

RELATED ABSTRACTS

ARCHAEOOMETRY and ANTROPOLOGY – INORGANIC MATERIALS

Dating European Palaeolithic Cave Art: Progress, Prospects, Problems. Over the last decade several dozen direct dates on cave art pigments or associated materials have supplemented more traditional style-based attempts to establish a chronological (and developmental) scheme for cave art. In the "post-stylistic" era an holistic integration of pigment "recipe" analysis, formal stylistic analysis and direct chronometric dating have been applied to a handful of dates. Here, we examine the state-of-the-art of Palaeolithic cave art dating, with particular emphasis on certain radiocarbon and Uranium-series projects. We examine the relative successes and weaknesses of this cutting edge science. We conclude that there are several weaknesses in current applications that are in serious need of addressing. Issues of sample contamination and of the heuristic relationship between materials dated and the production of the art are particularly problematic. It follows that one should at present be very cautious about straightforward interpretations of apparent "dates" of cave art.

P. Pettitt, A. Pike, JOURNAL OF ARCHAEOLOGICAL METHOD AND THEORY,
14, 1, 27-47, MAR 2007

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Luminescence dating of monumental stone architecture at Chavin de Huantar, Peru. Optically stimulated luminescence (OSL) is applied to quartz extracted from mud mortar collected from Chavin de Huantar, an early Andean monumental center. The samples appear to have been only partially exposed to sunlight during construction, so a minimum age model is applied to equivalent dose distributions. Complications, including complex radioactivity, low sensitivity of the quartz, and limited sample, prevent high precision, but the 14 dates obtained cluster around 1000 BC largely in agreement with radiocarbon assays on charcoal also collected from the mortar. Results suggest a relatively rapid construction for the monument. This work develops OSL as a method for directly dating architectural mortar.

J.K. Feathers, J. Johnson, S.R. Kembel, JOURNAL OF ARCHAEOLOGICAL METHOD AND THEORY,
15, 3, 266-296, SEP 2008

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Archaeometrical Investigation of Sicilian Early Byzantine Glass: Chemical and Spectroscopic Data. A series of early Byzantine glasses, recovered in Ganzirri (Sicily, Italy), was analysed for major, minor and trace elements. All the analysed fragments were found to be natron-based silica-lime glass. Concerning minor and trace elements, the samples can be divided into two groups: glass with high Fe, Ti and Mn contents (HIMT glass) and glass with low levels of Fe, Ti and Mn. These results, strictly in agreement with literature data for glass of the Mediterranean region, can be interpreted as a consequence of the wide trade network established in this region and of the intense circulation of raw glass and artefacts from different Mediterranean areas. X-ray absorption spectroscopy studies at Fe and Mn K-edges, performed on HIMT glass, indicate that Fe is in the oxidized form while Mn is in the reduced form.

R. Arletti, C. Giacobbe, S. Quartieri, G. Sabatino, G. Tigano, M. Triscari, G. Vezzadini,
ARCHAEOOMETRY, 52, 1, 99-114, FEB 2010

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Mortar Studies Towards the Replication of Roman Concrete. The use of strong and durable materials is one essential ingredient leading to the survival of many monumental Roman concrete structures. Replicated concrete mortars with different lime to pozzolan ratios, encompassing the range likely to have been used by the Romans, have been studied here to determine their relative compressive strengths as a function of time. This has been supplemented by the use of the scanning electron microscope to delve into the structure and composition of the binders formed within the strongest and weakest mortars, leading to a deeper understanding of the reasons for the differences in compressive strength.

H. Goldsworthy, Z. Min, ARCHAEOOMETRY, 51, 6, 932-946, DEC 2009

A New Method for the Determination of the Provenance of White Marbles by Chemical Analysis of Inclusion Fluids: The Marbles of the Mausoleum of Belevi/Turkey.

A new method is presented in this paper to pinpoint the origin of white marbles using the chemical analysis of fluids occurring as micro-inclusions in calcitic or dolomitic marbles. Beside the conventional methods usually applied for this purpose, the analyses of significant anions and cations in fluids extracted from white marbles were used to characterize different types of marbles. Using this new approach it is possible to distinguish different groups of marbles which cannot be separated isotopically. A case study was performed on the mausoleum of Belevi, close to Ephesus in Turkey, and the quarries in the area of the mausoleum. The marbles used for the architecture of the mausoleum cannot be distinguished isotopically but were split into two groups when using fluid inclusion analysis. The corresponding quarry for the high-quality marble (cella walls, columns etc.) turned out to be the Kentli Ciftligi quarry, which also supplied the marbles for the classical Artemision. According to the chemical and fluid data it can be shown, however, that neither the adjacent famous antique quarry of Belevi nor the underground mine of Kusini, some 5 km away from the mausoleum, are the sources for the marbles used for the construction or decoration of the mausoleum.

