated to the 15-20th centuries were analyzed and the results compared to those obtained by the step by step analysis on the cross section.

It was found, that in the case of layer thickness greater than 1 μm (e.g. some 15th century Italian threads) line profiling should be used, while the energy dependent measurement is clearly superior for thin layers of pure Au

(e.g. 20th century galvanoplated threads) down to thickness of 10-20 nm, well under the spatial resolution of conventional profiling.

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255. Technical examinations of medieval ferrous metallurgical finds found in Hungarian sites (8 - 13th cent. AD)

Béla Török

University of Miskolc

The study gives account of chemical, metallographic and mineralogical examination of iron ores, slags from smelting furnace and smithy workshop and furnace wall-fragment found in Hungarian sites of Medieval iron-making. There is a connection with Dr. János Gömöri's work (Museum of Sopron), who directed the most of the excavations connected with the examined material, and put the samples at my disposal.

In the chemical examinations the samples were analysed by wet assay, X-ray fluorescent spectrometer, gravimetric and spectrophotometric methods and LECO carbon-sulphur analyzer in the laboratories of the Departure of Ferrous Metallurgy and the Departure of Analytical Chemistry of the University of Miskolc and at METALCONTROL Kft. of Diósgyőr Steel Works. The samples also were examined by Scanning electronmicroscope as a metallographic and by X-ray diffraction process as a mineralogical analysis at the Departure of Physical Metallurgy and the Department of Mineralogy of the University of Miskolc.

The results afford help with gaining more knowledge of used technology and metallurgy of iron-making in that ages. On the basis of the analysis some important conclusions can be drawn about characteristic of ores and the different types of slags. The examinations often render help to typify the slags from metallurgical point of view (smelting or forge slag; tap-slag or cinder etc.). This is one of the newest and richest collection of data from examination of ferrous metallurgical finds from 8-13th century.

256. Characterization of a sedimentary matrix by particle size and chemical analysis to determine activity areas in a quarry tunnel at Teotihuacan, Mexico

Claudia Trejo

Lab. de Prospección Arqueológica, Inst. de Investogacines Antropologicas, UNAM, Circuito Exterior s/n Ciudad Universitaria, Del. Coyoacan 04510 Mexico D.F, Mexico

The examination of the sediments and chemical analyses of archaeological deposits provided useful data the identification of cultural activities. Analyses of culturally modified sediments, using control profiles for comparison, were applied to over 350 samples. The archaeological context integrated by domestic, ritual and mortuary features, shoed successive cultural occupations that initiate during the terminal Classic period (700-900 AD.) at the Teotihuacan site in Mexico. The application of particle size and chemical analyses - carbonates, pH, phosphates, and color-helped to infer distinct types of activities within each occupation. Techniques were incorporated to the archaeological methodology to form a solid corpus for the correlation with other archaeological materials.

257. Chemical Characterisation of Calcareous Bronze Age Pottery Fabrics from Central Crete

A. Tsolakidou*, V. Kilikoglou*, P.M. Day**

*Laboratory of Archaeometry, N.C.S.R. Demokritos, Aghia Paraskevi, 15310, Attiki, Greece.
**Department of Archaeology and Prehistory, University of Sheffield, Northgate House, West Street, Sheffield S1 4ET, UK.

The relative potential of major, minor and trace elements in terms of their discriminative power amongst Cretan Bronze Age pottery fabrics is examined in the present study. Seventy-two pottery samples were analysed from three wares with calcareous fabrics (Vasiliki Ware, Grey Ware and Dark-on-Light Ware). They were characterised and classified typologically and then by thin section petrography. The mineralogy of their non-plastic component is distinctive enough to allow confident ascription of provenance. In an exercise to further evaluate the most effective mode of chemical discrimination within Crete, the same samples were then analysed by instrumental neutron activation analysis. Statistical evaluation of the trace element data has revealed the existence of three major chemical groups, each dominated by samples from a particular geographical region on the island; the Mesara Plain, the South Coast and the Mirabello Bay area. However, the regional discrimination from trace element data is not free form overlaps. This appears to be because the base clay of all three fabrics consists of Neogene marls and the inclusions that discriminate the material petrographically do not seem to affect significantly the trace element concentrations. As it became evident that the effect of Ca in the discriminations is of importance, further analysis of the pottery samples for the determination of the major elements was carried out by X-ray fluorescence. The results are compared with those by INAA and the statistical analysis of the two subsets (major/minor elements and minor/trace elements) of variables are presented.

258. Spatial Autocorrelation on the Analysis by Several Types of Artifacts within a site of Ceramic Workshops at Knidos, Tekir in Turkey.

Numan Tuna

Middle East Technical University, Ankara.

In 1986 and 1987 a team of Turkish-French archaeologists launched a joint project of a systematic survey on Hellenistic workshops of Knidos in the south-west corner of Turkey. The survey aimed to study the scale and methods of production, as well as its spatial characteristics. It was decided to undertake an intensive survey to examine various types of artifacts on the surface by unit of grids.

In order to detect disturbance effects of the spatial patterning, spatial autocorrelation on the type of analysis had been tested employing quadrant methods for diagnostic types of potsherds. It was found that certain types of artifacts occur in positive association that greatly effected by locational preferences of ceramic production process through Hellenistic epoch.

259. Pozzolanic properties of some medieval masonry mortars

S. Sarp Tuncoku*, Emine N. Caner-Saltik, Hasan Böke

Middle East Technical University Dept. Architecture, Materials Conservation Lab., 06531 Ankara Turkey

Pozzolanic characteristics of the mortars used in a stone masonry structure have been studied to understand their technological and durability characteristics. The stone masonry structure is a waterside palace built in Seljuk Period (12th and 13th centuries) situated an Beysehir-Konya and known as Kubadabad Palace. It was first excavated in 1965, extensive excavations have started 1980 and continued to the present.

Authentic mortars collected from the palace walls constructed at different periods have been analyzed for their basic physical and mechanical properties as well as for their compositions.

Physical properties have been determined by RILEM Standard Test Methods and mechanical properties by ISRM - Point Load Tests. The pozzolanic properties of the lime as a binder, the properties of the binder and aggregate interface within the mortar, and, the mortar's interface with the building stone have been studied by optical microscopy, Scanning Electron Microscopy (SEM) together with Energy Dispersive X-ray Analyzer (EDAX), X-ray Diffraction Analysis (XRD) and Fourier Transform Infrared Spectroscopy (FTIR).

The mortars are porous, and their percent porosity values are in the range of 30 to 47. The bulk densities of these mortars are in the range of 1.40 - 1.76 gr/cm^3. Their uniaxial compressive strengths can be estimated to be around 20 Mpa. Pozzolanic properties of the mortars have been established by the fillers based on the several types of calcium and aluminium silicates observed in the binder and in the binder-aggregate interface and mortar-stone interface, and the overall durability and compatibility characteristics of the mortar in relation to the stone masonry.

260. The Origins and Dispersal of Maize Agriculture: A Review and Critical Assessment of the Isotopic Evidence

Robert H. Tykot

University of South Florida

The application of stable isotope analysis of human skeletal remains to reconstructing ancient diet has now been in practice for two decades. Initial studies focused on interpreting carbon isotope ratios, which primarily reflect differences between C3 and C4 plants in human food chains, through the analysis of bone collagen. In the Americas, the typical application has been documenting the dietary importance of maize, generally the only significant C4 crop exploited by Native Americans. Most research efforts now also include the measurement of nitrogen isotope ratios, which are ultimately dependent on how plants obtain their nitrogen(by symbiotic bacterial fixation or from soil nitrates) but are also affected by rainfall and other local conditions. The combined analysis of both carbon and nitrogen isotopes is especially critical for sorting out the consumption of marine foods in areas where C4 crops such as maize also were available. It is also necessary to establish the isotopic values for both marine and riverine/lacustrine resources on a local basis in order to interpret properly the human bone isotope data. Most recently, it has been established that collagen carbon and nitrogen is derived primarily from the protein portion of the diet, while bone apatite/tooth enamel carbon appears to be derived from all dietary components. Since maize contains only 10% protein, small contributions of meat or seafood to Native American diets would dominate the isotopic signal in bone collagen, thus requiring the analysis of both bone collagen and apatite (or tooth enamel)to reconstruct ancient diet. In this paper, a critical synthesis of the isotopic data accumulated in the last two decades for Native American diets will be presented, based on evidence from countries including the United States, Canada, Mexico, the Caribbean, Belize, Honduras, Guatemala, Panama, Venezuela, Ecuador, Peru and Argentina, and including isotopic data from the author's own as yet unpublished research. In combination with traditional faunal, botanical, palynological and other data (e.g. pottery residues, phytoliths) relevant to prehistoric maize use, a chronological and spatial model of the origins of maize agriculture and its dispersal throughout the Americas will be formulated. Specific pathways of maize dispersal, as well as diverse local patterns of consumption, will be presented. Lastly, areas for future research which will explicitly test these hypotheses will be suggested.

