

THE  
BRITISH  
MUSEUM



# 10<sup>th</sup> European Meeting on Ancient Ceramics, EMAC '09

The British Museum



## ABSTRACTS



## **EMAC (European Meeting on Ancient Ceramics)**

**Organised by the Department of Conservation and  
Scientific Research, The British Museum and  
The Institute of Archaeology, University College London**

**Held in the Clore Centre of the British Museum**

**10-13 September 2009**

## Preface

### EMAC09

The UCL Institute of Archaeology and the British Museum Department of Conservation and Scientific Research are proud to organise the tenth anniversary European Meeting on Ancient Ceramics this year. We would like to welcome you to the British Museum, to London, and indeed the UK.

This is a year of big anniversaries; 2009 sees not only the tenth EMAC, but also 250 years since the public opening of British Museum, and the 250<sup>th</sup> anniversary of Wedgwood, the iconic ceramic company. The British Museum was one of the first institutions to establish the scientific study of archaeological materials, be it for conservation purposes or in pursuit of knowledge about materials, technologies or cultures. Josiah Wedgwood almost single-handedly transformed pottery production from a cottage industry in the West Midlands into a true science-based enterprise, inventing *inter alia* the pyrometer, and systematically experimenting with clay mixtures and glaze batches. Thus, we felt it appropriate to place EMAC09 under the title 'From Craft to Science', highlighting the unique British contributions to the history of ceramic research.

When we first applied for funding to organize EMAC, we told the funding body that "the main focus of EMAC is the scientific study and archaeological interpretation of ancient ceramics. Bringing together established scholars and young researchers from a wide range of academic backgrounds, including ceramic petrologists, chemists, material scientists, geologists, archaeologists and art historians, EMAC stimulates an international and cross-faculty exchange of ideas and approaches." Although the application in question was ultimately unsuccessful, we are very pleased to see that our description of what EMAC is about, and how it brings together many colleagues, students and friends across academic and geographical boundaries, has been confirmed again this year.

Stimulated by the Wedgwood anniversary and the numerous contributions that he and his contemporaries made to the development of ceramics materials science, we introduced a special session, **From Craft to Science**. We are delighted that Dr Gaye Blake-Roberts, the Director of the fabulous new Wedgwood Museum in Stoke-on-Trent, has agreed to give us a public lecture on Friday evening, under the title '**Wedgwood – the Arts and Sciences United**', and look forward to an insightful special lecture. Do not forget to visit the Wedgwood Museum in Stoke-on-Trent, if you can at all!

The second special focus of this EMAC is on Islamic Ceramics, to highlight the British Museum's collections of Islamic materials and the truly splendid **John Addis Islamic Gallery** at the British Museum, as well as the increasing interest in Islamic archaeology on a wider scale. The reception on Thursday evening in this gallery will give you a taste of how beautiful ceramics can be. We are still negotiating with the sponsor of this EMAC how best to announce their support, and hope to have the Addis Gallery as the fitting venue for this.

However, we are not neglecting the traditional topics of EMAC, and the final programme now includes nearly one hundred presentations and posters on a very wide range of topics, including Method Developments, Building Materials, and Technology and Provenance. Of course, the relative proportions of these within the overall programme vary, and reflect the number of papers in each category as submitted by the participants. As always, there were many more requests for oral presentations than we could accommodate within the three short days of this conference, and we had to ask many authors to present their work as posters. However, we hasten to add that the distinction between posters and oral presentations was done primarily on practical considerations and suitability of medium, and does not imply a different level of scholarship or quality between the two. Of course, all presentations, oral and poster, will be invited for

submission to the peer-reviewed conference proceedings, and treated absolutely equally in the review process.

Looking at the programme now, we are proud to have presentations from scholars from across the world, including papers by our keynote speakers: Ian Freestone, Clive Orton, Hector Neff, and Venetia Porter. Unfortunately, Prudence Rice, who also had agreed to give a keynote lecture, had to pull out at the very last minute. But the programme is still truly global, with speakers and topics from China, across Asia and Europe, and right to the Americas. Yes, it is still the European Meeting on Ancient Ceramics, but as much as ceramics travelled far and wide, as much can we only gain from a look across the shoulder of our colleagues elsewhere. Not for nothing is UCL calling itself the '*Global University*' and the British Museum 'A museum of the world, for the world'.

All this would not have been possible without the fantastic support we had from colleagues at our two institutions. We would like to acknowledge the support of the British Museum and UCL Institute of Archaeology in providing the venues and facilities for hosting EMAC09. We would particularly like to thank those at the British Museum and the UCL Institute of Archaeology for all their support and assistance in organising and hosting these events which are usually less visible than the official Organising Committee, but who have done much of the 'leg work' to make EMAC09 happen: staff and students from the Institute and colleagues in the Department of Conservation and Scientific Research and in the Department of the Middle East, and last but not least the most crucial Audiovisual, Information Services and box office staff. The local organising committee apologise if in editing these abstracts we have inadvertently changed the authors' meaning.

We thank the Scientific Committee for its generous advice on the programme, their support and balanced comments on difficult decisions regarding the acceptance or rejection of papers, the distribution of papers between oral and poster presentations, and more generally for encouraging us along the way. We are sorry that not all of its members are able to join us today to see the fruits of their labour, and to celebrate the achievements of so many scholars in the field of ancient ceramics, over the last few years.

We mentioned above that our funding applications were not as successful as we had hoped; but we are most grateful for the generous support we have received, without which this conference would not have been possible. In addition to the contribution to the organisational costs, it enables us to promise each participant a free copy of the resulting proceedings: hopefully in time for the next meeting in two years. So make sure you stay in touch and come to the next EMAC, to collect your complimentary copy of EMAC09 – From Craft to Science.

We believe that EMAC09 will provide you a unique opportunity to experience a little bit of the immense contribution which Britain has made to the development of pottery production in the past, as well as for the scientific study of ancient ceramics more recently. There is an outstanding range of collections of ceramics of all periods and origins in London, not only at our two institutions, and visiting these will further contribute to the richness of your visit. We hope you enjoy EMAC09, your visit to the British Museum and, as ever, we hope to create an informal, productive and friendly atmosphere for the exchange of ideas and discussion.

The local organising committee

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## **Legend of abbreviation for common techniques mentioned in the abstracts:**

DTA: differential thermal analysis

EDXRF: energy dispersive XRF

EPMA: electron probe micro-analyzer

FTIR: Fourier transform infrared

INAA: instrumental neutron activation analysis

LA-ICP-MS: laser ablation inductively coupled mass spectrometry

MC-ICP-MS: multi collector-inductively coupled plasma mass spectrometry

NAA: neutron activation analysis

OM: Optical microscopy

OSL: optically stimulated luminescence

PGAA: prompt-gamma activation analysis

PIGE: particle-induced gamma-ray emission analysis

PIXE: particle induced x-ray emission

PXRF: portable XRF

XRD: x-ray diffraction

XRF: x-ray fluorescence

XRPD: x-ray powder diffraction

REE rare earth elements

SEM: scanning electron microscope

SEM-EDS: scanning electron microscopy used with energy dispersive spectroscopy

SEM-EDX: scanning electron microscopy used with energy dispersive spectroscopy

TL: thermoluminescence

WD-XRF: wavelength dispersive XRF

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## **Chemical investigation of blue ceramic glazes of some mosques in Isfahan (Iran)**

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Ancient Islamic monuments are usually coated with coloured glazed tiles or ceramic mosaics, and the use of blue glazes is wide-spread. The manufacturing technique of these wall coatings is unique in the world and it is particularly well known in Iran. The glazes are obtained using quartz as the matrix material with lead as a 'softener', and further contain inorganic pigments for colouration. The blue glaze can be produced using different types of pigment, mainly cobalt minerals, copper compounds and sometimes lapis lazuli. Of course, these pigments give rise to different blue tonalities, and they are used in different amounts. Many of the glazes have shown severe degradation effects over time, including decolouration, so that frequent restoration works are necessary.

In this paper, many samples from historical mosques in Isfahan, dated from the seventeenth to the eighteenth century, were taken into consideration, mainly in order to explain the mechanisms of decolouration of some blue glazes. The samples include original and restoration materials. Sometimes it is difficult to distinguish original and modern tiles, but this distinction becomes easier after their characterisation. In addition, commercial blue pigment powders and samples of recent tiles utilised for restoring very damaged façades, were included in the study.

The characterisation of ancient and modern materials were carried out through observation of thin sections using optical microscopy, chemical analyses by X-ray fluorescence and inductively coupled plasma emission spectroscopy, mineralogical analyses through X-ray diffraction, thermal gravimetric and differential analysis, and chemical microanalysis using a scanning electron microscope equipped with energy dispersive spectroscopy. It was found that the kind of pigment and the sintering process are closely related to the resistance of the glaze to ageing processes such as bleaching and pulverisation. It is suggested that only glazes with lazurite (synonymous of lapis lazuli) type pigments undergo severe degradation, initiated by UV radiation and propagated by rainwater.

## **Computerised documentation of painted decoration on pottery vessels employing 3D scanning**

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Computerised recording and analysis of ancient pottery vessels has advanced considerably in the past few years and its importance to archaeological research has been demonstrated and acknowledged. Several studies have managed both to record large quantities of pottery sherds efficiently and accurately, and to analyse their morphology and typology in a mathematical manner. However, the painted decoration on the surfaces of the vessels has not yet been treated using these procedures.

The paper examines the possibility of the incorporation of painted decoration on pottery into the computerised documentation of ceramics, employing 3D scanning. Painted decoration on pottery, when present, is one of its significant components in relation to archaeological research and interpretation, yet, so far, very few studies tackle the issue of computerised analysis of painted decoration on archaeological artifacts, whether in regards to 2D or 3D acquisition. The computerised documentation of pottery decoration entails several methodological issues that will be evaluated and discussed. A geometrical issue is the projection of a drawing from a curved surface (the vessel's surfaces) to a plane. This is a problem dealt with in detail in cartography, and will be applied here for the computerised documentation of decoration on pottery vessels. Another issue deals with transforming the digitised texture signal obtained from the 3D scan to a depiction which conforms with the conventions and standards of archaeological publications. A new method is described for the recording of standard decorations painted on the surfaces of pottery vessels as 2D images, viewed in various projections. The diverse images are captured directly from the 3D model after it was accurately positioned. The output is automatically incorporated together with the final drawing of the vessel in the final publication. Several archaeological examples are presented and discussed.

## **Luminescence dating of ceramic building materials: application to the study of early medieval churches in northwestern France and southeastern England**

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Within the framework of a European research project, brick samples from early medieval religious buildings in Kent and Essex (England) and Normandy and Pays de Loire (France) were analysed in the luminescence laboratories of the universities of Bordeaux (France) and Durham (UK). The archaeological purpose was to determine whether medieval builders practised the reuse of ancient building materials salvaged from neighbouring ruined Roman sites or if the bricks used were made for the purpose of the medieval building, and therefore were contemporary to it.

To determine the origin of the production of the ceramic material, luminescence dating was applied on bricks sampled from standing Anglo-Saxon or Carolingian churches. Furthermore, intercomparative studies were performed on the same samples divided between the two laboratories, in order to evaluate the precision and the accuracy of both luminescence methods (optically stimulated luminescence, thermoluminescence), of the various techniques (polymineral fine grain or quartz techniques) and protocols (additive dose with regeneration procedure on multiple aliquots, single aliquot regeneration technique etc) employed.