W. Prochaska, S.M. Grillo, *ARCHAEOLOGY*, **52**, 1 59-82, FEB 2010

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Late Classic Maya Pottery Production: Review and Synthesis.

Studies of the organization of Maya pottery production have been pursued via numerous methods but without theoretical models. I review available data on production of Late Classic southern lowland Maya polychrome pottery in light of my calendrically based may model of geopolitical organization. I conclude that: (1) production arrangements vary by "kind" of pottery; (2) "craft specialization" and "workshops" are inappropriate concepts; (3) study of polychrome production necessitates multiple approaches, including analysis of decorative content; (4) better "bridging arguments" and "middle-range theory" are needed; (5) figural polychromes were "inalienable" wealth goods; and (6) they were painted in palaces of primary and secondary centers-may and k'atun seats in the model-in realm-specific signature styles.

P.M. Rice, *JOURNAL OF ARCHAEOLOGICAL METHOD AND THEORY*,
16, 2, 117-156, JUN 2009

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Study of Some Atypical Formations from the Bulk of the Iron Artefacts by Means of Complementary Analytical Techniques.

The paper presents the experimental results obtained by applying non-invasive methods such as the optical microscopy (OM), the Scanning Electron Microscopy coupled with the EDX Spectrometry for determining the surface and the internal microstructures (cross-section) for the elements arranged within the corrosion crust on the metallic fragments with atypical formation discovered in cremation and inhumation graves from the IInd and IIIrd centuries A.D. The archaeological artefacts are from the site at Valeni-Botesi, Neamt County. Thus, we have studied the nature and the microstructural arrangement of the chemical components resulted from the corrosion and contamination processes, characteristics very important in the authentication, the determination of the conservation state and the establishing of the proper procedures for the active conservation and the restoration of the artefacts.

I. Sandu, O. Mircea, I. Sarghie, A.V. Sandu, *REVISTA DE CHIMIE*,
60, 10, 1012-1020, OCT 2009

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Archaeometallurgical characterization of some ancient copper and bronze artifacts from Albania,

Ancient copper and bronze artifacts from different Albanian archaeological sites have been analyzed by X-ray-fluorescence analysis to determine the type of alloy and elemental composition and by Optical Microscopy for the investigation of corrosion products and microstructure of the bulk metal. Three bronze coins excavated in Dyrrahu, dating to the IIIrd -IInd century B.C, are composed of copper, tin and lead. Both studied nails, one excavated in Dyrrahu (IVth -IIIrd century B.C), and the other one found inside an amphora in an ancient ship close to the coast of Saranda (VIth -IVth century B.C), are composed of copper. The strata-graphical morphology and microstructure images from microscopic examinations allowed us to identify different corrosion products and the diverse stages of metallurgical and mechanical treatment during their manufacture.

T. Dilo, N. Civici, F. Stamati, O. Cakaj, *AIP CONFERENCE PROCEEDINGS* (7th International Conference of the Balkan Physical Union; Alexandroupolis; 9 September 2009 through 13 September 2009; **Code 79345**),
vol. 1203, 985-990, 2009

Pedological stratification effect of corrosion and contamination products on Byzantine bronze artefacts. The present paper deals with the identification of six ancient Byzantine bronze coins found in the same archaeological site of Nufarul (Tulcea County, Romania), by corrosion product and alloy analysis. The microstratigraphies (i.e. layers), together with microchemical tests including reflection colorimetry, IR spectroscopy, X-ray diffraction and scanning electron microscopy assisted by X-ray spectrometry have rendered evident the stratified morphology of three types of patina. They are the primary type resulting from redox processes, the secondary type determined by acid-base and related hydrolytic processes and the ternary type (or the contamination patina) from segregation, diffusion and osmosis processes. The stratigraphical distribution of the chemical components in the structure of the patina is caused by the pedological (soil) processes at the archaeological sites and can be the main factor used in the authentication of ancient bronze artefacts.