261. A Multidisciplinary Study on Ancient Iznik Ceramics

E.Uzgil*, G.Saglamer*, A.Tekin*, A. Batur*, G. Tanyeli*, Y.Kahya*, T.Tulun* A.Altun, B.Arli**, H.Arli**, V.Cobanoglu**, C.Erel****

*Technical University of Istanbul, Maslak 80626 Istanbul, Turkey
**University of Istanbul, Faculty of Letters, Archaeology Department, Beyazit, Istanbul, Turkey

For years, the composition of ceramic bodies were kept secret even among the representatives of the same culture, probably, due to the technological competition. Therefore, it was not achieved to are producible data for the ancient ceramic materials, and the questions on the origins of the different technologies are still discussed. Furthermore, due to the complexity of the fundamental chemistry and physics of ceramic raw materials, the structural changes which occur during the production process carry uncertainties, and thus "try and cut" method is still valid in the ceramic technology. Consequently, studies done on the ancient ceramic artifacts give valuable information for today ceramic technology.

In the present study, a multi disciplinary program of research on Iznik ceramics which refer to Ottoman tiles and fritwares from 16th century A.D. were carried out. Iznik tiles were the main decorative elements of ceramics. Firstly, a typological study of the pottery based on the excavation records, forms and motif assemblages and the architectural investigation of construction assemblages and the full stylistic analysis of decorative variety of tiles from dated monuments were done and the interdisciplinary data-base were planned.

The mineralogical composition of a sample of eighteen ceramic body was determined by XRD powder technique. The result showed that the samples consisted mainly of quartz and admixture minerals such as calcite, feldspar and a lesser amount of clay. Major and the minor elements of ceramic body and glaze were determined by wet chemical analysis and Atomic Absorption technique.

The textural structure, glassy phase, size, shape and orientation of aggregates and particles as well as mineral nature of ceramics were examined with petrographical analysis by observation of thin sections with SEM. The

bulk chemical compositions of glaze and body were determined in-situ energy dispersive X-ray analysis (EDA) with SEM.

By using this combination of techniques, results show that Iznik pottery contains quartz-frit bodies, quartz-frit slip, lead-soda glazes and underglaze decoration. The main specific elements of the decorative colours are copper and iron. The greenish-blue and the reddish-brown colours are governed by these elements depending on the glaze formula, kiln atmosphere and firing temperature. Manganese also contribute to brown colour and chromium give the black outline of the decoration.

262. Origin of the Rosette-Stamped Royal Storage Jars from Ancient Judah

Joseph Yellin, Jane Cahill

The Hebrew University of Jerusalem

Excavations undertaken throughout the last century in southern Israel have produced more than 250 ceramic jar handles bearing rosette stamp seal impressions. All of the well stratified rosette stamped vessels derive from destruction levels marking the end of the Iron Age I confirming Aharoni's (1979: 400) idea that they succeeded chronologically the lmlk stamp vessels of the 8th century BCE. Nevertheless, preliminary results from the gamma-ray spectrometry following neutron capture (neutron activation analysis) performed on more than 90 rosette stamped vessels suggests that the rosette jars were manufactured from the same clays used a century earlier to produce the lmlk stamped vessels. The neutron activation analysis performed on the rosette stamped vessels both supplements the results of a similar study conducted more than a decade ago on lmlk - stamped vessels (Mommsen, Perlman, and Yellin 1984: 89 - 113), and demonstrates a previously unrecognized continuity in the ceramic industries of Judah during the 8th and 7th centuries BCE.

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263. Evaluation of ancient diet: Dietary tracing by stable isotope analysis of consumer tissues

Suzanne M. M. Young, Nikolaas J. van der Merwe

Harvard University, Archaeometry Labs. Peabody Museum, 11 Ninity Ave., Cambridge, MA 02138 USA

The reconstruction of past human diets through isotopic analysis of archaeological human skeletons has been successfully used for nearly two decades in tracking the adoption of C4 cultigens into C3 biomes, e.g. the origin and spread of maize agriculture in the Americas. Contradictions between isotope data and other evidence suggest that the relationship between the dietary importance of maize and the carbon isotope ratios of consumer bone collagen (or hair, muscle, etc.) is not linear, as the initial model (the "scrambled egg" model) proposed. Recent experiments with rats showed consumer apatite to reflect whole diet, rather than only energy components, and consumer collagen to be dominated by, but not entirely formed from, dietary protein, thus demonstrating the failing of the other model, the "Routing" model. A correct model requires an appreciation of biochemistry.

In order to provide basic metabolic information for future archaeological interpretations of human diets, experimental diets in this study have also been designed to simulate the introduction of maize to C3 biomes in the Americas. We measured natural stable isotope ratios in the tissues (bone, muscle, hair) of pigs (large omnivores with the same essential amino acids as humans) in order to study the biochemical routing from dietary components to consumer tissues. We raised pigs on 13 different diets, using foods that are naturally labelled with stable carbon and/or nitrogen isotopes. Their diets are designed to identify the dietary components used in the synthesis of pig protein tissues, particularly where more than one protein source (animal and/or plant) is available, and also to determine whether dietary carbon is averaged during the formation of mineral bone carbonate. The full set of results on our first generation of pigs will be presented. Requirements in a new biochemically informed model will be discussed. Final results will make it possible to interpret isotopic dietary signatures in archaeological human skeletons with much greater accuracy in all global regions.

264. Provenance of the Marbles from Katapoliani Church in Paros: The Problem of Discrimination between Parian and Proconnesian Marble

Th. Vakoulis, Y.Maniatis, K. Polykreti

Laboratory of Archaeometry, NCSR "Demokritos", 153 10 Ag. Paraskevi , Attiki, Greece

The complex of Katapoliani Church, consisting of the central basilica devoted to Virgin Mary, the chapel of Aghios Nikolaos, and the Baptestrerion which is said, according to the tradition, to be an imperial donation, is dated to the middle sixth century AD.

Eighteen marble samples were taken from specific architectural elements from Katapoliani church such as collumns, capitals, collumn bases and the kiborion. Archaeologists believe that some of them are made in Proconnesian marble.

Marble samples were analyzed with the technics of Electron Paramagnetic Resonance Spectroscopy (EPR) and optical microscopy. Characterisation, grouping and tracing of the possible provenance were the purposes of the study. At the same time new Proconnesian and Parian geological samples of grey and white with grey striations marble were added to the marble data bank of the Archaeometry Laboratory, NCSR "Demokritos", in order to extend the range of material available for comparison.

The problem of discriminating between Parian and Proconnesian marble is well known to specialists in the field and is still difficult even after the application of several scientific techniques.

Applying various combinations of parameters we were able to assign the provenance for ten pieces of Katapoliani. The rest were unresolved leaving still both options open for future research.