The final results of the luminescence dating show both practices were used in both countries: besides the reuse of salvaged Roman materials, brickmaking was not unknown to medieval builders, as has long been assumed. The data of the intercomparison generally indicate good agreement in the measurements between the two laboratories; however, some discrepancy appears in the age calculation depending on the technique used, regardless of the laboratory. A synthesis of the results obtained on the dating of bricks from early medieval churches is presented here, and an assessment of these contributions to the history of medieval building is offered.

## **Similar yet different: trace element discrimination of Early Iron Age fine ware productions in Central Crete**

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Interest in the Early Iron Age of Crete is rapidly expanding and focuses upon the social and political developments that took place between the end of the Bronze Age and 'the emergence of the polis' from the 8<sup>th</sup> century BC onwards. However, scientific analyses in the form of intensive application of geochemical and petrographic analyses have mainly been directed towards prehistory, leaving the early periods of the 1<sup>st</sup> millennium BC somewhat neglected. One aim of our project was to transfer the rich analytical knowledge of Cretan Bronze Age pottery to the subsequent periods. To this end, a large-scale analytical study of coarse and semi-fine wares from central Crete was designed to investigate pottery technology and regional exchange networks. A total of 414 pottery and 28 geological samples were analysed by thin section petrography. Comparison between the petrofabric groups of two different communities, Knossos and Thronos Kephala (ancient Sybrita), allowed us to shed some light on the extent to which there was basic continuity in the production and consumption of coarse and cooking wares during this period and the degree to which production was geared to local consumption. Moreover, the degree to which Knossos or Thronos Kephala was importing coarse wares either from within Crete or from elsewhere in the Aegean and the Mediterranean was also assessed.

This paper will specifically focus on new elemental data obtained by NAA, in an effort to complement petrographic results for those finer-grained fabrics that were not successfully characterised under the microscope due to the absence of a diagnostic rock or mineral coarse fraction. Therefore, the main goal of chemical analysis on a sub-sample of 203 semi-fine sherds and 12 clays was to differentiate the fine fabrics of Knossos from those of Thronos Kephala and relate them to already existing reference groups in central Crete. Given the geochemical affinity of the two areas and the similarity in technology of manufacture, it was possible to achieve a fine discrimination of the pottery profiles. Group formation was based on successive Mahalanobis distance probability calculations of all individuals against initial small core groups, and gradually adding to them the individuals with the highest probability. The final results confirmed the pottery exchange identified by petrography and suggested some further exchange of the fine wares.

## **Ceramic workshop differentiation during the Classical and Hellenistic period on the territory of ancient Sagalassos (SW Turkey). An archaeometric approach**

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Archaeometric material studies form a substantial part of the research within the Sagalassos Archaeological Research Project (SW Turkey). Since the excavations at Sagalassos started in 1990, interdisciplinary research has advanced to reconstruct the economic history of the site and region. Current objectives specifically concerning ceramic studies involve reconstructing the regional economy of the study area (approximately 1200 km<sup>2</sup>), mainly focusing on the Classical and Hellenistic period in relation to the development of mass ceramic production at the (Roman) site of Sagalassos. In order to understand the evolution of regional ceramic production patterns and identify the associated clay raw materials, an integrated approach of typological, petrographical and geochemical methods was developed.

Within the analytical approach, petrographic analysis is of major importance. A dataset of approximately 250 thin sections forms the basis of this research. Apart from being a fundamental classification technique of the different fabrics attested, this dataset also represents a reference collection for correlation with macroscopic observations. Further, it provides indicators of provenance on a regional level. Moreover, petrography has the potential for determining pottery production features. This paper will focus both on the possibility and constraints for determining technological features in thin sections and the potential for reconstructing regional ceramic assemblages.

Within the studied assemblage, it is possible to discriminate between different production processes and firing conditions by studying thermal transformations that may be visible within a certain thin section. These include sintering processes, formation of isotropic, amorphous and/or glassy areas in the matrix, fissuring of quartz clasts, decomposition of calcites, contraction voids and the occurrence of primary and secondary pores. Analysis of the ceramics from several Classical-Hellenistic sites within the study area shows an initial production pattern corresponding to intra-montane valley systems. A large variation in fabrics is observable, and shows notable structural and textural differences, as well as some compositional differentiation determined by geochemical techniques. From the research perspective, these groups can be described as an assemblage reflecting different workshops or traditions, on a synchronic or diachronic basis. With the aid of geochemical data, we can propose a system of self-sufficient local and regional production entities during the Classical and Hellenistic periods, where the continuous use of mineral resources for a wide functional spectrum of ceramics can be observed over a relatively long period.

This case-study represents a case-study for identifying regional workshops of ceramic production and its constraints.

## **Technological signatures of ceramics: a methodology to define and interpret skill and learning strategies**

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Skill is central to the production and reproduction of all material culture forms and is the basis of all technological activity. Skill can, however, only be passed on through reference to that which has gone before; it cannot come out of nowhere. This is true even for innovation to occur. Ethnographic studies have shown that the transfer of skill from one generation to another is embedded within socially sanctioned learning strategies that influence, and are influenced by, social and cultural continuity or change. This relationship between skill and broader social mechanisms makes it, along with learning strategies, an important subject for archaeologists to explore in their quest to use material culture to interpret past life courses.

For many years archaeologists have been aware that the plastic additive nature of clay means that the actions of potters become permanently embedded within the structure of a pot at the time it is fired. These are referred to here as the technological signatures of production. Such things as coil joins or slab joins have been observed and recorded as a way of assessing how the pots of different communities have been manufactured. Within the field of prehistoric pottery studies this phenomenon has largely remained a mechanism to distinguish between wheel-made or handmade pottery, and to further distinguish probable manufacturing methods such as coiling or slab building. A deep understanding of the principles of pottery manufacturing and an investigation of skill acquisition as non-discursive knowledge has made it possible to extend the usefulness of this phenomenon. Through careful observation of the investment of skill across a range of technological signatures related to specific vessel forms it becomes possible to map back to the way in which skill acquisition and learning strategies have been utilised within specific communities of practice. This skills methodology has now been used on two projects and has proven fruitful as an analytical tool in both cases, but with very different results.

Analysis of Middle Bronze Age vessels from the settlements of Százhalombatta and Dunaújváros-Kosziderpadlás and the accompanying cemetery of Dunaújváros-Duna-dűlő in Hungary highlighted a complex 'scaffolded learning' system that protected the continuity of high status vessel forms that would have been implicated in the maintenance of this highly stratified society through social display. More recent analysis of pottery related to the period of cultural transition from the Late Bronze Age Urnfield tradition to the Early Iron Age Hallstatt tradition in Central Europe (eighth to sixth century BC) is still in progress, but even so it is clear that the skills methodology has worked to reveal a very different scenario of skill investment to that of the preceding case study.

The case studies will be used to demonstrate the usefulness of the methodology as an analytical tool that can be applied to contemporaneous prehistoric pottery assemblages and to varied interpretative questions.

## **The discovery of the thirteenth-century Archaic Majolica and lead glazed pottery production at Barcelona**

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In recent years, several archaeological surveys conducted in Barcelona have provided us with evidence of local Archaic Majolica pottery production. In addition, for the first time, a kiln dated to the thirteenth century AD has been identified in the city centre and its lead glazed pottery production has been fully studied. Therefore an archaeological and archaeometric study has been conducted within this framework.

A significant number of Archaic Majolica and lead glazed pottery pieces have been analysed by XRF and XRD. According to the results, some pieces have been selected for petrographic analysis by optical microscopy of thin sections. Moreover, some individuals have also been examined by SEM. The results have enabled the establishment of the reference group of the Hospital kiln production. Comparisons between this production and the Archaic Majolica and lead glazed pottery recovered in different surveys in Barcelona have confirmed that Archaic Majolica was produced at Barcelona during the thirteenth century. One of the most striking results is that the thirteenth-century Majolica is unrelated to the Majolica produced in Barcelona from the fourteenth century onwards. Under such circumstances, the thirteenth-century Majolica does not seem to be a clear precedent for the important Majolica production of Barcelona, and a significant change in the structures of pottery production seems to occur at the end of thirteenth century.

## **Ceramic intruders in the Cyclades? Provenance and technology of a 'Kastri Group' deposit from Akrotiri, Thera**

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Recent excavations at Akrotiri, Thera have revealed a large number of underground rock-cut chambers, filled at different points in the site's history. Several of these chambers contain fills of the Early Bronze Age, some comprising important, closed, single phase contexts. The westernmost of two chambers in Pillar Pit 35 - the focus of this paper - comprises a single period, later Early Cycladic II deposit containing a rich assemblage of the 'Kastri Group'. This is a period in the Aegean which is characterized by the appearance of a new set of pottery whose stylistic roots lie in Anatolia. This has prompted ideas of the migration of people from Asia Minor to the islands of the Cyclades, and suggestions of a period of instability and disruption at the end of the second millennium BC.

Using a combination of thin section petrography and SEM, we examine aspects of provenance and technology, especially the choices made in the selection and manipulation of raw materials. Rather than comprising imports from Asia Minor, the depas cups, tankards, one handled mugs, and leaf spouted jugs of the Kastri Group are shown to exist in a variety of fabrics and technologies, indicating varied Aegean sources for these characteristic Anatolianizing shapes.

In the period that follows that of Renfrew's 'International Spirit', it is not only these well-known drinking shapes that reflect a widespread movement of pottery. High quality pouring vessels such as urfurnis sauceboats and Cretan 'Vasilike ware' join large amounts of talc ware and cooking vessels that show evidence of extensive exchange. Of special interest is a range of incised handled transport jars, which contained products from islands in the Western and Central Cyclades.

The analytical work reveals what seems to be a period of prosperity, with clear continuity from earlier ECII horizons, and 'Kastri Group' pottery embedded in the patterns of regional production and exchange in the Cyclades.

## **The manufacture 'Royale' of Samadet (1732-1838): characterisation of a faience production**

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This work falls within the framework of a research programme on the production, the technological development and the dissemination of the Adour basin faiences (southwest of France) in the wake of the Industrial Revolution. The study reported here focuses on the characterization of the products of the Samadet manufacture. The manufacture was established in 1732 on his lands at Chalosse (Landes, Aquitaine), following the impetus provided by Charles Maurice du Bouzet (1660-1752), Marquis of Roquépine, Baron of Samadet. This was possible as the work of 'faïencier' was considered as noble and so it did not lead to loss of noble status. The manufacture acquired the title of 'Manufacture Royale' and many privileges in 1732. The production continued until the 1830s and reached its peak in the second part of the eighteenth century.

The study of these faiences is being undertaken, in collaboration with the Museum of Samadet with the intention of rediscovering the lost secrets of the 'Manufacture Royale' and to solve the problem of attribution based, until now on stylistic considerations. In order to determine the characteristics peculiar to this production, 28 fragments coming from the excavation of the manufacture were observed and analysed. The bulk chemical compositions of the glazes and the decorations were, among other characteristics (like homogeneity, thickness...), determined by SEM-EDS. The analyses were conducted directly on sample surfaces (low vacuum) and on sections (high vacuum). The biscuit ware was analysed on powder by SEM-EDS, XRF for the chemical composition and by XRD for the crystallography composition. The analyses suggest the use of the same glazing mixture. Tin-opacified lead glazes were decorated with cobalt for blue, lead antimonate (also known as Naples yellow) for yellow, manganese for purple and a mixture of cobalt and lead-antimonate for green. All these results contribute to the development of an 'identity card' for those faiences and give the first results concerning their manufacture.