I. Sandu, N. Ursulescu, I.G. Sandu, O. Bounegru, I.C.A. Sandu, A. Alexandru, CORROSION ENGINEERING SCIENCE AND TECHNOLOGY, **43**, 3, 256-266, SEP 2008

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Early stages of copper corrosion behaviour in a Tunisian soil. The early stages of copper corrosion in a Tunisian soil were studied using mass loss, surface analysis (optical microscopy, visible spectroscopy, IRTF and atomic force microscopy) and electrochemical characterizations (polarization curves and cyclic voltammetry). The corrosion rate dependence with immersion time was $m = atb$. Two behaviours for the material surface were evidenced when varying the soil concentration and temperature. Then, the apparent kinetic constant, the soil reaction order and the apparent activation energy were calculated. Analytical and electrochemical characterizations showed that a rough patina layer was build up as a result of the interaction between soil and copper.

N. Souissi, E. Triki, MATERIALS AND CORROSION, **61**, 6, 431-438, JUN 2010

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Petrography and Provenance Interpretation of the Stone Moulds for Bronze Daggers from the Galdong Prehistoric Site, Republic of Korea. This paper presents material characteristics and raw material provenance of the stone moulds for bronze slender daggers from Galdong. This type of bronze dagger is uniquely distributed in the Korean Peninsula and these stone moulds were the first to be found by excavation. The stone moulds were made of igneous hornblendite with course-grained holocrystalline textures. Based on petrological, mineralogical and geochemical characteristics, the original rock materials of the moulds were inferred to be derived from the Jangsu or Namwon areas which are about 50 km away from the excavation site. It is a notable achievement that this provenance study confirmed the domestic production of Korean-styled daggers.

C.H. Lee, J. Kim, M.S. Lee, ARCHAEOLOGY, **52**, 1, 31-44, FEB 2010

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The Effect of Salts on Thermal and Hydric Dilatation of Porous Building Stone. Fifteen desalinated sandstone drill core samples from Umm Ishrin Sandstone Formation in Petra (Cambrian age) were used for this study. The samples were mineralogically analysed using X-ray diffraction and their physical properties were also determined. Samples with similar physical properties and mineralogical composition were taken for further experimental work. After desalination, thermal and hydric dilatation coefficients were measured, then three types of salts (NaCl, KCl and $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$), which have high solubility and consequently are the most dangerous to building stone (and are also detected in the sandstone monuments in Petra), were introduced into the samples and their contents were calculated. The results show that salt crystallization in the pores of building stones can increase their thermal dilatation and decrease their hydric dilatation to varying extents, depending on the nature of the salt. The average increase in the thermal dilatation coefficient per unit mass of salt is the lowest for the $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ -salted samples with a value of 5.3%, while the NaCl-salted samples have the highest value with 7.8% per salt mass. The average percentage of the decrease of the hydric dilatation coefficient is 1061% for $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ -salted samples per mass of salt content; the NaCl-salted samples have a value of 1510% per mass of salt content, and the KCl-salted samples almost the same value. For the salt-free samples, it was found that in climatic conditions with a high temperature range, the deterioration of sandstone due to temperature fluctuation is more effective than that caused by change in the moisture content, while samples with high salt content suffer more from hydric dilatation.

M. Al-Naddaf, ARCHAEOLOGY, **51**, 3, 495-505, JUN 2009

Evidence for the Use of Egyptian Blue in an 11th Century Mural Altarpiece by SEM-EDS, FTIR and SR XRD (Church of Sant Pere, Terrassa, Spain). The present study shows the analysis performed on pigment samples taken from Sant Pere (Terrassa, Catalonia, Spain), a remarkable church built in the Romanesque style. On the basis of the results obtained from the analysis, an interesting discussion arises after finding evidence of Egyptian blue in one of the samples, a discovery that was not expected due to the time period of the samples. The pigments were identified by the combined use of FTIR and SEM with an EDS facility. For the blue pigment, since the EDS and FTIR analyses suggested the possible presence of cuprorivaite, micro-XRD experiments using synchrotron radiation were run.