265. Chemical Characterisation of Frankincense and Pine Resins from Qasr Ibrîm

P.F. van Bergen, R.P. Evershed, T.M. Peakman, E.C. Leigh-Firbank, M.C. Horton P.A. Rowley-Conwy

Organic Geochemistry Unit, School of Chemistry, University of Bristol, Cantock's Close, Bristol BS8 1TS, UK
Department of Archaeology, University of Bristol, Woodland Road, Bristol BS8 1TB, UK
Department of Archaeology, University of Durham, South Road, Durham DH1 3LE, UK

Frankincense is the best known of the aromatic gum resins being used throughout the world as incense in religious ceremonies. A wide range of ingredients may have been used by the ancient incense-maker and such materials would have been important trading products in the region of Syria and Mesopotamia[1]. The earliest archaeological evidence for the burning of incense comes from the Old Kingdom in Ancient Egypt, where spoon-shaped incense burners with long handles have been found, however, in no case has chemical evidence been provided for the exact resin which was burned.

We provide here the first chemical evidence for frankincense in the archaeological record obtained from the site of the major frontier settlement of Qasr Ibrîm, Egyptian Nubia. The material came from levels associated with the Post-Meroitic occupation of the site (c. 400 - 700 AD). The samples were recovered during sieving of the room fills of a house.

The resins were characterised by a combination of gas chromatography (GC) and mass spectrometric (MS) techniques, employing both solvent solubilisation and derivatisation, and pyrolysis techniques. The data obtained show the presence of pentacyclic triterpenoid components that can be definitively linked to frankincense. Especially characteristic are the α- and β-boswellic acids and the corresponding O-acetyl derivatives that dominate the GC chromatograms. These data were supported by the detection of 24-nor-oleana-3,12-diene and 24-nor-ursa-3,12-diene dominating the Curie-point (610°C) pyrolysates of the extracted residues. The boswellic acids are characteristic of the fresh aromatic gum resins from trees of the genus Boswellia. Other pieces pf amorphous resin recovered from the same excavations at Qasr Ibrîm were shown to comprise tricyclic diterpenoid acids, including isopimaric acid, abietic acid and dehydroabietic acids, which clearly indicate Pinaceous resin. Resins of this type, and their derivatives, have been reported previously at archaeological sites, particularly as surface deposits in transport amphorae. The finding of two types of resin at the same location in the Post-Meroitic house points to their use together in incense burning.

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266. Characterization of pigments in Mercatellis manuscripts by total reflection X-ray fluorescence and Raman-microscopy

Peter Vandenabeele*, Bernhard Wehling*, Luc Moens*, Martine de Reu, Guido Van Hooydonck**, Alex von Bohlen***, Reinhold Klockenkämper*****

*University of Gent, Laboratory of Analytical Chemistry Proeftuinstraat 86, B-9000 Gent, Belgium
**University of Gent, Department of Library Sciences Rozier 9, B-9000 Gent, Belgium
***Institut für Spektrochemie und Angewandte SpektroskopiePostfach 10 13 52, D-44013 Dortmund, Germany

The identification of the pigments used in a manuscript can reveal important information for art historians, conservators and restorers. One of the topics where pigment analysis can be helpful is the assignment to different workshops of manuscripts of one collection. This was the case with the collection of Rafael de Mercatellis (Flanders, late 15th - beginning 16th century). The colours of several paragraph-marks, running titles, initials and illustrations in margin on different pages of different books where examined. These precious works where sampled by a virtually non-destructive microsampling method. A combination of Raman-microscopy and Total Reflection X-Ray fluorescence (TXRF) made it possible to reconstruct the palettes used in the manuscripts. Pigment characterization by two different techniques on the same small sample (less than 1 μg) was possible because of the high sensitivity of the methods used. Raman-microscopy is a fast and easy method for the examination of the grains of the pigment, while TXRF leads to a more quantitative description of the elemental composition of the samples. This delivers a good basis for the identification of the workshops of the different manuscripts. This can lead to a new vision on the relationships between the manuscripts of the Mercatellis collection.

267. Identification of ancient proteins on a ceramic sculpture of Mictlantecutli at the Templo Mayor, Mexico

Rocío Vargas-Sanders, Edith Ortiz, Rubén D. Martinez

Instituto de Investigaciones Antropologicas Universidad Nacional Autonoma de Mexico, Circuito Exterior s/n, Ciudad Universitaria 04510 Mexico D.F. Mexico

The identification of ancient proteins found on different archaeological materials offers a new approach to understanding the past. One of the proteins that can be detected and identified is haemoglobin. This presentation will show the results of the biochemical and immunological analysis that we have developed in a experimental model applied on a ceramic sculpture found at the "Templo Mayor", in Mexico City. This ceramic figure represents the Mexican God of the Death: Miclantecutli, that was covered with blood in ritual ceremonies, as is apparent in the Magliabechi Codex. The objective of our research is not determine the presence of the haemoglobin on this piece, but try to identify whether this haemoglobin is human or not.

268. A study of migration in Mexican Prehispanic populations by DNA analysis

Rocío Vargas-Sanders, C. Zayil Salazar

Instituto de Investigaciones Antropologicas Universidad Nacional Autonoma de Mexico, Circuito Exterior s/n, Ciudad Universitaria 04510 Mexico D.F. Mexico

The movements of Mesoamerican Mexican populations through the Mexican territory have been motivated by different natural and social causes.

The results of archaeological research show similar cultural characteristics between Teotihuacan and Tula populations which are represented clearly by Coyotlatelco and some Mzapan ceramics (Epiclassic occupation). This fact suggest that both populations could belong to the same genetic group in this Epiclassic occupation.

The objective of this work was to compare if the genetic frequencies of these populations are in agreement with historical sources.

Ancient DNA (aDNA) was obtained from skeletons from archaeological sites of Teotihuacan, Mexico and Tula, Hidalgo, México. The aDNA was amplified and hybridized for 5 genes as Amplitype Kit of Perkin Elmer manual indicates.

Comparative analysis if genetic frequencies of these populations show differences in 3 of the 5 genes tested, giving a probe of the genetic flow in those times.

269. Method of formalized comparative petrological analysis of ancient ceramic and is application to the Greek amphora studies

S. Y. Vnukov

Institute of Archaeology, Dept. of Rescue Archeology Russian Academy of Sciences, Moscow Russia

The method of comparative petrological analysis of pottery was elaborated to group the samples applying statistical criteria to clay composition of ceramic. It can be summarised in a formalised petrological description of the samples using several indices. The quantitative data relating to these indices were estimated using a four-point system. A data matrix was compiled on the basis of this formalised description of the mineral composition. Using this data matrix different coefficients of similarity between each pair of samples may be then calculated. The results of the pair-based comparison were examined by hierarchical agglomerative clustering and the group average clustering methods.

The general aim of the studies was to distinguish the petrological groups of classical ceramic and to determine production centres of some amphorae types. 280 pottery samples from the main amphora production centres of the Black Sea region and from some Aegean centres were used for the studies. They are dated from the 4th century BC till the 3rd century AD. Both control samples from stamped amphorae and tiles of known centres for References and samples of unknown origin were examined. It allowed to distinguish the petrological groups, to connect these groups with morphological types of the vessels and with the certain amphorae's production centres. Interesting data on the clay composition and technology of the samples were also obtained.

270. X-ray Fluorescence as a Tool for the Identification of Copper ore Processing Sites on the Great Orme, North Wales, UK.

E.C.W. Wager , D.A. Jenkins, B.S.Ottaway***

* Research School of Archaeology and Archaeological Science, University of Sheffield, West Court, 2 Mappin St., Sheffield S1 4DT, UK.

**School of Agricultural and Forest Sciences, University of Wales, Bangor, Gwynedd LL57 2UW, UK.

The copper mine on the Great Orme, north Wales, UK, has one of the largest and best preserved sequences of Bronze Age workings in Europe. There is considerable evidence for the extraction of copper at this site, but few traces of the subsequent stages in the copper production sequence (ore processing, smelting and metal working) have been identified. If the nature of the exploitation at this mine during the second millennium BC is to be conceptualised in greater detail, these sites of related activity must be found.

Copper mineralisation on the Orme is restricted to an area near the summit; therefore the identification of elevated copper concentrations in other areas can indicate the debris of mining-related activity. A portable X-ray Fluorescence Spectrometer was used to measure the copper concentration of soil deposits sampled at two locations, Ffynnon Rhufeinig and Ffynnon Gaseg, identified by excavation (Wager 1997), topographic and reconnaissance geophysical survey as potential copper ore processing sites. Analysis was carried out rapidly, effectively and economically in the field.