In parallel, methodological research was carried out on the non-destructive and non-invasive analyses, preceding the identification of the production of pieces. PXRF was used on the surface of the same samples analysed by SEM-EDS. This methodology helped to distinguish the production of the different contemporary manufactures present in the Adour basin, like those of Saint-Vincent de Xaintes (Dax) and Saint-Esprit (Bayonne).

Another aspect of the research project is the study of manufacture and production from an economical and historical point of view (in particular with work on archives). This assists in understanding and determining the works and stakes of the establishment and development of this manufacture from the eighteenth century to the Industrial Revolution.

## Capodimonte porcelain: an unique manufacture

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In Europe in the early seventeenth century, the first factories of porcelain were placed next to Royal Palaces. Porcelain was, in fact, considered a luxury good, that only royal families could afford. Fascinating for its translucent white colour, its elegance but especially for its mysterious composition, porcelain unleashed a race among European emperors and kings who wanted to own it and produce it during the pre-industrial period.

The Bourbon court's attempt to produce porcelain in Naples fits well in this context. The Bourbons' wish was to realise products that could be competitive with the other European manufactures. The life and the success of the Capodimonte manufacture were, however, not so lucky. The will to obtain a magnificent product was not sufficient to reach this aim. The raw materials at their disposal were not completely suitable to realise artifacts that could stand up to the competition with the other European productions. However, the Capodimonte objects produced during the first period of the royal manufacture represent a beautiful example of an unique porcelain.

Twenty-four samples, carefully selected from among about two hundred finds recovered from a rescue excavation in the Royal Park in Capodimonte, have been investigated in order to better understand the composition and the technological characteristics of this porcelain.

Observations of thin sections by optical microscope, chemical analyses by scanning electron microscopy coupled with energy dispersive spectrometry, and phase analyses by X-ray diffraction have been used to answer the technological questions. The results obtained show evidence that the chemical composition (85% SiO<sub>2</sub>) is unique among the coeval European productions. But this specific characteristic presents problems during firing, due to the restricted maturation range of the ceramic paste.

## Microanalysis of later prehistoric granodiorite-tempered pottery from the East Midlands

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Petrological studies of later prehistoric pottery from the East Midlands have identified several distinctive fabrics characterised by angular granitoid inclusions that may derive from the Mountsorrel granodiorite complex of Charnwood Forest (Knight, 2002; Knight *et al.*, 2003). If verified by further work, this would add significantly to the growing evidence for long-distance ceramic exchange networks in first millennium BC Britain. A recent review of thin section analyses of later prehistoric granodiorite-tempered pottery concluded that the results should be tested by chemical analyses aimed at comparing individual mineral and rock inclusions with samples from different granodiorite rock sources in order to distinguish between potential sources (Knight *et al.* 2003, 122). Such an approach is of particular importance since the granitoid inclusions in prehistoric pottery thin sections generally comprise only a few crystals, which given the coarse-grained nature of these rocks does not enable sufficiently robust comparisons to be made with the putative Mountsorrel source.

This paper presents the initial results from a pilot study of later prehistoric pottery using a combination of thin section petrology and electron microprobe analysis. We will also discuss how the results from this research could provide an interesting complement to studies of early medieval pottery from the East Midlands, in which the occurrence of granodiorite-tempered pottery was first recognised (Barley, 1957; Walker, 1978; Williams and Vince, 1997).

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## **Shades of white: variability and experiment in mid-eighteenth century British porcelain production**

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From the 1740s, there was a proliferation of porcelain manufactories in Britain, which had varying degrees of commercial success, some surviving for only a few years. Analytical programmes over the past two decades have identified many different body types, extending the glass-, steatite- and phosphate- based subdivision typically cited in the older literature. There is a temptation to produce increasingly detailed and specific schemes of classification based upon chemical composition. This approach can confuse the underlying relationships and lead to the inference of spurious connections between workshops.

Throughout the period, glass was frequently added to clay bodies to improve their properties and this practice can be traced back to John Dwight of Fulham who, in the late seventeenth century, had added bottle glass and/or specially prepared frits to a range of products, including a vapour-glazed white stoneware and crucibles made in imitation of the Hessian type. An often-overlooked document dating to 1732 indicates that the concept of vitrification and the role of glass as a flux were well understood by this time. On the other hand, it appears that there was some confusion as to the differences between plastic materials, such as kaolin, mica and talc. A patent of 1744 specifies porcelain made by the addition of glass to clay imported from North America, and analysis has almost certainly identified the corresponding wares. However, the extent to which this is the 'landmark' claimed by some depends crucially upon how the categories of raw material used were understood by the people making ceramics at that time, and this is not always clear from the few surviving documents.

## **Site synthesis: pottery from Vörs, Máriaasszony-sziget (SW Hungary)**

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The multi-period archaeological site Vörs, Máriaasszony-sziget (Hungary) lies southwest of Lake Balaton. It is situated on a sandy peninsula of the former lake. As it has always been a favourable place for habitation, the site has finds from almost all periods of prehistory and later; pottery finds span from the Early Neolithic (c. 5500 BC) till the Early Mediaeval Conquest period.

Previous studies have already proved that there was a common pottery raw material available and used in all periods examined. It was tempered in different ways in different cultures: with vegetal material (in Starčevo culture), with grog (in Lengyel, Kostolac and Kisapostag cultures) and with carbonate sand (in Celtic times).

The issues of provenancing pottery raw materials in the Carpathian Basin, and the advantages a multi-period archaeological site can offer, are also discussed.

In this study the authors attempt to bring all archaeological, spatial, statistical and archaeometrical evidence together in order to trace trends among data sets. Chronology, vessel type and function, petrographical, mineralogical and geochemical composition will be considered in order to make diachronic comparison between changes in composition and variations in vessel types and function.

## Using production step measures to assess changes in the control and standardisation of Chimu and Chimu-Inka pottery and textiles

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This paper derives from a doctoral study focussing on the collections of Chimu and Chimu-Inka pottery and textiles (c. 900 ceramics and 100 textiles) in the British Museum to analyse cross-media relations within craft production on the Peruvian north coast (c. AD 1000-1532). A central focus of the study is the level of control exerted on different crafts during the periods of Chimu and Inka state rule, with the aim of assessing the extent to which different means of manipulating clay and fibres can be considered as 'state' technologies.

The Chimu polity held sway over the north and most of the central coast of Peru from c. AD 1000 until incorporation into the Inka empire in AD 1476. Significant re-organisation and intensification of Chimu craft production occurred under Inka aegis but Inka respect for Chimu artisanship was considerable and Chimu material becomes spread far beyond the territorial limits of the Chimu polity.

The study uses the concept of the *chaîne opératoire* to reconstruct production sequences manifest in items of clay, cloth and metal, to explore how knowledge, skills and conceptions of materials and methods are transferable across media. This approach allows assessment of how and at what point of the production sequence features such as colour-and iconographic features are added. Feinman *et al.*'s (1981) 'production step measure' is applied to quantify the quantity and quality of work needed to achieve particular stages of ceramic production sequences, particularly post-mould work.

This paper focuses on the application of the 'production step measure' to a sample of Chimu and Chimu-Inka vessels to obtain empirical data on the relative labour costs of producing different (non-wheel-made) vessels. The measure is used to estimate the balance between the degree to which the individual artisan was able to exercise artistic expression in relation to how techniques such as the use of the mould allowed greater levels of control over the artisan's work. The data obtained can then be used to say something of the levels of control exerted over ceramic production, the extent of iconographic (de-) standardisation and how such patterns alter under Inka aegis and the accompanying intensification of production. This can be related to Gell's (1998) discussion of planner/practitioner or agent/patient relationships, and in this case the analysis permits an assessment of the degree of artisan agency in Chimu vessels and how this changes in vessels made under the Inka occupation.

The study also adapts the 'production step measure' for use with textiles to quantify the Chimu versus Inka attributes in garments and cloth made during the Late Horizon, to assess the degree to which Chimu cloth production also facilitated some control over technical traits or if artisans created styles using more 'aesthetic' traits. This approach permits a comparison of the organisation and labour going into ceramics and textiles produced under the Chimu and Inka states, offering a different perspective on the ways in which state expansion influenced craft production.

## Early hunter-gatherer pottery in Eastern Siberia: towards an integrated analytical approach

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Since the middle of the last century, there has been a growing appreciation of the active roles played by hunter-gatherers in the emergence of ceramic technology around the world. However, while this phenomenon is now widely recognized, there are many questions surrounding the invention, adoption, integration and dispersal of ceramic vessels in these complex and innovative societies, which need to be addressed. The region of Eastern Siberia has a long history of hunter-gatherer pottery and provides an ideal context in which to begin to explore some of these issues in detail. Although the earliest ceramic material in this region dates back to the Pleistocene, it has remained largely unknown outside Russia and has not been the focus of the kind of analytical studies applied in neighbouring regions (e.g. Zhushchikhovskaya, 2005). That situation is now changing.

This project explores the emergence and spread of pottery among hunter-gatherers in Eastern Siberia through an integrated programme of macroscopic, microscopic, chemical and biochemical analysis. The principal aims of the project are: (1) to demonstrate the potential value of taking ceramic studies beyond regional cultural categorization and technological generalization and into a structured phase of scientific analysis, and (2) to explore the place of pottery in contemporary society and examine the possible reasons for its adoption. In order to achieve these aims, three case-study sites were selected from a variety of archaeological, environmental, cultural and chronological settings, drawing on ceramic collections housed at Irkutsk State Pedagogical University and Irkutsk State University:

<i>Ust' Karenga</i>	<i>(Upper Vitim Basin)</i>	<i>Habitation site</i>	<i>c.12,000-10,500bp</i>
<i>Shamanka</i>	<i>(Southern Baikal Coast)</i>	<i>Cemetery</i>	<i>c.7,000-6,000bp</i>
<i>Popovskii Lug</i>	<i>(Upper Lena Basin)</i>	<i>Habitation site</i>	<i>c.5500bp.</i>

Early ceramic material from these sites was examined, using a combination of macroscopic analysis, ceramic petrography, SEM, XRD, FTIR and GC-MS.

Reconstructing production technology and use-life, by investigating every stage in the 'lives' of these ceramic containers; from the selection and manipulation raw materials to the eventual discard of broken sherds, we have revealed a fascinating tangle of social and technological choices. Although there are *still* many questions to address, intriguing patterns are beginning to emerge and it is already possible to pull out some important threads. Working with these, we can form tentative conclusions about the varied roles of early ceramic vessels in these hunter-gatherer societies and emphasize potential benefits and limitations of applying this approach more widely.

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## **50 left feet: the manufacture and meaning of effigy censers from Lamanai, Belize**

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Elaborate human effigy censers are widely distributed at sites across the Maya lowlands in the Late Postclassic period (ca. AD 1250-1540). These censers represent people dressed in costumes combining martial and supernatural elements. They may have been broken at various sites as part of rituals associated with pilgrimage, but details of their production, movement across the landscape, and meaning remain unclear. A stylistically varied assemblage of fragmented censers of this type have been recovered from Lamanai, Belize, and have been subjected to detailed stylistic/iconographic and petrographic examination by independent analysts. The combined results have revealed a higher level of variability in visual and compositional characteristics than has been recognized previously, demonstrating connections to both local and foreign producers and to several geographically distant production localities. These results have important implications for current understanding of the nature and meaning of these vessels, specifically as concerns associated patterns of production and deposition.