A. Lluveras, A. Torrents, P. Giraldez, M. Vendrell-Saz, *ARCHAEOLOGY*, **52**, 2, 308-319, APR 2010

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Multitechnique characterization of lapis lazuli for provenance study. Lapis lazuli is one of the oldest precious stone, being used for glyptic as early as 7,000 years ago: jewels, amulets, seals, and inlays are examples of objects produced using this material. Only a few sources of lapis lazuli exist in the world due to the low probability of geological conditions in which it can form, so that the possibility to associate the raw material to man-made objects helps to reconstruct trade routes. Since art objects produced using lapis lazuli are valuable, only nondestructive investigations can be carried out to identify the provenance of the raw materials. Ionoluminescence (IL) is a good candidate for this task. Similar to cathodoluminescence (CL), IL consists in the collection of luminescence spectra induced by megaelectronvolt ion (usually protons) irradiation. The main advantage of IL consists in the possibility of working in air while measuring simultaneously the composition of major and trace elements by means of complementary ion beam analysis techniques like particle-induced X-ray emission (PIXE) or particle-induced gamma-ray emission (PIGE). In the present work, a systematic study of the luminescence properties of lapis lazuli under charged particle irradiation is reported. In the first phase, a multitechnique approach was adopted (CL, scanning electron microscopy with microanalysis, micro-Raman) to characterize luminescent minerals. This characterization was propaedeutic for IL/PIXE/PIGE measurements carried out on significant areas selected on the basis of results obtained previously. Criteria to identify provenance of lapis lazuli from four of the main sources (Afghanistan, Pamir Mountains in Tajikistan, Chile, and Siberia) were proposed.

A. Lo Giudice, A. Re, S. Calusi, L. Giuntini, M. Massi, P. Olivero, G. Pratesi, M. Albonico, E. Conz, *ANALYTICAL AND BIOANALYTICAL CHEMISTRY*, **395**, 7, 2211-2217, DEC 2009

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Infrared Reflection Spectrometry Analysis as a Non-Destructive Method of Characterizing Minerals and Stone Materials in Geoarchaeological and Archaeometric Applications. The purpose of this paper is to show the benefits and applications of using mid and far infrared reflection spectrometry (IRS) in the analysis of archaeological materials. Infrared spectral databases do not yet exist for rocks and principal minerals. In support of IRS techniques, a catalogue and new spectral database have been created with over 500 infrared reflection spectra in mid and far ranges from more than 250 different archaeological minerals and stone materials. The reflection spectrum serves as a "fingerprint" of all these materials. This new, non-destructive method is useful for spectrometric identification and crystal chemical characterization of many rocks and minerals commonly found in archaeological contexts. Three brief examples of IRS analysis of archaeological materials are presented as test cases. It is suggested that: IRS could and should become a routine approach in geoarchaeology and archaeometry for identification and provenance studies.

M. Ostrooumov, *GEOARCHAEOLOGY-AN INTERNATIONAL JOURNAL*, **24**, 5, 619-637, SEP-OCT 2009

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Role of laser ablation-inductively coupled plasma-mass spectrometry in cultural heritage research: A review.

Cultural heritage represents a bridge between the contemporary society and the past populations, and a strong collaboration between archaeologists, art historians and analysts may lead to the decryption of the information hidden in an ancient object. Quantitative elemental compositional data play a key role in solving questions concerning dating, provenance, technology, use and the relationship of ancient cultures with the environment. Nevertheless, the scientific investigation of an artifact should be carried out complying with some important constraints: above all the analyses should be as little destructive as possible and performed directly on the object to preserve its integrity. Laser ablation sampling coupled to inductively coupled plasma-mass spectrometry (LA-ICP-MS) fulfils these requirements exhibiting comparably strong analytical performance in trace element determination. This review intends to show through the applications found in the literature how valuable is the contribution of LA-ICP-MS in the investigation of ancient materials such as obsidian, glass, pottery, human remains, written heritage, metal objects and miscellaneous stone materials. The main issues related to cultural heritage investigation are introduced, followed by a brief description of the features of this technique. An overview of the exploitation of LA-ICP-MS is then presented. Finally, advantages and drawbacks of this technique are critically discussed: the fit for purpose and prospects of the use of LA-ICP-MS are presented. (c) 2008 Elsevier B.V. All rights reserved.