The results demonstrate that portable field XRF is a highly effective tool for the identification of copper ore processing sites on the Orme and at other locations with a similar detectable metal anomalies, particularly when used together with topographic and geophysical surveying techniques.

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271. Luminescence dating of ceramics and sediments from the La Cadena site, Ecuador

G.A. Wagner*, I.B. Wagner*, A. Lang*, M. Reindel**

*Forschungsstelle für Archäometrie der Heidelberger Akademie der Wissenschaften
Max-Planck-Institut für Kernphysik, Heidelberg, Germany
**Seminar für Völkerkunde, Universität Bonn, Bonn, Germany

The archaeological site La Cadena is situated near Quevedo in the northern Guayas basin in Ecuador. This area which is part of the coastal plain is archaeologically still little known.

The La Cadena site consists of several mounds, so-called tolas. Within these layered mounds and in ground between them artifacts, most commonly ceramic sherds and obsidian flakes, occur. The area around the site is built up by fluvial sediments of the Estero Chollo and Estero Pise.

In order to contribute to the chronology of the archaeological layers as well to understand the function of the mounds, luminescence dating was applied to ceramic sherds and sediments. The sherds were taken during the excavation of two of the tolas and a test ditch in-between. Thermoluminescence dating was applied to the fine-grain and quartz fractions of the potsherds. The TL dates range from the middle of the first century BC up to the late first century AD. The chronological significance of these results will be discussed. Infrared stimulated luminescence dating was applied to the fine-grain fraction of silty deposits from three profiles in the fluvial sediments. The IRSL age data render basic information for the geoarchaeology of the site.

272. Racemization of Aspartic Acid, Using Dentine Proteins to Test the Method

Emma R. Waite*, **Matthew J. Collins*, G. Howard Moody**, Saheb Al-Qattan**

*Fossil Fuels and Environmental Geochemistry, NRG, Drummond Building, University of Newcastle, Newcastle upon Tyne, NE1 7RU;
**The Royal College of Surgeons of Edinburgh, Dental Faculty, Nicolson Street, Edinburgh, EH8 9DW UK;
***Oral Medicine Department, Dental Centre, Ministry of Health, P.O. Box 65022, Kuwait

The aspartic acid racemization reaction has been used to date organic remains for over 20 years. However, the validity of racemization dating has been questioned, probably due to some spectacular dates generated in the 70's. The most notable example was the dating of California palaeoindian skeletons (Bada et al., 1974)., which suggested that humans had migrated into North America during the Upper Pleistocene (50-60k).

We believe that the problems with this method are caused by a lack of understanding of the underlying mechanisms of the racemization reaction. We are examining the in vivo racemization of human dentine proteins as a model for the post-mortem degradation processes in bones and teeth. The tooth acts as a unique "temperature-controlled oven" in which to look at the diagenesis of proteins. The mechanisms of protein degradation in metabolically isolated dentine are complex. Deamidation and isomerization reactions will occur in addition to epimerization.

The D/L ratio of aspartic acid in dentine has been measured using Gas Chromatography. Artefacts caused by inappropriate sample preparation and the role which various factors play in the rate of epimerization in dentine have been investigated. Gaining a better understanding of the kinetics and optimising the experimental procedures for analysing dentine will serve to improve the accuracy and reliability of the technique, which may then be applied to dating and age at death determinations with more confidence.

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273. The Earliest Carbon Fibre was discovered in Chinese Black Pottery

Changsui Wang*, Xingcan Chen, Zhonghe Liang****

*University of Science and Technology of China, Hefei, Anhui, 230026, China
**Archaeological Institute, Academia Social Sinica, Beijing, 100710, China

The ancient black egg-shell pottery is a kind of very precious relics. It was made at the Longshan Culture period (4300-4800 B. C.) in China. It is unimaginable that ancient people handle high technique very skilfully.

One sherd of black egg-shell pottery was measured by use of XRD, SEM, Raman spectrum, EDS and HREM. A lot of graphite was found in the sherd by XRD and Raman spectrum. There are many fibre in the SEM photo. EDS points out that the element of the fibre is Carbon. It probably is the earliest Carbon fibre. This discovery is very interesting and of benefit to further researching how to make the black egg-shell pottery.

274. Preliminary research on the provenance of pottery Zun with Big mouth of the Dawenkou Culture

Changsui Wang*, Anwu Xu*, Xingcan Chen, Zhonghe Liang****

*University of Science and Technology of China, Hefei, Anhui, 230026, China
**Archaeological Institute, Academia Social Sinica, Beijing, 100710, China

A lot of pottery Zun with big mouth at the Neolithic Age in China were found in Yushishi site of Mengcheng city, Anhui Province, and Zhoujiazhuang and Dazhujiacun sites of Ju county, Shandong Province. There are same engraved designs of "sun, moon and mountain " on the surfaces of pottery Zun with big mouth from above-mentioned sites. It suggests there is some cultural relationship between above-mentioned two areas. It is necessary to research on the provenance of pottery excavated from above-mentioned sites for exploring their relationship.

11 sherds of Zun with big mouth in which 6 come from Yushishi site, 1 is from Zhoujiazhuang site, and 4 belong to Dazhujiacun site, were measured by using ICP and petrographic methods. The results show that the petrographic compositions of above-mentioned two areas are very similar and their trace element data have some overlap, but their petrographic structures exhibit obvious different features. The feature of pottery Zun from Mengceng city has no or weak directional structure, but the sherds from Ju county have clear directional structure. It seems that these pottery Zun was made from local soil, and the same engraved designs were only related to the cultural custom or religious belief on Dawenkou areas.

This work is beneficial to research further on the source and stream of pottery Zun with big mouth at the Neolithic age.

275. The structure of the surface of Chinese Black Mirrors and its Formation Process

Changsui Wang*, Minoru Suzuki,**

*University of Science and Technology of China, Hefei, Anhui, 230026, China
**Yamanashi Research Institute, Teikyo University, Japan

Black mirrors occupy an important position in the Chinese bronze cultural relics. According to the appearance and the surface structure, they can be classified as two sorts: Heiqigu and common black mirrors (CBM). Almost all of Heiqigu mirrors made during between Spring-Autumn and the Northern and Southern Dynasty, and almost all of CBM appeared after Tang Dynasty. Tang Dynasty is an obvious line made known that there are different preparing techniques for Heiqigu and CBM. Calculated result according to 2 theta/alpha film diffraction on the surface of black mirrors and topography of SEM shows that there is outer part of surface about 8.5 micron deep, which is only composed of SnO_2. It suggested that the outer part of black mirror surface came mainly from treatment with rich tin materials.

It is interesting that the grain size of SnO_2 in the black mirror surface is about 5 nanom measured by SAXS and lattice images of HREM. The Raman spectra reflects heavy lattice distortion in SnO_2 particles. Ultrafine SnO_2 films on the bronze substrate have been prepared by a improved sol-gel procedure and erosion of different alkaline solutions. It was discussed for relation between the thickness and quality of the film and its preparing procedure.

276. The identification of pigments in medieval manuscripts by Raman-microscopy

Bernhard Wehling, Peter Vandenabeele, Hubert Cardon, Brigitte de Keyzer and Luc Moens

Instituut voor Nucleaire Wetenschappen, Proeftuinstraat 86, 9000 Gent, Belgium

The identification of pigments in old manuscripts, paintings, textiles etc. is from art historical interest, provides restorers with important information and can help in detecting forgeries. Raman-microscopy is ideally suited for these purposes.

The technique delivers vibrational spectra which can be considered as a fingerprint of the substance investigated. Use is made of a low power laser beam, that is focused on the sample of the pigment layer or in situ on the artefact itself.