A central focus of our paper is to discuss methodological issues relating to the integration of extensive data sets characterizing compositional and stylistic/iconographic attributes, including the interplay of variability in technological and provenance characteristics and style. We also explore the significance of such integrated approaches to understanding Maya interregional interaction just prior to the Spanish conquest.

## **Assyrian palace ware: definition, chaîne opératoire and archaeological implications**

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The importance of the Neo-Assyrian empire (934-610 BCE) for Levantine archaeology necessitates a thorough understanding of imperial material culture: its definition and function in the central polity and transmission, adoption/rejection and hybridisation in annexed territories. Assyrian palace ware, a distinctive fine ware, has been associated with the Neo-Assyrian elite since it was first described in a brief note by Rawson (1953). Rawson's general observations were never intended to be definitional and were limited to basic descriptions of vessel form and colour, from which technological information is supposed. These observations were refined by Oates (1954, 1959), who divided 'palace ware' into two subgroups based on wall thickness, but never expanded upon or formulated a cohesive set of criteria for palace ware. Recent studies have looked at the provenance of palace ware in the Negev (Engstrom 2004) and dated its appearance in southern Palestine (Na'aman and Thareani-Sussely 2006). The aim of this paper is to refine and establish the technological criteria for Assyrian palace ware in order to facilitate archaeological discussions about the imperial dynamics of the Neo-Assyrian empire in general and the semiotics of palace ware specifically.

Palace ware from the Neo-Assyrian central polity will be examined macroscopically, petrographically and using electron beam and radiation methods to establish a chaîne opératoire. X-ray radiography will be used to evaluate vessel formation, firing and finishing techniques. SEM-EDS and EPMA analyses will be employed to examine raw clay processing techniques and refine provenance assignments of these ceramics because palace ware is extremely difficult to provenance due to the rarity of mineral inclusions (<0.5%) (Hunt 2007).

These analyses were carefully selected to provide measurable and quantifiable technological signatures of the manufacturing process. The technological signatures of central polity made palace ware are crucial to understanding the semiotics of palace ware in annexed territories; whether the manufacture location and/or manufacture technique influenced the social identity of the vessels. This contribution is part of ongoing research by the author into the dynamics of Neo-Assyrian imperialism in the southern Levant.

## **Romita ware: between two worlds. Hybrid technology in Colonial Mexico?**

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Romita ware, also called Indigena ware, is a unique pottery found in Colonial archaeological contexts throughout Mexico, and is most often recovered from sixteenth century archaeological contexts in Mexico City. Romita ware features a very thin transparent lead-silica glazed outer coating. Unlike true majolica pottery, tin was not used for opacifying Romita ware glazes; instead, a slightly thicker engobe layer was used to create a white surface that covered the red paste ceramic. In addition to the plain ware, a so-called Romita sgraffito combined the engobe technique with carved decoration beneath the transparent lead glaze. Romita ware provenance and the extent of a possible hybrid technology, which combined traditional pottery making with Spanish ceramic styles, are discussed. Conclusions regarding provenance and manufacturing technology are supported by data derived from SEM, LA-ICP-MS and XRD analyses of 72 Romita plain ware sherds.

## **Inferring provenance and firing temperatures of the Monagrillo Ware (c. 4,500-3,200 BP), Panama's first pottery**

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Scholars from various fields of the arts and sciences have theorised about when, why, and how technological change occurs. Archaeologists have explained the emergence of new technologies and artifacts from the perspectives of cultural diffusion, population movement, and local inventions. The emergence of ceramics and its relation to culture change is a topic of great interest to archaeological scientists who have engaged in innovative materials-based research, especially in eastern Russia, southwest Asia, eastern Europe, and, to a lesser degree, in the United States.

The earliest radiocarbon dated pottery in the New World has been reported in South America, in contexts dating to 7,000-6,000 BP. Archaeologists disagree whether pottery spread outwards from a single place of invention (i.e., Brazil) or whether this technology was invented more than once in several locations. Although many researchers have described the stylistic and technological characteristics of these early ceramics from various locations in Central and South America, their assumptions about their movements and adoption by different cultural groups have rarely been tested using scientific methods. The Monagrillo pottery of central Panama (c. 4,500-3,200 BP) and the Tronadora pottery of northwestern Costa Rica (c. 4,000-2,500 BP) are the oldest ceramics known in Central America. Monagrillo pottery was first described in the 1950s from sites around the marine littoral of Parita Bay. Since then it has been recovered at inland sites, including one on the Caribbean slopes.

The archaeological and geomorphological contexts of the Monagrillo pottery and the settlement patterns and subsistence behaviour of the people who used it have been investigated by reference to paleobotanical and zoological materials. Nevertheless, archaeologists have paid little attention to the technology of Monagrillo pottery and its behavioural components. In this paper, recent studies that begin to redress this imbalance are presented. A petrographic study of small samples of Monagrillo pottery from different biotopes suggests that most vessels were made at, or near, the sites that used them. But some vessels were transported from distant locations. Manufacturing technique at one highland site and another in the lowlands were examined visually and with xeroradiography. These methods suggested that all the sampled sherds came from vessels built up with layered slabs. It was also possible to infer firing temperatures from the microstructures of a small sample of sherds and their sub-samples, which were recovered at a highland and a lowland site, using SEM. The inferred firing temperatures ranged between 850-950 °C. Thus it can be concluded that Monagrillo pottery was mostly produced locally and was fired in a temperature range that is high for earthenware. .

## **Technological studies on architectural glazed tiles of Huangwa Kiln: a rare ceramic system in ancient China**

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Huangwa Kiln, located in Anshan City, Liaoning Province, was an imperial kiln producing glazed tiles for palaces, mausoleums and temples in northeast China during the Qing Dynasty (1644-1912). According to historical documents, Huangwa Kiln used to be a folk kiln producing vats, dishes and bowls prior to the almost 300-year period of tile production. From 2002 to 2006, fieldworks were carried out by archaeologists from Anshan Museum. A large number of glazed vats, dishes and bowls were found in the west, east and north of the site, while architectural glazed tiles were mainly found in the centre. In addition, two clay deposits of red clay and white clay were discovered and are thought by the archaeologists to have been the raw materials of the bodies of architectural glazed tiles. XRF, XRD and SEM-EDS were used to analyse the bodies. Preliminary studies revealed that the chemical compositions of the bodies fell into the MgO-Al<sub>2</sub>O<sub>3</sub>-SiO<sub>2</sub> ternary system, a rare ceramic system in ancient China. Another phenomenon was that there was a large quantity of white inclusions in the bodies.

There are three questions addressed by this paper:

(1). Why was this rare system used? Could the raw materials mentioned above form ancient bodies? Why were two types of raw materials used rather than one type? What was the recipe? Two types of clay samples were separately fired at controlled temperatures and their properties were observed. Mixtures of different ratios of the clays were also fired at different temperatures. Chemical composition and mineral phase of fired mixtures were compared with those of ancient bodies. It was found that the fired mixture with the ratio of 2:1 of red clay and white clay was very similar to the ancient bodies.

(2) Were white inclusions in the bodies from raw materials or formed during the firing process? If the latter, how did they come into being? It was found that white inclusions contained higher MgO and lower Al<sub>2</sub>O<sub>3</sub> than the matrix. Enstatite and forsterite were found in white inclusions. According to these characteristics, they might derive from hard blocks in white clay.

(3) Are there any differences in raw materials and firing techniques between vats, dishes, bowls and tiles? It was found that the chemical compositions of the bodies were all similar but those of the glazes were different. The firing temperature and the microstructure of the bodies were different too. The results showed that ancient potters could select different techniques in accordance with the function of the products.

## The second life of ceramics: a new home in a lime environment

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Ceramic fragments have been added to lime mortars since antiquity, a procedure which has been connected to the increased strength and durability properties that they offer mortar mixtures. Lime-ceramic mortars are known as *cocciopesto* or *kourassani* in Greek. It is generally assumed that ceramic wasters and/or sherds from broken ceramic vessels or construction materials were used for this purpose, effectively recycling material which no longer fulfilled its original purpose.

Parameters such as chemical composition and firing temperature of the ceramic component affect its reactivity with lime and, therefore, the performance characteristics of resulting lime-ceramic mortars. Consequently, the selection of specific types of ceramic material to be used as additives would have influenced the service life and durability of these particular mortar constructions.

This paper presents the results of a systematic investigation of the pozzolanic activity of different ceramic types on experimental ceramic-lime mixtures. On the basis of these results the performance of different archaeological mortars, in terms of chronology and applications, is discussed. The study compares and contrasts two groups of lime-ceramic mortars from Greek monuments, dated to the Roman-Hellenistic and the Byzantine periods respectively. The ceramic component of the mortars was analysed using thin section petrography, SEM and XRPD, so as to retrieve information pertaining to its composition and technology. In conjunction with the analyses performed on the experimental ceramic-lime mixtures (pozzolanic activity test and testing of mechanical properties) this information allows not only the assessment of the reactivity of particular ceramic materials and their influence on the overall performance of the mortar, but investigation of wider questions related to raw material choice, performance and suitability. In turn, this provides insights into matters such as the recycling of materials and the relationships between different crafts and craftspeople.

## **From fabrics to recipes to landscapes: linking ancient and modern pottery production on the island of Aegina, Greece**

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Potters do not necessarily conceive of and classify materials, tools and techniques in the same way that geologists, material scientists or archaeologists do. For a ceramic analyst, with either archaeological or scientific background, well-chosen criteria related to the colour and the texture of the clay paste, the type, shape or quantity of inclusions, form the basis for the definition of individual fabric classes. Each class is assigned meaning, in terms either of provenance or technology, or a combination of both. Consistency in the application of certain criteria and a high degree of accuracy and precision in measurements remain standard requirements in ceramic studies, especially concerning the use of analytical techniques. But what does the same variability reflect in terms of the original potters' concepts and choices? And how accurate and precise were the potters in their categorisation, evaluation, selection and processing of raw materials, in relation to our scientific criteria?

These issues have been explored widely through integrated archaeological and scientific research on the environmental and cultural dynamics affecting pottery production through time on an Aegean island. The study concerned pottery production, in antiquity and modern times, on the island of Aegina. Archaeological and scientific work has provided ample evidence on the emergence and development of an important pottery production centre during the second and part of the first millennium BC on the island. After detailed macroscopic study of the archaeological ceramics, a total of almost 400 samples were selected for analysis, representing various functional types from a range of chronological horizons covering more than a millennium. Through refiring tests, petrographic thin section examination, chemical analysis (ICP-OES), and SEM, the compositional and textural variability was explored and characterised. The meaning of the identified variability, in terms of potters' concepts and choices changing through time, was approached in two ways. The first concerned understanding the variability and behaviour of the locally available raw materials through their comparative analysis and replication experiments. The second was associated with the study of modern traditional potters on the island, focusing on their concepts and choices of the known local materials and how these were reflected in their final products, a sample of which were again analysed comparatively. Issues such as variability observed among products of the same workshop within the same generation of potters were also investigated.