A. Giussani, D. Monticelli, L. Rampazzi, *ANALYTICA CHIMICA ACTA*, **635**, 1, 6-21, MAR 2 2009

On-site analysis of archaeological artifacts excavated from the site on the outcrop at Northwest Saqqara, Egypt, by using a newly developed portable fluorescence spectrometer and diffractometer. Blue-painted pottery was produced in the New Kingdom, Egypt, and decorated with blue, red, and black pigment. In this study, two newly developed portable instruments, a portable X-ray fluorescence spectrometer and a portable X-ray powder diffractometer, were brought to the site on the outcrop at Northwest Saqqara, an archaeological site in Egypt, to verify their performance in on-site analysis of excavated artifacts at the site. Pigments used for the blue-painted pottery and plasters in the New Kingdom were analyzed by these instruments on the basis of both their chemical compositions and crystal-structural information. The blue pigments were identified as two different pigments, Egyptian blue and cobalt blue. The diffraction pattern of the blue pigment of the painted pottery exhibited that of spinel structure. The XRF spectrum of the blue pigment obtained by the same instrument from the same position indicates the presence of Mn, Co, Fe, Ni, and Zn. The possibility of compositional transitions of the cobalt blue pigment with time was revealed on by detailed analysis of the XRF data. The reason for the transitions is considered together with the archaeological background of the New Kingdom, Egypt.

Y. Abe, I. Nakai, K. Takahashi, N. Kawai, S. Yoshimura, ANALYTICAL AND BIOANALYTICAL CHEMISTRY, 395, 7, 1987-1996, DEC 2009

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Archaeometric investigation of Roman tesserae from Herculaneum (Italy) by the combined use of complementary micro-destructive analytical techniques. Vitreous tesserae from two mosaics in Herculaneum (Italy) dating from the 1st century AD have been investigated in order to gather information on Imperial Age opaque glass. The combined use of complementary micro-destructive analytical techniques, namely optical microscopy (OM), scanning electron microscopy (SEM) with energy dispersive spectrometry (EDS), inductively coupled plasma-mass spectrometry (ICP-MS), transmission electron microscopy (TEM), and X-ray powder diffraction (XRPD) allowed to define the nature of formers, fluxes, chromophores and opacifying compounds and to determine the type of raw materials employed for their introduction. The results confirmed the high technological level of Imperial Age glassmakers and clarified some details of the production processes. Experimental data have been obtained concerning formation of antimony-based opacifiers. The presence of tin-containing Ca- and Pb-antimonates has been ascertained in various green, yellow and turquoise tesserae. Moreover, unusual divergences from the established Roman age 'low magnesia-low potash' (LMLK) glass composition have been found for some red and green samples.

I. van der Werf, A. Mangone, L.C. Giannossa, A. Traini, R. Laviano, A. Corralini, L. Sabbatini, JOURNAL OF ARCHAEOLOGICAL SCIENCE, 36, 12, 2625-2634, DEC 2009

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Archaeological and historical glasses: A bibliometric study. Glass is one of the materials more widely developed throughout History. In the last decades, it has been stated a growing demand in the application of chemical-physical techniques to obtain more detailed information on technology and production of glasses in past societies. This research field lies within the domain of archaeometry. Results of a bibliometric study undertaken on 201 scientific articles published on ancient and historical glasses between 187 and 2008 are presented in this paper. The study was carried out with the aim to address the evolution of glass archaeometric investigations in the last 20 years. Date of publication, journal and article types, topic, glass typology, analytical techniques, origin country of authors, and geographic location of samples were analyzed in this study, among other parameters. Resulting data indicate that archaeometric research on glasses has experienced all exponential growth in the period 2000-2008. Roman and Medieval glasses have been the materials more frequently investigated.

T. Palomar, M. Garcia-Heras, M.A. Villegas, BOLETIN DE LA SOCIEDAD ESPANOLA DE CERAMICA Y VIDRIO, 48, 4, 187-194, JUL-AUG 2009

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Occurrences of Green Earth Pigment on Northwest Coast First Nations Painted Objects. An analytical study of First Nations painted objects from the Northwest Coast showed that green earth (celadonite) was used as a green pigment by Tlingit, Haida and Tsimshian artists. Green earth appears to have been used less frequently by Heiltsuk and Kwakwaka'wakw artists and was not found on Coast Salish or Nuu-chah-nulth objects. Microscopical samples of green paint from 82 Northwest Coast objects, as well as several pigment sources and mineral specimens, were analysed using Fourier transform infrared spectroscopy or X-ray diffraction. Green earth was the most frequently identified green pigment, found in approximately 40% of the samples.

I.N.M. Wainwright, I. N. M., E.A. Moffatt, P.J. Sirois, ARCHAEOLOGY, 51, 3, 440-456, JUN 2009