Raman-microscopy (1) offers a number of unique features: Use can be made of microsamples (< 1 g) that can be taken without any visible damage to the artefact. Individual microscopic pigment grains can be analysed, no special sample pre-treatment is required and the analysis is non destructive, thus can be used in a multi-method approach. In this work the same micrograins were also analysed with total reflecting x-ray analysis and electron microscopy, yielding a maximum of information from a minimum amount of sample. Mixtures can be investigated easily, because it is possible to see the different micrometer-small particles under the microscope. Thus it is possible to determine the composition of the sample semi-quantitatively. The latter information allows for example to distinguish different artists based on the palette they used, a feature which is of great significance in the study of manuscripts. In this work the use of the technique is demonstrated for the analysis of a medieval manuscript (Brevarium Mayer van den Bergh, approx. 1480).

Nearly all coloured pigments from the manuscript could be identified by Raman-microscopy, and evidence was found to support the thesis that different artists contributed to the illumination.

Reference

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277. Antique Metalloenzymes

Ulrich Weser

Anorganische Chemie, Physiologische Chemie Institut der Eberhard Karls Universität Hoppe-Seyler-Strasse 4, 72076 Tübingen Germany

Ancient conservation techniques led to surprisingly well preserved large Mr biopolymers including nucleic acids, carbohydrates and proteins. Apart from the exceedingly good conditions the molecular intactness should likewise be reflected in the respective biological function of the examined component. It was attempted to isolate both biochemically and immunologically active alkaline phosphatase from antique bone samples of different archaeological sites and age. In particular specimen from pharaonic Egypt, bog finds, air drying and seawater conservation being up to four thousand years of age were used.

Gel filtration, ion exchange and affinity chromatographies were employed to optimize the preparation of the ancient enzyme resulting in a specific activity of up to 50 % to that of an enzyme from modern autopsy. The possibility of microbial contamination was checked by employing specific monoclonal antibodies directed against the human bone enzyme. Fortunately, ubiquitously present specified microorganism on the respective ancient bones did not cross react with these antibodies while the ancient enzyme reacted with high specificity. Alkaline phosphatase mimics could be excluded as in the presence of the inhibitors 1.10-phenanthroline and homoarginine the enzyme activity was diminished. The presence of orthovanadate as a substrate analogon aolished the catalytic function of the enzyme. Likewise heating to 100 C and replacement of Zinc(II) by Cadmium(II) resulted in a dramatic loss of activity. In conclusion alkaline phosphatase appears to be a useful marker enzyme in molecular archaeology.

278. Analysis of copper-based metals from Three Mi'kmaq Sites in Nova Scotia

R.H. Whitehead*, L.A. Pavlish, R.M. Farquhar**, R.G.V. Hancock*****

*Nova Scotia Museum, Halifax, Nova Scotia, Canada, B3H 3A6
**Department of Physics, University of Toronto, Toronto, Ontario, Canada, M5S 1A7
***SLOWPOKE Reactor Facility and Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario, Canada, M5S 3E5

Instrumental neutron activation of sixty-one copper-based metal samples from Mi'kmaq First Nations archaeological sites at Northport, Pictou and Avonport in Nova Scotia show that all samples were of European origin. There are two brass and one gun metal sample; all are of different trace element chemistries. The remaining fifty-eight pieces of European copper displayed between six to thirteen different trace element chemistries, implying that a minimum of this number of cooking pots was associated with the assemblage. Six of the seven Northport copper samples match with different Pictou copper chemistries, linking the sites.

Since two Northport samples were from essentially whole pots, and since they match trace element groupings 1 and 2i, at least two pots of each of these chemistries must have arrived at Northport and Pictou. On the other hand, the two copper samples from Avonport are chemically unique in this small collection, matching nothing from Northport or Pictou.

279. Interpretation of black surface of ancient Chinese bronze mirrors

Wendell Williams*, Pankaj Sarin, Changsui Wang, Sarah Wisseman*****

*Univ. of Illinois Physics Dept.2214 S. Lynn Street, Urbana IL 61801 USA
**University of Science and Technology of China, Hefei, Anhui, 230026, China
***University of Illinois at Urbana-Champaign ATAM, 116 Observatory, 901 S. Mathews Urbana IL 61801 USA

Ancient, beautifully-patterned Chines bronze mirrors which have shiny black surfaces and resist corrosion have challenged archaeologists, curators, conservators and materials scientists for over sixty years. The major archaeological/anthropological issue is: did craftsmen prepare the black surface to protect the underlying bronze, or did it develop from burial in soil for 2000 years? Scientists have already formulated and proposed answers to several relevant questions: What is the chemical composition of the black surface? (Mostly tin dioxide). What is its microstructure? (Includes nanoscale tin dioxide particles). Why does it resist corrosion? (Because of the oxide surface coating). Can it be replicated by laboratory experiments? (Yes, using, for example, humic acid).

The present study had five goals: (1) to identify the specific minor compounds in the black coating using X-ray diffraction software, (2) to confirm the presence of glassy matrix for particles by using transmission electron microscopy and selected area electron diffraction, (4) to determine the elemental composition of not only the mirror surface using Auger electron spectroscopy and SEM/EDS but also the patterned reverse side with some soil particles still retained, (5) to repeat the XPS (ESCA) chemical analysis of the first few atomic layers, (6) to determine what causes the black appearance.

A fragment of a typical Han Dynasty high-tin, black-surface, bronze mirror was analyzed using the above techniques. Evidence of silica glass matrix was found, in which particles of many different phases are embedded. In addition to the well-known bronze mirror near-surface compounds-cassiterite, cuprite and delta-phase, another compound developed from bronze was found: romarchite (SnO). Several others based on rocks and minerals appeared in the glassy surface matrix: anorchite, tridymite, fayalite, rankinite, calc-flinta, magnetite, cuprite and romarchite. The data collected from several techniques also confirmed that both front and reverse mirror surfaces contain 7-8 atomic % iron. Since iron was removed from copper by successive smelting processes when the mirrors were produced, its presence must be the result of soil adherence to the buried mirror and diffusion into oxidizing surface. Cassiterite (tin oxide) containing iron impurity is known to be black, as is the case with dozens of other minerals having Fe 2+. This argument and the presence of particles of rock/mineral compounds embedded in the matrix combine to support the position that the black, oxidized surface resulted from burial.

280. Analysis of Copper-based Metals from the Ball and Warminster Sites, South-Central Ontario, Canada

G.C. Wilson*, L.A. Pavlish, R.G.V. Hancock***, R.P. Beukens****, D. Knight*****, R.M. Farquhar******

*Turnstone Geological Services Ltd, P.O. Box 130, Station "B", Toronto, Ontario M5T 2T3; IsoTrace Laboratory, University of Toronto, Toronto, Ontario M5S 1A7
**Archaeometry Laboratory, Department of Physics, University of Toronto, Toronto, Ontario, M5S 1A7
***SLOWPOKE Reactor Facility and Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario M5S 1A4
****IsoTrace Laboratory, University of Toronto, Toronto, Ontario M5S 1A7
*****Department of Anthropology and Sociology, Wilfrid Laurier University, Waterloo, Ontario N2L 3C5
******Department of Physics, University of Toronto, Toronto, Ontario M5S 1A7

European copper-based metal kettles became an increasingly sought-after item in early European- Amerindian fur trade transactions, with at least a small number of these vessels reaching Ontario Iroquoian groups by the beginning of the seventeenth century. Portability may have contributed to their increased popularity.

Using accelerator mass spectrometry of precious metals, instrumental neutron activation analysis (INAA) of trace elements and Pb isotopic studies, the objective was to establish broad copper-based metal types and to assess the relative similarities and differences within the chemical sub-groups with respect to age, major, trace and rare-earth elements and Pb isotopes.

Secondary goals included using the European copper and brass data to establish the distribution of different chemistries around the site.