## **The ceramic ecology of Red-on-Buff ceramics from Northern Afghanistan: an enigma at Aq Kupruk**

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Afghanistan has been at the crossroads of Eurasian commerce for more than four millennia. In the 1960s Louis Dupree and I excavated archaeological sites near Aq Kupruk, Balkh Province, situated on the Balkh River, providing way stations ('caravanserai') for north-south transit from the Turkestan Plains through the Hindu Kush of the western Himalayas ultimately to Bamiyan, the Kabul and Indus Rivers and the Subcontinent. The longest stratified archaeological sequence in Afghanistan is at Aq Kupruk I (Ghar-i-Mar or 'Snake' Cave), spanning Upper Paleolithic through Contemporary Nomadic. Unique to Aq Kupruk is the 'Red-on-Buff Wares Group' (n = 8 types, # 45-52; 1,083 specimens) dated to the later Early Iron and Late Iron Age, e.g., 1500 BCE to CE 700, but with a vast majority of the specimens dating from 100 BCE to CE 700. Characteristically these have a monochrome red (and variants) on a buff or natural surface (natural or occasionally self slipped) and have not been reported from any other site in Afghanistan; 69 design motifs (mostly geometric) have been defined.

A perplexing issue is that similar painted decorations date from 5000 BCE into the first millennium BCE, suggesting Chalcolithic and Bronze Age rather than an Iron Age chronology. However, similar motifs occur on Black/Red painted ceramics from Bronze Age Baluchistan, notably in Gedrosia (Stein 1931). More recently, de Cardi (1983) has redefined Parthian period Londo Ware to include a 'Late Londo' Ware that is chronologically Scytho-Parthian and Kushan in date that also resembles the Aq Kupruk series. A potential remnant of the Red-on-Buff painted pottery tradition may be seen in ethnographic ceramics produced in the Northwest Frontier Province of Pakistan during the twentieth century (Rye and Evans 1976). The results of ceramic typological, macroscopic, binocular and petrographic microscopy (thin-section analysis and point counting) as well as design analyses are reported and cultural associations discussed.

## Paul-Louis Cyfflé's (1724-1804) Terre de Lorraine: a technological study

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This paper presents a study of Terre de Lorraine biscuit figurines most probably coming from Cyfflé's (1724-1804) workshop in Lunéville (Lorraine, France). In 1766, Cyfflé asked the French Government for permission to found his own manufacture in this city saying that he intended 'to produce at home in Lunéville earthenware which, without actually being porcelain, would be more beautiful than pipe clay (terre de pipe), and called Terre de Lorraine'. Two years later, an edict of the French Royal Council of State authorised Cyfflé to produce only Terre de Lorraine, not porcelain. Cyfflé specialised in the production of small unglazed and undecorated white biscuit figurines and had a notable success. In 1775, twenty-seven people were employed in his manufacture, which closed down in 1780.

The secret recipe for making Terre de Lorraine biscuit has never been published or handed down to succeeding generations. Cyfflé himself speaks of a marble-like paste. However, one can find in literature four hypotheses speculating on the body composition of Cyfflé's Terre de Lorraine: (1) a phosphatic soft paste porcelain; (2) a frit porcelain with a terre de pipe flux; (3) a terre de pipe body fired at temperatures of white stoneware or (4) a Ca-bearing hard porcelain, comparable to early Meissen porcelain. Four unglazed figurines from the collections of the Castle of Lunéville, destroyed in the blaze of 2 January 2003, were sampled. The fragments were subjected to porosity analysis, modal analysis, X-ray fluorescence analysis, X-ray diffraction analysis, backscattered-electron image analysis – coupled with energy dispersive spectrometry – and electron backscatter diffraction analysis to determine the porosity, bulk, major, minor and trace element compositions, and the composition and the proportion of their constituent phases. Cyfflé's Terre de Lorraine wares embrace two distinct types of paste, a traditional calcareous (terre de pipe) and an aluminous-siliceous one. Both are porous (9-25% water adsorption). Cyfflé's recipes of both pastes were calculated from the chemical and the modal analyses. The former consists of a mixture of different proportions of ground quartz or calcined flint, ground Pb-glass and calcium carbonate with a refractory clay. These figurines were fired at temperatures of 950-1,050 °C, which are the usual firing temperatures of a classical French faience kiln. The aluminous-siliceous paste is an invention of Cyfflé. For this complex material, he mixed different elements such as ground pure amorphous SiO<sub>2</sub> (white flint or opal), ground quartz or calcined flint, ground porcelain, ground Na-Ca-glass and coarse grained kaolinite with a fine grained kaolinitic clay. The use of ground porcelain is puzzling. Did Cyfflé produce porcelain himself or did he purchase broken, unglazed porcelain kiln furniture from other manufactures? The figurines were fired below 1,050 °C, resulting in a porous hard paste porcelain-like material. His clever choice of a hybrid technique – the use of vitreous temper recalling the French soft porcelain technique and the introduction of quartz, kaolinite and K-feldspar from the recipe for German hard paste porcelain – may very well have been Cyfflé's answer to the French king's prohibition of the making of porcelain, in which case one better understands the sibylline message in his statement that '... without actually being porcelain, would be more beautiful than terre de pipe'.

## **Archaeometrical study of the ceramic technology in Termez (Uzbekistan): pottery making in the ancient Bactriana province during and following the Hellenistic Period**

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The site of Ancient Termez, situated in southern Uzbekistan (ancient Bactriana province), is probably identified as the Antiocheia Tharmata or the Alexandria Oxeiana cited in ancient sources. Founded by Achaemenids and conquered by Alexander of Macedonia, it is a major urban site occupied in the Hellenistic and the Kushan-Sassanian periods. Due to its location at an intersection of many intercontinental routes derived from the Silk Road, the historical importance of Ancient Termez is obvious.

So far no attempt has been made to study the production and distribution of the pottery in this area and there is almost no data about the local and regional commercial systems of these periods.

This is the first exhaustive archaeometric study, within a larger programme, methodologically based upon the systematic archaeometrical and archaeological characterisation of pottery production and diffusion inside the Bactriana province, which aims to make inferences on the cultural interactions between Central Asia and Western Mediterranean.

The present study has been carried out upon pottery sherds coming from several workshops recently found at Termez and in the surrounding area of Tchinguiz Tepe. The analysed material includes a hundred painted common wares and unpainted common wares dated from the third century BC to the fifth century AD according to radiocarbon dating.

The archaeometrical study has been carried out by applying chemical, mineralogical and petrographical analysis. The chemical composition has been determined by XRF and the mineralogy has been studied by XRD. A petrographic analysis by optical microscopy has been carried out upon some selected samples. Furthermore, a complete microstructural and surface treatment study has been performed by scanning electron microscopy equipped with an SEM-EDX.

The chemical results point towards a general homogeneity among the analysed ceramics, revealing a very similar geochemical origin. Concerning technology, the manufacturing process of this pottery seems to be standardised. In archaeological terms these results point towards the persistence of a similar ceramic tradition at Termez over several centuries and the imposition of the local technological tradition, even though there are cultural and political changes in the site during this period.

## Evidence of tin-glazed earthenware technique experimenting in Brittany

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In France, during the medieval period, the tin-glazed earthenware technique is little known, rarely produced and not recorded in historical documents and its expression appears essentially only in the form of floor tiles. The decorated tile pavement found *in situ* in the chapel *extra muros* at the Château de Suscinio (France, Morbihan, Sarzeau), the residence of the Dukes of Brittany, is an example of this. The pavement was studied within the context of a wider multidisciplinary research project dedicated to acquiring a better knowledge of tin-glazed earthenware technique transmission and ways of diffusion in France.

Dated precisely from the years 1330-1350, remarkable in the variety of the ceramic techniques employed as well as the iconographic repertoire, this decorated tile pavement is the only example identified in Brittany so far. The exogenous tin-glazed earthenware technique coexists with bi-coloured decorated tiles, a medieval innovation specific to northwestern Europe. This decorated tile pavement is thus a cultural and technical point of junction between East and West.

In spite of previous technical and stylistic studies, the manufacturing of these tiles still raises various questions. Where do they come from? Who made them? Were they produced in a single workshop? With the help of the Council of Morbihan, the physico-chemical characterisation (petrography, cathodoluminescence, SEM-EDS, XRD) of a representative collection of samples representing the different ceramic techniques used has made it possible to verify if the same clays were used, if they have a local origin and if the different ways they were prepared are similar. The purpose of the study was to estimate homogeneity in the production and to determine the technological transmission mode.

After studying the characterisation of the different floor tile components (decoration / glaze / earthenware), regardless of the technique used it is possible to assert that it is the production of a single, local workshop, probably of tilers using the resources locally available, whose similarities to Breton ceramics suggests a regional production. In this context the tin-glazed earthenware technique appears experimental.

## **Technological implications of the microstructures present in ceramic glazes**

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The microstructure developed in the glazes depends on the ceramic process – manufacture, drying and firing – and raw materials – body paste and glaze – employed. The presence of grains, bubbles and new crystalline compounds in the vitreous matrix gives significant information on the optical properties but also about the technology. The final microstructure depends on the composition and texture of the body-paste, the size and composition of the glass raw materials, on the method of application (single or double firing, glaze thickness applied, pouring or brushing, etc) and, finally on the firing conditions (temperature reached, heating and cooling rates, atmosphere, etc.).

The glaze microstructures developed in alkaline glazes applied over different stone pastes, alkaline, mixed or lead glazes applied over non-calcareous and calcareous pastes and corresponding tin glazed productions from the ninth to the eighteenth centuries AD are analysed. The glaze microstructures developed in replications made in laboratory controlled conditions are also studied. The cross sections of the glazes were analysed by scanning electron microscopy coupled with an SEM-EDS and synchrotron radiation micro-XRD which has a small beam size, adequate to obtain the structural information of submicron crystalline compounds, and a high brilliance, optimal for determining the crystallites even when present in very low amounts. Unreacted grains, reaction compounds, polymorphs, crystallisations and alteration compounds, and their space distribution are determined. The technology employed in each case is discussed.

## **Thermal shock resistance of ancient cooking vessels: myth and reality**

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Cooking vessels are exposed to thermal stresses during daily use. Potters' choices, in particular the selection of temper materials, have been connected to the capability of a cooking pot to resist such stresses. Recipes observed in the production of cooking ware are often explained as enhancing their performance, especially with regard to thermal shock. Accordingly, diachronic changes in the manufacture of cooking wares have sometimes been linked to the evolution of an 'ideal' cooking pot. However, only rarely has thermal shock resistance been determined experimentally when it comes to archaeological ceramics. In most cases the explanation offered for technological variation in the archaeological record is based solely on theoretical considerations, which may be problematic.

In the context of a study of Bronze Age cooking ware from Akrotiri, Greece, diachronic changes and synchronic variation in tempering practices were observed, prompting the question whether they might be linked to increased thermal shock resistance of the respective fabrics. To tackle this question, experimental briquettes were manufactured and the influence of various parameters, in particular the type of temper, on the thermal shock resistance of the ceramic material was assessed.

The experimental results indicate that higher amounts of temper and a change from platy to more angular temper shapes increases thermal shock resistance with regard to strength reduction of the material. Importantly, however, it is not only strength but also fracture toughness which plays a crucial role in defining a material's ability to withstand the stresses which develop in a vessel that is used for cooking. Unlike strength, the toughness of the tested ceramic materials increased upon thermal shocking; in many cases thermal shocking induced a change in the fracture mode. Assessments of vessel suitability are further complicated by the fact that thermal shock resistance depends not only on the material, but to a large extent also on the shape of an object and the conditions of thermal shock.