Eight hundred copper-based metal fragments, recovered from the Ball site in south-central Ontario, were sub-sampled at the Wilfrid Laurier University archaeology lab. A further sub-sample of four hundred and fifty items from the Warminster site were obtained from the University of Toronto collections. A suite of samples from each site were characterized and classified with the above-mentioned techniques. The data recovered show that both indium-rich and indium-poor copper items were present on these sites, and that the brass samples, examined also by electron microprobe analysis of polished shards, ranged in their zinc compositions from a few percent to 30%. The seriation of the copper/brass ratio at these sites indicates that Ball is the earlier of the two sites. Radiocarbon results on copper-preserved organics and thermoluminescence results from associated pottery from these two sites are consistent with this interpretation. Pb results suggest that "Basque-like" copper items from New Brunswick, Canada, approximately 1000 km to the northeast, are similar to artifacts from the Ball site with respect to the geological formation ages of their parent deposit(s). The age appears to be consistent with Swedish copper deposits thought to have been inactive from the fall of the Hanseatic League to the time of the Reformation. This observation has implications for early New World historical trade and population movements of Native groups.

281. Fresco pigments from Byzantine Cappodocia, part II.

Sarah Wisseman*, Pankaj Sarin, Robert Ousterhout, Eric De Sena, Wendell Williams*****

*University of Illinois at Urbana-Champaign ATAM, 116 Observatory, 901 S. Mathews Urbana IL 61801 USA
**American Academy in Rome, Via Angelo Masina 5, Box 113, 00153 Roma, Italy
***Univ. of Illinois Physics Dept.2214 S. Lynn Street, Urbana IL 61801 USA

Fresco pigments from a Byzantine church have been analyzed in an attempt to clarify painting phases within a single building. The pigment samples were taken in 1994 with the permission of the Turkish Ministry of Culture and the Aksaray Museum from the church known as Canli Kilise ("Bell Church") in central Turkey. The 11th century church was constructed in three phases: 1/ the naos, 2/ the south narthex and the north narthex, and 3/ the parekklesion. All four spaces were decorated with frescoes, which are now in poor condition.

Our research objective was determine whether pigment analysis could confirm the relative chronology of construction and decoration proposed by the archaeologist. Examination of the site suggested that the naos and south narthex belong to the same phase of decoration (in other words, the naos may have been painted only after the second construction phase). In addition, although the two parts of the narthex were constructed simultaneously, they may not have been decorated at the same time. Finally, later repairs to some frescoes may correspond to the original painting of other frescoes.

A program of analysis begun in 1995 has now been completed at the University of Illinois. XRD and SEM with EDS were employed to characterize the mineral phases and major elements of red, green, and blue pigments from all four parts of the church. The results indicate that different types of plaster were used in the naos and south narthex (calcite, $CaCO_3$) than in the rest of the building (gypsum, $CaSO_4\ 2H_2O$). Is this difference due to accidental exposure to sulphur in the atmosphere, or is it due to a deliberate change in plaster materials by the fresco painters? Also, the pigments do vary in composition between the older and newer parts of the building. For example, the blue pigments show considerable variation, with the relatively rare ultramarine violet ($Na_5HAl_4Si_6S4O_24H_2O$) being present in the north narthex only, whereas copper-containing litidionite ($KNaCuSi_4O_{10}$ and $(CuNa_2K_2)\ Si_3O_7$) is present in both the north narthex and the naos.

While the data may not support exactly the chronological sequence proposed, it is likely that the frescoes were painted in several stages using different pigments.

282. An application of the "Zeus" program: The necropolis from Banatului St. (Cluj, Romania)

Wittenberger, Mihai, Mircean, Cristian

National History Museum of Transylvania, 2 C. Daicoviciu St. 3400 Cluj Napoca Romania

Noua culture is the last culture of the Bronze Age in Transylvania and makes the transition to the Hallstadt period. The pottery belonging to Noua culture has a marked specificity: it is relatively poor in shape and ornaments. As a result, up to now there has never been possible to create a complete typology of Noua pottery, and in consequence, to structure this kind of pottery according to its periods of evolution. The almost total lack of vertical stratigraphy in Noua settlements, has compelled us to look for alternative methods of classification.

The National History Museum of Transylvania has created the "Zeus" computer program designed to arrange and classify the pottery in accordance with its essential characteristics. We experimented this procedure with the pottery belonging to the biggest necropolis in Transylvania, the necropolis from Banatului St. in Cluj. All 50 graves were grouped in three series corresponding to three distinct periods in the existence of the necropolis. The same computer program was also capable of classifying the graves in conformity with the anthropological attributes of the dead. In this case four series of graves were determined, each representing specific properties ascribed to the anthropological type.

283. Technical investigation of bricks from St Urban (13th century Cistercian monastery, Lucerne, Switzerland): First Results of A Firing Experiment

Sophie Wolf

Institute of Mineralogy and Petrography, University of Fribourg, Switzerland

The bricks from St Urban have been the focus of scientific enquiry for rather less than a decade. In 1995, excavations at St. Urban monastery revealed 13th century bricks of extraordinary quality, design and size. The majority of these red coloured bricks are 45 * 34 * 11 centimetres, making them extremely unusual building materials. Firstly, the research focuses on the technical aspects of the manufacture of these bricks. As it seems difficult to compare firing conditions in small electric kilns with production in the thirteenth century, a kiln was built to imitate medieval brick making and firing. A firing experiment using this kiln was carried out in September 1997.

During 10 days of firing the temperature distribution in the kiln was registered at 18 different positions. We also measured the composition of the firing atmosphere by analysing 7 different gases (O2, CO2, CO, NO, NO2, SO2, HC) as well as the gas temperature and velocity. To fire the kiln we used dry fir wood only. Maximum temperatures reached about 1300 °C near the flue, and over 900 °C in the bricks.

Thin sections of the old and recent bricks were made in order to compare textures, grain size distribution and quantity of the tempering material. The drying sensitivity and firing behaviour of the raw materials were also studied. X-ray diffraction and Hg- porosimetry were used to analyse the mineralogical composition and porosity as an indicator of the temperature gradient within the bricks. Finally, the characteristic values including water absorption, compressive strength, bulk density were used to describe the technical and physical properties. The comparison of the Cistercian bricks and their imitations allowed us to assess the production facilities and conditions in the 13th century.

284. Isotopic Anomalies in the Element Copper: A New Metal Provenancing Method?

A.P. Woodhead*, N.H. Gale*, Z.A. Stos-Gale*, A. Walder, I. Bowen****

*Isotrace Laboratory, University of Oxford, U.K.; **VG Elemental, Winsford, Cheshire, U.K.

At present comparative lead isotope analyses of copper ores and artefacts is the only method available for tracing the ore source of the copper used to make a prehistoric copper-alloy artefact (e.g. Gale and Stos-Gale

1989); chemical analyses are useless alone, but in special cases may strengthen an attribution made by lead isotope analysis.

It has always been recognised that a more direct way to provenance copper might lie in using possible variations of the isotopic composition of copper itself, but hitherto this possibility has not been investigated. Work will be discussed which shows, by the difficult application of thermal ionisation mass spectrometry to copper, that earlier work (Shields et al. 1965) reporting small differences in its isotopic composition in certain copper minerals, though widely doubted, was in fact substantially correct. Applications to Bronze Age Mediterranean artefacts which also show small isotopic variations will be examined. The confirmation of these effects using much more precise ICPMS/magnetic sector multicollector mass spectrometric methods will be presented, and an assessment given as to whether these effects may be used as an aid to provenancing, or whether the processes of smelting, alloying, melting or fabrication make this impossible by changing the isotopic composition of copper away from that in the relevant copper ores.

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Gale, N.H. and Stos-Gale, Z.A., 1989, Bronze Age archaeometallurgy of the Mediterranean: the impact of lead isotope studies, in *Archaeological Chemistry IV, Advances in Chemistry 220,* (ed. R.O. Allen), 159-198, American Chemical Society, Washington D.C.

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285. A modified TL technique (Foil technique) for Dating calcite shells from an Upper Pleistocene Marine

N. Zacharias*, C. T. Michael*, D. Dimotikali, E. Vardala-Theodorou***, Y. Bassiakos***

*Laboratory of Archaeometry, Institute of Material Science, N.C.S.R. «Demokritos»15 310 Ag. Paraskevi, Attiki, Greece.
**National Technical University, Chemical Engineering Department, Iroon Polytechniou 9, 15 780 Zografou, Greece.
***Goulandris National History Museum, 13 Levidou Str. 14 562 , Kifissia, Greece.

Fossil shells were collected from an Upper Pleistocene formation next to the Sanctuary of Hera at Perahora (Central Greece). The hosting formation consists of marl limestone including significant fossil fauna. The techniques of Thermo-luminescence (TL) and ESR were used.

The aim of this work is to test and compare the results of the dating and also to compare with the biostratigraphic evolution during the Upper Pleistocene period in this area.

The samples which were to be dated using TL, were collected carefully with the appropriate precautions (conditions of reduced day light). The shells found to be in aragonite form, by means of XRD, were rejected and TL measurements were performed on the remaining of Ostrea edulis (Linnaeus 1758) shells (calcite form). A new technique (foil technique) in TL dating was used, due to the advantages it offers in the estimation of the palaeodose. Specifically, this technique permits the use of high heating rates which facilitate an increased TL signal and also reduces significantly the spurious TL. For these reasons foil technique was the most suitable in this case, as the samples had low sensitivity and thus gave signals very low to be measured by other means. This was the first time the foil technique had been applied to calcite shells.

Fossil shells of the Glycymeris glycymeris (Linnaeus 1758) and Callista chione (Linnaeus 1758) were dated by means of the ESR technique, using the datable signal at g=2.0033.

The results of both techniques are in close agreement and coincide with our knowledge of world climatic changes during this period.

286. Attribution of some Stamped Sherds of Galloroman Terra Sigillata Imitations from Western Switzerland

Angela Zanco

Institute of Mineralogy and Petrography, Pérolles, CH- 1700 Fribourg

Waste pieces (supposed to be local) of Galloroman Terra Sigillata Imitations (1st-3rd Century A. D.) from Lausanne (Atelier du Stade), Yverdon (Atelier Faustus) and Avenches (Atelier du Faubourg N-E), were studied and characterised with several methods. Petrographic observation, mineralogical investigation (XRD), chemical analysis (XRF) and physical characterisation (Hg-porosimetry) have permitted the establishment of three new

Reference groups. These groups have constituted the indispensable basis for the provenance and technological study of stamped ceramics production from several sites (Lausanne-Vidy, Yverdon, Avenches, Martigny, Nyon, Vindonissa).

The aim of this study is to define the geographical provenance of these products, to attribute them to the workshops and to study craftsmen associations. Chemical data together with petrographic observations, phases analysis and statistical elaboration, permit to understand and compare the characteristics of clays used by different potters. Among all the sample (about 85) only 14 could be exactly attributed and permit to understand potters' deplacements. The amounts of the sherds were not equal, as products of some craftsman are very rare. Therefore, while some important and well-known potters (as Vepotalus, Villo, Faustus, Sabinus) could be represented and studied by several analysis (from 7 up to 12) some others (Coius, Genialis, etc.) have been studied only by few sherds (from 1 up to 6). Another aspect concerning some verification analysis have been made on productions already analysed and known, as La Péniche and Florus group found in Martigny. They confirm the equality of characteristics between Martigny group and Florus sherds and the presence of Iuvenis, Pindarus, Iucundus potters in La Péniche workshop.

287. C-14 dating of the Mesolithic of East European forest zone (a critical review)

Mickle G. Zhilin

Institute of Archaeology RAS, Dm. Ulyanov Street 19 117036 Moscow Russia

By now more than 100 C-14 dates are available from Mesolithic habitation sites and cemeteries, situated at the territory of the forest zone of Eastern Europe, from Eastern Baltic countries to Urals and from Karelia to the upper flow of the Dnieper, Oka and Don rivers. But various regions of this large territory are not equally studied. More than 30 dates are known from the Eastern Baltic, about the same from Karelia and from Upper Volga, about 10 from the Eastern Onega lake region. Only several dates are known from other parts.

The second problem is reliability of many dates, obtained at various laboratories, especially of those, produced in the sixties and seventies. In many instances publications give no information about what material was dated. Relationship of the dating and cultural layer is also not certain in many cases. Some recent, yet unpublished dates from the author's excavations will also be introduced and discussed. The aim of the paper is to select reliable dates of Mesolithic sites and cemeteries and to discuss the chronology of the Mesolithic of East European forest zone, comparing the C-14 data with dates, achieved by other methods.

288. The Technical Arrangement of the Bath-houses in the Golden Horde and its Genesis

E.D. Zilivinskaya

Moscow State Institute of Archaeology, Russia

The culture of the Golden Horde, one of the largest states which arose as a result of Mongol conquests, represents a specific symbiosis of the nomad way of life and developed urbanism. More than 100 cities which were founded by the Golden Horde khans in the second half of 13th - first half of 14th A.C. possessed all the features and institutes of a typical medieval town. One of such features were public bath-houses; apart from their hygienic functions they also served as a specific ``clubs'' for different social levels. Rich farmsteads included also private bath-houses.

Nowadays more then 20 such structures were excavated in the Golden Horde cities. Independently of the planing and external decoration all the Golden Horde bath-houses had the similar technical arrangement. All of them had a sub-flour heating. To warm the floor in the bath-rooms, the system of heat conducting channels was built beneath. For this purpose the surface was carefully levelled, upon it small pillars (of 70-90 cm high) were erected and upon these the floor slabs were mounted. Hot air came to the sub-floor space through magistral channels from the fire chamber situated in the opposite to the entrance side of the building. The same fire chamber served also for heating the water. The water was supplied to the bath-rooms through ceramic pipes. In order to reduce the heat loss bath-houses were sank into the ground and had massive walls. Such an arrangement of heating was first applied in Ancient Rome. Later it was used in Byzantium; with Arab conquests it came to the Orient and got the further specific development there. Oriental bath-houses (hammam)

differ from Roman ones considerably in functions, planning and the structure of rooms. At the same time in the Middle Ages the bath-houses of the Roman tradition co-existed with the Oriental ones. In the Golden Horde cities both the two types of the bath-houses were found. The choice of the bath-house planning was usually determined by several (social etc.) factors.

289. Physico-chemical Characterization of the Archaeometallurgical Findings from the Late Antic and Early Middle Age Sites in Banat and Backa

D.Zivkovic*, S.Janjic, V.Trujic*, M.Gavrilovski***, R.Curcic****, S.Trifunovic*****

*University of Belgrade, Technical Faculty, Dept. of Metallurgy, 19210 Bor, Yugoslavia
**Copper Institute, 19210 Bor, Yugoslavia
***SARTID 1913, Institute for Metallurgy, 11300 Smederevo, Yugoslavia
****ITNMS, 11000 Belgrade, Yugoslavia
*****Museum of Vojvodina, 21000 Novi Sad, Yugoslavia

Physico-chemical characterization of the archaeometallurgical findings from the late antic and early middle age sites (Padej - Visnjevaca, Padej - Ciglana, Sanad - Kopovo, Horgos - Stub 76, Kolut - Bacan, Kolut - Ritska dolina, Baranda - Ciglana, Banatski Karlovac - Kalvarija, Dobrica - Velike Njive) in Banat and Backa, Yugoslavia is presented in this paper. Results obtained by using of chemical analysis, X-ray analysis and microscopic investigations confirm the existence and development of early ferrous metallurgy in these areas.

290. Archaeometrical method in the study of the nautical signalization on Roman Limes in the Iron-Gate area.

Radmila Zotovic, Sofija Petkovic

Institut Archéologique, 11000. Beograd.

The Limes on Danube in the Iron-Gate gorge was founded during the Roman conquest of the Central Balkan region. The construction of the road and fortifications with permanent garrison along the Danube was completed in the last quarter of the 1st century A.D. This was confirmed by two stone Tablets of Tiberius from 33-34 A.D. and Claudius from 46. A.D. found at Gospodin Vir. Several phases of the construction were the following up to the renovation of Justinian I. in the 6th century A.D.

The function of the fortifications in the Iron Gate's section of Limes could be observed in the military - strategic scope, but also from the economical point of view. We could presume that these fortresses on Danube had the important merchant communication and provided the overcoming of the natural obstacles on this way.