This paper highlights different aspects and pitfalls of the concept, as well as the assessment of thermal shock resistance of archaeological ceramics. It is proposed to consider thermal shock resistance in a more integrated fashion than has been the case to date, producing meaningful conclusions on the performance of cooking ware in terms of its response to thermal shock.

## **Pots as signals: explaining the enigma of long-distance ceramic exchange**

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Ceramic pots do not travel well. They are bulky and fragile. Further, the raw materials for pottery make up most of the earth's surface, so perfectly adequate pots can be made virtually anywhere on earth. There would appear, then, to be little rational economic motive for long-distance ceramic exchange. Yet, ceramic provenance investigations consistently demonstrate that pots did, in fact, travel, often over huge distances, and even, as in the New World, where they had to be carried on the backs of human beasts of burden. In this paper some of the most striking instances from prehistoric Mesoamerica of long-distance ceramic exchange are discussed. Some suggestions based on signalling theory about how to approach explanation of this seemingly irrational human behaviour are then offered.

## Lessons from the Elephant's Child: questioning ancient ceramics

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While looking for a way into this session's topic of 'Methodological development', I re-encountered Rudyard Kipling's *Just-So Story* of the Elephant's Child. The Elephant's Child was characterised by his 'insatiable curiosity', and this seems to be a good paradigm. More focus for curiosity is provided by a rhyme in this story:

'I keep six honest serving men  
(They taught me all I knew);  
Their names are What and Why and When  
And How and Where and Who.'

This rhyme provides a useful alternative typology for our questions and hence our methods – we can group them according to the questions that they seek to answer. We can then go further and examine the progress made in each area, and whether there have been trends in the popularity of the questions. My feelings before I started to look for evidence was that there had been a trend during my working career, from 'when' questions, through 'where' and 'how', leading perhaps to 'why', so I made a very selective literature search to see if this was in fact the case.

It seems useful to follow up this overview with an examination of the applicability of our methods – which methods can be applied to all relevant ceramics, and which (for reasons of cost or time) can only be applied to a sample? A more difficult, but perhaps more important, question, is whether they should be applied universally, or whether there are good reasons for sampling, over and above sheer necessity? Finally, there is the link back from sampling to interpretation, a link which can easily be overlooked or over-simplified, and what this implies for communication between different branches of our discipline.

## Exchanging pottery in the Neolithic: the case of Thessaly (Greece)

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Thessaly during the Neolithic period was a rather densely populated area, characterised by a rich pottery production. Previous archaeometric research on Neolithic decorated pottery from Thessaly verified the circulation of particular wares, by chemically analysing a large number of surface pottery finds using XRF. Until recently it was widely accepted that Neolithic pottery was rarely traded, and when it was, this concerned only highly decorated fine wares, which acted as rare goods. Present research re-examines pottery exchange during the Neolithic period, focusing on the study of both undecorated and decorated wares, which date to Middle Neolithic III-Late Neolithic I (c. 5500-4000 BC) and derive from 12 stratified excavation assemblages (Theopetra Cave, Platia Magoula Zarkou, Agia Sophia, Otzaki, Arapi, Makrychori 2, Halki 1, Sesklo, Tsaggli, Achilleion, Orgozinos, Magoula Sykeon).

Detailed macroscopic examination, petrographic analysis and refiring tests were applied on a total of 480 pottery sherds and 34 geological samples. Additionally, 200 thin sections, deriving from the pottery assemblage chemically analysed by Schneider *et al.* but not published in detail, were used as comparative material and provided an important link to published results of chemical analysis. Major research objectives were a) to shed light on the networks of pottery exchange, and in particular on their structure and organisation, and b) to clarify the way and the extent to which each settlement participated in these networks.

The integrated approach adopted, along with the combination of old and new analytical data, resulted in a) the characterisation of production for each ware studied, b) the identification of 6 fabrics, which generally are ware-specific and have different spatial distributions throughout Thessaly (for both coarse undecorated and fine decorated pottery), c) the more secure identification of provenance for all 6 fabrics, and d) the indication of the parallel activity of different exchange networks, with different distributions and variable degrees and forms of participation by each settlement, resulting in three different patterns of settlement involvement in pottery exchange.

The archaeological implications of this study for understanding of the Thessalian Neolithic are rather significant. The pottery that is exchanged mostly involves vessels for food/drink consumption and display, regardless of surface treatment, pointing to an activity of consumption ritual, not necessarily the same for all wares. The detection of different production centres, most frequently ware-specific, and the distribution patterns of the pottery produced, have significant connotations for the unravelling of the complex relations and exchange networks developed between settlements in Thessaly, with some playing noticeably different roles: Platia Magoula Zarkou could be characterised as a production settlement, being very active in 'exporting' pottery, Halki 1 stands at the exact opposite end being a 'receiving' settlement, participating in all networks identified, while Otzaki and Makrychori 2 stand between the two ends, presenting a balance between 'importing' and 'exporting' pottery.

## **Lead glazes in Islamic pottery from the Iberian Peninsula: materials and technology used during the eleventh to twelfth centuries**

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The period of the Taifas (small kingdoms in the Iberian Peninsula during the last phases of Muslim political authority) corresponded to a period of flourishing cultural and economic development of these small kingdoms, also demonstrated in the ceramic technology. Albarracin Taifa (in the south of the current Aragon region) was an independent kingdom since the beginning of the eleventh century AD, and, although the territory passed to Christian hands in 1170, it still preserved some independence for a century. This privileged position during more than two centuries helped Albarracin to maintain economic contacts and advantageous cultural relations with Muslim areas, but also with Aragon and Castille. Ceramic production in the Albarracin Taifa is thus very interesting in terms of pottery technology and actual exchanges between different workshops in the eleventh to twelfth centuries.

Fragments of glazed pottery were previously analysed by inductively coupled plasma (ICP)-atomic emission spectrometry, and glazes studied by scanning electron microscopy with energy dispersive X-ray spectrometry. The knowledge of raw materials was completed by the investigation of lead-isotope and copper-isotope ratios by ICP-quadrupole mass spectrometry. Results from some of the most interesting ceramic types will be presented in order to emphasise the main differences and similarities between them and also in relation to other Islamic areas.

The present study of these Islamic ceramics was focused on the determination of lead isotope ratios in the glazes, a tool already used in metal-alloy research, in order to distinguish production areas and glaze types. Values obtained allowed a clear discrimination among the groups of samples investigated. In this case, a distinction among lead sources chosen for producing different glaze types (transparent or tin-opacified) could be observed in some ceramics: glazes produced at the same site and during the same period can be distinguished by their lead-isotope ratios.

## The tiles of Damascus

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This lecture will look at tile-work in Syria, particularly in Damascus, at two periods in time. The first is when Syria was ruled by the dynasty of the Mamluks with their capital at Cairo (AD 1250-1517), and the second during the succeeding Ottoman period, when Syria became a key province of the Ottoman empire. The styles and designs are quite different from one period to another and show different sets of influences on the work. The Mamluk tiles respond to the designs and colour scheme of Chinese blue and white porcelain which was one of the main imports into the Middle East at this time, while the second are closely linked to the vibrant ceramic production of Ottoman Turkey made at Iznik. Tilework *in situ* in Damascus will be discussed along with individual groups of tiles in the British Museum, Leighton House and other collections.

## The technology and optical properties of silver rich Islamic lustres

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The study of the structural properties of silver rich Islamic lustres has provided a clear understanding of the technological requirements for their production and their evolution since the beginning of lustre production (Iraq, ninth century AD) until the end of the Fatimid lustre production (Egypt, twelfth century AD). An adequate combination of analysis which include the oxidation state of copper and silver in the lustre layers (determined by extended X-ray absorption fine structure (EXAFS) and X-ray absorption near-edge structure (XANES) spectroscopy), size of the nanoparticles (determined by micro-XRD), volume fraction of the metal nanoparticles and thickness of the lustre layer (determined by Rutherford backscattering spectroscopy (RBS)) have given direct clues concerning the reasons for their colour and shine. Theoretical calculations based on the experimental data are compared to the measured ultraviolet-visible (UV-Vis) spectra and the reasons for those differences are clarified. The differences in the technology of production between lustre productions are related to the colour and shine shown.

## **REE and other trace elements as chemical tracers for the establishment of archaeological ceramics provenance**

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Different geochemical patterns found in clays from different geological contexts form an important basis for their comparison with archaeological ceramics, since the identification of the clays used for certain productions can contribute to delimiting a potential area of clay resources and thus establishing provenance. This is particularly useful when no archaeological evidence of production exists.

In this work several case studies of ceramic investigations from Roman archaeological sites of the Iberian Peninsula are presented. The precise and accurate determination of chemical element compositions of ceramics and clays was obtained by INAA using the Portuguese Research Reactor. The results obtained show that REE patterns and other trace elements distributions can be particularly useful to identify and distinguish ceramic productions, and their relation with raw materials, which is crucial to pursue studies of provenance establishment and reconstruction of ancient trade routes. Geochemical patterns of ceramic groups of several types, from different archaeological sites within the Portuguese territory with evidence of ceramic production, were established and distinguished from imports from other sites within the Roman Empire, particularly Campania (Italy), and Tarraconensis and Baetica (Spain).

## Identifying potential sources of Late Bronze Age pottery from Cyprus using lead isotopic analysis

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This provenance study, which is part of a larger multidisciplinary project at the Vrije Universiteit Brussel pertaining to the study of man and paleoenvironments, uses lead isotopes as a tracer of sources of raw material used in pottery production. Lead isotopes commonly trace the provenance of metal artifacts or lead-rich materials, but so far, they have not been applied to the analysis of the raw material used for pottery production.

A selection of eighty sherds from the most common pottery wares (Canaanite, Coarse, Base Ring, Black Slip, Bucchero, Plain White Wheel-made, Red Lustrous Wheel-made, White Painted, White Slip) from the Late Bronze Age site of Hala Sultan Tekke in southeast Cyprus were analysed and compared to thirty potential clay sources collected in the surroundings of this site. The samples were selected based on their lithology: Quaternary clayey sediments, Pliocene, Miocene and Palaeogene marls, and clayey weathering products from the ophiolitic complex. Lead isotopes were measured using MC-ICP-MS. In addition to the isotopic analysis, elemental geochemistry and mineralogical analyses were carried out on a selection of sherds and sediments.

A preliminary set of results on a limited number of sherds from the Late Bronze Age site of Hala Sultan Tekke and clays demonstrated the effectiveness of lead isotopes for tracing pottery provenance and the use of local sources for pottery production (Renson *et al.* 2007). The scope of the provenance research was then enlarged and supplementary sherds and clays from other Late Bronze Age sites in Cyprus were analysed (e.g., at Sanidha). Current results focus on the lead isotopic composition of the local pottery production at Hala Sultan Tekke and its comparison with the composition of the potential clay sources collected in the vicinity. Furthermore, White Slip (WS) sherds were analysed to test the hypothesis of their possible provenance. This pottery ware, which is found all over the Mediterranean, is considered to come mainly from Sanidha (south Cyprus) and may also be locally produced at Hala Sultan Tekke (Hatcher 2002). Therefore, the composition of 31 WS sherds from Hala Sultan Tekke have been compared to the composition of 22 WS sherds from Sanidha and to the composition of the potential clay sources collected in the surroundings of both Hala Sulan Tekke and Sanidha (c.15-20 km).

## **Heartland and periphery: petrographic and chemical analyses of Halaf fine ware production**

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One hundred and eleven potsherds from the Halaf culture sites of Tell Halaf (Syria), Chagar Bazar (Syria), Domuztepe (Turkey), and Arpachiyah (Iraq) were analysed in thin section. Forty-eight of these were also analysed by SEM-EDX. The aim of the project was to identify whether there is a production centre for the fine Halaf pottery within the core region of this culture around Arpachiyah, and separate production centres in a peripheral western zone that includes Domuztepe.

The petrographic results show that different recipes were used for the pottery production at Domuztepe; in particular, a specific formula was used for the manufacture of coarse ware. This is in marked contrast to the common recipe for the fine, painted ware produced at the four Halafian sites. The Domuztepe cooking pots were probably manufactured locally, whereas the fine wares, which were made of fine, levigated and micritic clays with serpentine inclusions, are very similar to thin-walled painted ceramics found at the sites of Tell Halaf, Chagar Bazar and Arpachiyah.

SEM-EDX results show that the chemical composition of the painted ware from the four Halafian sites is very similar, especially among sherds from Tell Halaf, Arpachiyah and Chagar Bazar, but the Domuztepe fine ware was produced at a different site.

## **Moulding the 'Collapse': the technological characterisation of the Terminal Classic Ahk'utu' moulded-carved vases from Altun Ha, Belize**

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This paper presents the technological characterisation of 21 samples selected from an assemblage of ceramic vases recovered from the site of Altun Ha, Belize. The vases, classified as 'Ahk'utu' moulded-carved' in the type-variety naming system in use, constitute a ceramic tradition in which exterior decoration is moulded and carved. Previously characterised as an imitation of the better known ware widely found at sites in Mexico and Guatemala, Ahk'utu' moulded-carved vases were recently established as a distinctive pottery class, based on stylistic and epigraphic analyse (Helmke & Reents-Budet 2007), specific to the Terminal Classic period (AD 750/800 – AD 950/1000). What Mayanists call the 'Terminal Classic' was a transitional period of dramatic changes in sociopolitical order in the Maya Lowlands.

This research builds on the earlier stylistic and epigraphic studies and describes the physical, chemical and mineralogical properties of the selected samples of the Ahk'utu' moulded-carved vases determined by INAA and SEM-EDS, in combination with the traditional methods of visual examination and thin-section petrography. Technological characterisation of the samples provides the basis for identifying the production-related groups, reconstructing the manufacturing technology, delineating the organisation of production, and drawing inferences concerning the broader sociopolitical context under which these ceramics were produced.

Based on the analytical data, three compositional groups – namely the volcanic ash-, coarse calcite- and fine calcite-tempered – have been distinguished. Although compositional variations likely reflect different potting groups (Howie 2005), manufacturing technology largely conformed to a style in which most vases were pressed in concave ceramic moulds, then subsequently slipped, carved and then fired in a non-kiln open firing method at temperature lower than 800 °C.

These and other findings suggest that the production of the Ahk'utu' moulded-carved vases was organised by part-time producers who manufactured prestige items for the elites within a local or community context. This differed from Classic-period production of polychromes and may be related to alterations in political systems and political ideology during the Terminal Classic period. Following the disintegration of divine kingship, newly emerged elites may have attempted to legitimise their authority and build alliances at both local and regional levels via the exchange of prestige items. The application of moulding facilitated the production of highly standardised Ahk'utu' moulded-carved vases, which would have functioned as social and political currency in turbulent times.

## Technological choices in the production of Italian maiolica ceramics

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The technology of maiolica production in Italy in the sixteenth century AD is in general terms reasonably well understood thanks to the treatise, *The Three Books of the Potter's Art*, written by Cipriano Piccolpasso in c. AD 1557. According to this treatise the clay body was biscuit fired, probably to a temperature in the range from about 900-1000 °C. A tin-opacified glaze was prepared by milling a mixture of *marzacotto* (i.e., a sintered mixture of sand, wine lees and sometimes, common salt) with lead and tin oxides, and sometimes, further sand. This mixture was applied to the biscuit fired body. The decoration was then painted on the unfired powdery glaze surface, and a transparent glaze, referred to as *coperta*, was sometimes applied before firing the ceramic for a second time.

The microstructures and chemical compositions for a range of Italian maiolica ceramics dating to the fifteenth century AD onwards, as determined by the examination of cross-sections through the glaze into the body in an analytical scanning electron microscope, are shown to be fully consistent with the description given by Piccolpasso. However, examination of earlier Archaic maiolica dating to the thirteenth to fourteenth centuries AD revealed significant differences in the body clay and glaze types used, and in the concentrations of tin oxide in the glazes.

The benefits, in terms of ease of production and quality of the final product, resulting from the consistent use, from the fifteenth century AD onwards, of calcareous clays for Italian maiolica bodies in combination with lead-alkali glazes containing between 4-9 wt% of tin oxide are considered, together with the benefits of adding further sand to the glazing mixture and applying a transparent *coperta* layer over the painted decoration. Also discussed are the possible benefits resulting from the use, in the production of della Robbia sculptural ceramics, of body clays with higher lime contents, and glazes with higher tin oxide contents.

## **Rice temper: technological solutions and source identification in the Indian Ocean**

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This paper originates with a group of pottery that was identified on the Egyptian Roman period Red Sea sites of Myos Hormos and Berenike and was readily characterised by its very light weight, resulting from a high proportion of organic tempering. Occurring in a limited range of forms, heavily sooted and therefore associated with cooking, the type was subsequently identified along the South Arabian coast, and then linked to a concentration of the same fabric at a number of Early Historic (c. third century BC – third century AD) sites in the state of Gujarat in north-west India where it was produced.

Examination of the fabric under the binocular microscope suggested the use of rice for the organic tempering and this was confirmed with the petrological microscope. In this paper the samples from the Red Sea are compared petrologically with those from a number of sites in Gujarat in order to establish the degree of variability in the clay matrices. The rice tempering is examined by SEM in order to define how the rice was processed prior to inclusion in the clay.

The use of rice tempering has a wide application in south Asia. This paper examines the technological choice in this context and how rice affects the suitability of the pot for cooking over an open fire. Archaeologically the source identification and distribution of the type of pot in India have important ramifications for unravelling trade routes throughout the Indian Ocean, since embarkation ports are known in both north and south India. During the Early Historic period this rice-tempered pottery appears to be restricted to the northwest of India and therefore provides a mean by which to isolate trade activity directly related to the northern ports, such as Barygaza and Kamrej.

## **Ceramics production in medieval Beirut: between 'Frankish ware' and Islamic traditions**

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During the large-scale excavations undertaken in the 1990s in Beirut's city centre, pottery kilns and wasters dated back to the medieval period were unearthed. The archaeometric study of this material gave the opportunity to define chemical reference groups and to reconsider the questions of trade routes and diffusion of techniques in the Levant in this period.

Two main categories of ware were manufactured in medieval Beirut, which may each be related to a different tradition. A first category, made out of low calcareous, ferruginous clays, corresponds to lead-glazed cooking ware and table ware. The latter may be slip-painted or decorated with the sgraffito technique. This ware was widely exported, at least from the Fatimid period onwards, as testified by its presence in the Serce Limani shipwreck, and is typical of many Frankish sites of the Levantine coast. Another type of ceramic, which appears at a later date, shows quite different characteristics, associating high-calcareous paste and lead-alkaline turquoise or deep brown glaze. This ware may have been mistakenly considered until now as an Egyptian import and ties Beirut's ceramics production to the Islamic tradition.

Archaeological and archaeometric evidence for Beirut's local production and diffusion will be discussed.

## **Posters**

## **Pottery production and mineral resources management in Majorca (Balearic Islands, Spain) During Bronze and Iron Age (1700-123 BC): provenance, technology and society**

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The goal of this poster is to attempt a technological and social characterization of prehistoric Majorcan pottery through thin section analysis, XRD and XRF. Using these methods, we have studied the chemical and mineralogical composition and textures of a wide range of samples from diverse Bronze and Iron Age settlements. The results provide important information relating to different aspects of their production, such as their provenance, the preparation of the clay, addition of tempers and estimated firing temperature.

The archaeometric characterization suggests some interesting technological differences between Early Bronze Age (1700-1500 BC), Middle Bronze, First Iron Age (1000-500 BC) and Late Iron Age (500-75 BC). The most significant changes are related to the intentional introduction of crushed crystalline calcite into the paste by potters. Also some organic matter was intentionally added to the clay, especially during the later period when the use of calcite starts to decrease.

The study of the variability of both tempers provides the majority of information towards understanding the operative chain and technological traditions, including productive strategies and the level of specialism observed in the prehistoric communities from Majorca. It allows us to put forward some of the social and economic functions inherent in the technological choices of the potter.

## On the origin of compendiaro majolica coming from excavations in Amsterdam

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Archaeological excavations in Amsterdam by the Office of Monuments and Archaeology (BMA) over the past 40 years yielded a series of seventeenth century faience ceramics. Apart from local Dutch products, the Amsterdam archaeological record also contained Italian products, mainly from Liguria and Tuscany. In addition, tin-glazed ceramics in the so-called compendiaro style as well as completely white wares were found. These have been attributed to the production workshops in Faenza, but for the majority of the compendiaro finds and white wares this attribution seems incorrect according to some archaeological deductions.

The identification of imported ceramics from the Mediterranean was an important issue in the archaeological analysis of the role of Amsterdam as a centre in an expanding maritime network in the seventeenth century. Comparative stylistic research within the framework of a master's thesis at the University of Amsterdam raised questions on the validity of these identifications. There were indications of diverse production centres in Italy and even of production of Italian style ceramics outside Italy. Therefore verification of origin on the basis of archaeometric research of the pastes and glazes was opportune.

Thirty-five samples of compendiaro majolica coming from underwater archaeological excavations carried out in the historical centre of Amsterdam have been selected for the analyses, together with twenty-four majolica fragments of the same style coming from Faenza. Observations on thin sections through optical microscopy (OMP) have been carried out in order to characterise the microstructure and the morphology of the pastes and the glazes, while scanning electron microscopy combined with SEM-EDS has been used for the determination of their chemical compositions.

Investigations evidenced the presence of two groups among Dutch samples, distinguishable by microstructure and chemical composition. In particular, one is characterised by glazes with about 12% SnO<sub>2</sub>, and the other with lower amounts of tin oxide in the glaze (6-9% SnO<sub>2</sub>). More homogeneous data resulted from the analyses carried out on the Italian samples from Faenza, which all show fine-medium pastes and glazes with around 7% SnO<sub>2</sub>. Therefore it can be deduced that only part of the Dutch samples can be attributed to Faenza; the provenance of the others is still not clear. The next stage of the research will be the comparison with data on ceramic fragments from other Italian production centres (especially Ligurian) and from France.