The Iron Gate is consisted of the series of gorges at the Danube, section from Golubac to Karataš. It has nearly vertical slopes, over 800 m high in some places, intersected by small river's valleys linking the Danube bank with the inland of Upper Moesia.

The great density of the Roman fortifications in the Iron Gate gorge is obvious at the first glance. Thirty fortresses were recorded by archaeological research, up to now, between Golubac (Cuppae) and Karataš (Diana), at the right bank of Danube. The average distance between these fortifications is about 5 km in the air-line. In the Upper Gorge (Gornja Klisura), from Gospodin Vir up to Donji Milanovac (Taliata) the concentration of the Roman strongholds in even greater.

The position of the fortifications in the Iron Gate described, provided the facility of communication among the garrisons, by optical signalization at the first place. The signals could have been sent by natural or artificial light sources, amplified with the system of mirrors. Meanwhile, some of the fortifications were separated by cliffs, which made an optical barrier. The fortresses on the left bank of Danube, as well as the ships with military crew controlling the navigation, could have been the transmitter of these signals.

The methods we used were: 1. the analysis of the possibilities of the optical signalization and 2. the statistical analysis of distances and density of the fortifications on the Danube section in question.

The fortifications on the Roman Limes in the Iron Gate, according to the results of this analysis, had at least three functions:

1. to ensure the Frontier

2. to control the navigation on Danube in the Iron Gate and

3. as nautical stations for signalization, providing the safe sailing in the Iron Gate gorge.

291. Mesolithic gums and glues: analytical investigations and archaelogical implications

E. M. Aveling*, C. Heron*, L. Larsson**

*Department of Archaeological Sciences, University of Bradford, Richmond Road, Bradford, West Yorkshire, BD7 1DP, U.K.
**Institute of Archaeology and the Historical Museum, Krafts Torg 1, S-23350 Lund, Sweden

The source of amorphous organic substances surviving on Mesolithic artefacts or as isolated aggregates (often with human tooth impressions) has long been sought. Indeed investigation of such materials from Scandinavian bog sites dates back to the nineteenth century. More recently, the application of new analytical approaches offers a unique opportunity to study for the first time, a large number of samples. Whereas substances such as birch bark tar, conifer wood tar and beeswax have been identified in European Neolithic contexts, comparative studies of Mesolithic material have until now been minimal.

To this end we report results from a project funded by the British Academy, focusing on the characterization of natural products of Mesolithic date in northern Europe. Material from Star Carr, Yorkshire, and a number of Scandinavian sites including Ageröd V, Sweden, Barmose, Denmark, and Huseby Klev, Sweden has been studied. These samples date from the early Maglemose to the Ertebolle period. In addition an early example of a Neolithic adhesive from the Sweet Track (Somerset Levels) has been analysed.

The techniques used include gas chromatography and gas chromatography/mass spectrometry. The manufacture and characterization of modern reference materials is also being carried out. Identification of these samples allows consideration of the use of specific natural resources throughout the Mesolithic. Questions relating to possible social and medicinal functions of tars and resins as well as their technological functions are also being addressed.

292. Technology and organization of Inka pottery production: neutron activation analysis and Mössbauer spectroscopy studies

F. Hayashida*, M. Glascock, H. Neff**, J. Riederer***, U. Wagner***

*Physik Department E-15, Technische Universitaet Muenchen, 85747 Garching, Germany;
** Missouri University Research Reactor, Columbia, Missouri 65211, USA;
***Rathgen-Forschungslabor, 14059 Berlin, Germany

In the Andean Inka empire (ca. 1400-1532 A.D.) skilled artisans were relocated to provincial administrative centers to produce goods for the state. During recent fieldwork at two Inka centers on the North Coast of Peru, archaeologists discovered a series of state pottery workshops. Inka, local, and hybrid styles of pottery were manufactured using a variety of techniques. In addition, molds, firing pits, and unfired pottery were also found. Research at these sites provides the unique opportunity to document manufacturing techniques and to examine how production decisions might have been directed by the state.

Archaeometric analyses focus on reconstructing the technology and organization of production. Thin section and neutron activation analysis in combination with Moessbauer spectroscopy examine raw material selection and firing technology. Both sherds and pieces of unfired pottery were analyzed. Results indicate that local and Inka style vessels did not significantly differ in raw materials. However, large Inka jars used to serve beer at major state festivals were fired using a nonlocal (Inka) technique. Likewise, molds used to manufacture these politically important jars are highly standardized in composition, suggesting state-directed decisionmaking. Results of the archaeometric study contribute to an understanding of the Inka political economy and illustrate the importance of locating and examining manufacturing locations.

293. An archaeometallurgical survey in the ancient mining area of Hadim-Bozkir (Konya, Turkey)

Kemal Sertok*, Alberto M. Palmieri, Filomena F. Squadrone*****

*Gaziantep Museum, Gazientap-Turkey
**Istituto per le Tecnologie Applicate ai Beni Culturali, CNR Roma, Italy
***Dip. di Scienze delle Antichita, Univ. di Roma "La Sapienza", Via Palestro 63- 00185 Roma-Italy

The survey presented here took place on the NE slopes of Taurus Mountains at 1500-2000 m above sea level, in the actual districts of Hadim and Bozkir (Konya, Turkey), ancient Rough Cilicia or Northern Isauria, covering an area of about 400 km^2 .

During the excavation and cleaning operations done by the Konya Museum in the ancient site of Astra, which is situated within the borders of this region, were found large amounts of minerals, metals, slags and fragments of a furnace. This work gave us the opportunity to start a research in an area lacking of archaeometallurgical surveys.

The geological setting of the region reveals that it was very reach in lead, zinc and iron ores, and possibly used for ancient metal production since some slag deposit and ancient mining galleries were found by geologists. In the seventies some mining companies tried to produce metals following a primitive method, but Ottoman archives from the 19th century attest the effective production of lead as well as silver and gold.

On the basis of these informations we started our survey with the following goals:

1. - to localize ancient sites and areas of mining and metal production,
2. - to record the evidences of metallurgical activities (mining galleries, deposits of slags, furnaces, crucibles, etc.),
3. - to collect and analyze samples to get more information about:
    a - the mining activities and metal production steps.
    b - the cultural context,
    c - the chronological framework,
4. - to restore the ancient mining life, the circulation and uses of minerals and metals.

During few weeks in the summers of 1994 and 1996, we were able to localize at least fifteen ancient sites mostly unrecorded and possibly dating from roman period, and to limit four main sections by mining galleries and metal preparation-production areas. Twenty of the metallurgical samples (metals, slags and minerals) and two of the wood samples submitted to laboratory analyses gave information useful for a preliminary reconstruction of the archaeometallurgical and chronological framework. The results obtained after this short term work encouraged us to carry on our research.

294. Study of black layer on ancient Chinese bronzes

Quanyu Wang, John Merkel

Institute of Archaeology, UCL, Gordon Square 31-34, London WC1H 0PY

A large number of bronze objects were unearthed from the nobility tombs of the Jin State, one of the vast states during 1027-450B.C. at Qucun site, Shanxi, China from 1992 to 1994. Bronze fragments from the tombs are examined by macroscopic observation, metallographic observation, XRD analysis and SEM/microprobe analysis. The most interest is that a black layer is present on the surface of the original metal for some of these bronzes. The question has been raised: is the black layer intentional patination or natural corrosion product? What was the technique if it was a intentional patination? How did it form if it was from the corrosion process. This paper try to give a answer to this question.

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*

Hungarian archaeometrical research is specially indebted to: Miklós Bakos, Ida Bognár-Kutzián, György Duma, Ernő Gegus, Nándor Kalicz, Pál Kertész, Miklós Kretzoi, Amália Mozsolics († 1997) Pál Patay, József Verő

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ISBN 963 9046 18 3

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Edited by: Katalin T. Biró and Tünde Horváth

Printed in the Printing House of the Hungarian National Museum in 400 copies

Publisher: István Gedai

Printing Manager: Gyula Stemler