## Pottery production at Tell es-Safi/Gath: a *longue durée* perspective

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As pottery is the main tool in evaluating relative chronologies in archaeology, it is not surprising that most studies dealing with pottery focus on limited periods. Therefore, it is quite rare that the development of pottery production and technology is studied at a specific site over a wide range of periods. This is true of both stylistic-typological studies, as well as provenance studies examining the chemical and/or mineralogical composition of pottery. The development of pottery production during the Bronze and Iron Ages at Tell es-Safi/Gath, Israel, is examined in this study from a *longue durée* perspective based on the analyses of 224 pottery vessels representing most periods within this c. 1,700 year time frame. The main tools employed were visual examination of manufacturing techniques (such as wheel forming and finishing, coil forming) and petrographic thin section analysis. All these techniques were conducted on the entire group. This was combined with a chronological, functional, typological, and cultural characterisation of the samples. The results indicate a tendency of diachronic shift from the use of calcareous-based clays to non-calcareous clays, from the Bronze Age towards the Late Iron Age, although interestingly, throughout this time frame, the primary shaping techniques do not change. Intentional tempering, when relevant, is mostly type- or function-dependent. A tendency towards more highly-fired pottery in the Iron Age II was also detected. This trend seems to be evident at other sites in the southern Levant as well, where sufficient information enabled comparison of the technology of Bronze and Iron Age pottery. This phenomenon is probably related to the employment of higher firing temperatures by the potters, and may also be related, to a certain degree, to the decrease of the relative amount of decorated pottery that is seen during the Late Iron Age.

## Inside the shard

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Following the framework of the EU - Ancient cultural heritage and archaeological research methods project (CHARM), neutron techniques are being used to visualise the insides of archaeological objects. The main focus of the project is on metals and composite objects, nevertheless we also tried applying these methods to pottery. Looking at the multi-period archaeological site Vörs, where the petrographical and geochemical investigation of the pottery is at an advanced stage, we were able to compare the non-destructive possibilities of neutron imaging (to start with, neutron computer tomography (NCT) and PGA imaging) to existing petro-archaeological information on the ceramics.

Shards were selected from a variety of cultural units, representing Early Neolithic: Starčevo Culture, Early Copper Age: Lengyel Culture, Early Bronze Age: Kisapostag Culture and modern shards from the site area.

Neutron computer tomography images were made at BENSC. For comparison, X-ray computer tomography data were also recorded. PGA imaging is currently in progress at the Isotope Institute of the HAS, Budapest, while petrographic studies have been made in Budapest.

The methodology applied allowed an assessment of temper, form, volume and chemistry and a comparison with previous knowledge of raw pottery material.

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Ancient Charm project webpage <http://ancient-charm.neutron-eu.net/ach>

## **Early Roman ceramic production and consumption in the Civitas Tungrorum, Belgium**

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Early Roman pottery occurs in significant amounts at archaeological sites in the Civitas Tungrorum region of Belgium. Roman ceramic technology arrived in the Flavian period (third quarter of first century AD), and represents a cultural marker used to separate the historic period from the preceding Iron Age. Despite the importance of Roman ceramics in the archaeology of the Civitas Tungrorum, little attention has been paid to typological-chronological studies, and consequently, to pottery circulation. This project examines Roman pottery production and distribution in this northern province of the Roman Empire, as it represents an important means of reconstructing the cultural development of Roman society.

As part of this larger project, ceramics from the important site at Tienen have been analysed in detail, using a combination of thin section petrography and atomic absorption spectroscopy (AAS). The compositional analysis of Early Roman ceramics from the site at Tienen indicates that several distinct ceramic technologies were employed during the operation of the kilns. Several discrete fabric compositions were identified within the early Roman ceramic samples, relating to the raw materials and pottery technology. By placing ceramic compositional groups in their landscape, this project aims to come to a better understanding of regional ceramic production and the exploitation of natural sources in this area, as well as the distribution patterns within and beyond the Civitas Tungrorum.

## **Ceramic analysis and cultural interpretation of the Stacked Stone Site, Cuyamaca Rancho State Park, southern California**

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Forest fires in Cuyamaca Rancho State Park, San Diego County, southern California during 2003 revealed a previously unknown archaeological site containing permanent rock-built structures. A programme of research was initiated in 2005 to document and preserve the unique 'Stacked Stone Site', which consists of five circular enclosures. As part of this larger project, detailed ceramic analysis was conducted on a sample of undecorated pottery sherds that were recovered from the structures, with the aim of investigating the function of the Stacked Stone Site and its relationship to other native Kumeyaay sites within southern California.

Plain featureless ceramic sherds are a common characteristic of the Late Prehistoric (c. AD 950–1769) material culture of southern California. The lack of decoration or other distinguishing features on these ubiquitous artifacts has for many years hindered their meaningful classification. However, the recent application of thin section petrography and analytical chemistry is beginning to reveal an unsuspected level of compositional variation that offers significant potential in terms of reconstructing the movement, interaction and cultural identities of the greatly decimated native groups that once inhabited this area.

Analysis of the Stacked Stone Site sherds has indicated the presence of several distinct petrographic fabric classes, characterised by the use of different residual igneous raw materials that occur within the wider Laguna Mountains area which also includes several other important archaeological sites. In thin section, the ceramics of the Stacked Stone Site bear close correspondence with previously analysed material from the native settlement of Wikalokal, 25 km to the south, suggesting that many of the sherds at the two sites share a common origin.

No direct evidence for ceramic production has been found at the Stacked Stone Site and it may be that pottery was transported to this site from a larger Kumeyaay village such as Wikalokal or Ah-ha'-Kwe-ah'-mac, along well-known native trails that traverse the Laguna Mountains. With this in mind it might be postulated that the Stacked Stone Site was a satellite settlement that was used as a seasonal camp for resource gathering or perhaps served a non-permanent defensive purpose. Whatever the function of the unusual stone built structures, detailed analysis of ceramics suggests that the native inhabitants of this site did not live in isolation but were well connected to the wider Kumeyaay community that once covered this area of eastern San Diego County.

## Optimisation of preparation and measurement protocols for luminescence dating of small samples from a suite of porcelains and faïences

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As part of a wider study into the production and importation of porcelain and faïence into Portugal, stimulated luminescence is being used to test typology-based chronologies for ceramics from various archaeological sites in Lisbon and Coimbra. To achieve this, procedures are being developed to facilitate luminescence testing of small samples (<100mg) from these different types of ceramic, following a standard method.

Conventional approaches to luminescence measurement, take small samples from weaker ceramic fabrics such as faïence, and use powder obtained directly by drilling using a tungsten bit. Porcelain is compact and drilling or crushing can remove luminescence signals and alter a sample's behaviour, so it is conventionally measured in slices cut from a core drilled through the piece. Both approaches produce a polymineral sample and hence variations in luminescence behaviour depending on the sample's composition. A defined grain-size fraction may be separated from the powder by Stokes settling, but results from slices of porcelain could also be affected by differences in the doses absorbed by different grain sizes. Dating measurements are ideally conducted on specific mineral and grain-size fractions isolated from much larger samples (e.g. entire sherds ~20g).

In the present study cores have been drilled from the broken faces of sherds using hollow diamond tipped bits, and cleaned to remove any contamination. Initially, parts of some larger cores were coarsely crushed and unprocessed material was measured by TL using the Multiple Aliquot Additive Dose technique. Signal levels were used, but luminescence behaviour attributed to the presence of calcite was poor. Other crushed sub-samples were treated briefly in HCl and HF to remove carbonates and surfaces affected by crushing, and single aliquots were measured using a combined sequence designed to test the signal levels and behaviour of Pre-dose and Regenerative TL, and Regenerative OSL signals. Material losses from this preparation were unacceptably high, but the Pre-dose TL signal was identified as most commonly present at usable levels. Subsequent work focussed on the isolation of fine grains of quartz for Pre-dose TL measurement. Cleaned cores were treated in 1M HCl for 4 days to weaken the ceramic by removing carbonates: this allowed both faïence and porcelain to be disaggregated into powder. Pre-dose TL signals from the residual silicates from porcelains were low but behaved well. Those from faïences were higher but subject to interference. After settling to isolate the >60 and <11 µm fractions, samples were treated in fluorosilicic acid. Sufficient quartz enriched material (~5 mg) has been obtained for absorbed dose determination on a number of aliquots for each sample, to allow absolute age estimation based on the average of the Pre-dose TL results, combined with dose rates from INAA and a limited number of soil samples retained from the excavations.

## A Bronze Age pottery production in the Po valley

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During the Middle and Late Bronze Age (1700-1150BC) the Po valley was occupied by fortified villages (Terramare). This culture, which occupies a transitional area between the great innovative cultural zones of the Mediterranean and Central Europe, represents a significant landmark in Italian proto history (Bernabò Brea *et al* 1997).

The pottery production - handmade coarse ware - is one of the most significant pieces of archaeological evidence. To investigate the degree of craft specialization, over 1000 vessels from various archaeological sites in the Modena area were observed macroscopically, and approximately 10% were sampled (Cardarelli *et al.* 2007).

The pots have been analysed by petrographic, mineralogical (XRPD), chemical (XRF) and DIP (Digital Image Processing) analyses. Six groups of ceramic paste were identified by petrographic analysis: fine matrix, tempered with grog-calcite, calcite, calcareous sand, grog and sand and only grog. The grog tempered group is the most frequent, confirming a trend already observed in Bronze Age pottery in the Po valley (Jenkins *et al* 1999). The digital image processing (DIP) of the thin sections has been used to establish the dimensions and the quantity of temper used in the pottery (Carpenito *et al.* in press, Reedy 2006, Cuomo di Caprio & Vaughan 1993).

The mineralogical analysis revealed the consistent presence of quartz, feldspar (albite) and clay minerals (illite/muscovite), and sometimes amphibole and calcite. The chemical results underlined the low percentage of CaO, which represent a good marker to identify the possible raw materials.

In order to identify the local raw materials, 37 clay sediments from various geological units surrounding the sites were collected. The petrographical, mineralogical and chemical data were compared with the archaeological pottery set. In detail the statistical elaboration of the chemical elements seem to get out a good overlap between the pottery and the clay sediments poor in CaO, but some differences remain linked to clay minerals fraction and calcite.

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## **Ceramic production, distribution and prehistoric society in the Peak District National Park**

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The excavation of probable early farming communities on the Eastern Gritstone Moors west of Sheffield has altered our perception of Bronze Age society in the area now occupied by the Peak District National Park. The examination of these remains within a theoretical landscape perspective has suggested that a homogeneous scatter of small, self-sufficient local farming families may have extended across the region during the second millennium BC. This pattern contrasts with the hierarchical system of hereditary elites that appear to have existed elsewhere in Britain at this time and is therefore of great interest.

Significant quantities of coarse-ware ceramics have been found at prehistoric sites on the Eastern Gritstone Moors and elsewhere the Peak District. As one of the most common artifact types, they represent an important resource with which to further explore the unusual pattern of prehistoric settlement in this archaeologically-rich area. An on-going doctoral research project at University of Sheffield is applying thin section petrography to examine the compositional variability of Early Bronze Age–Early Iron sherds from the Peak District for the first time. By reconstructing the nature of ceramic production and distribution at numerous key sites across the region, including Gardom's Edge, Mam Tor, Ball Cross and Roystone Grange, this project is attempting to re-address a range of exciting issues that emerged in Peak District archaeology during the last 10-15 years.

Initial analysis of some c. 250 sherds from several sites across the park has revealed an extreme level of compositional homogeneity, with >90% of artifacts characterised by rounded basalt temper and fine non-calcareous base clay. Given the geological heterogeneity of the Peak District and the rather limited occurrence of basic igneous rocks, this finding suggests that pots were either being made at a single location and distributed widely, or that prehistoric people travelled considerable distances to obtain specific uncommon resources.

This surprising discovery, which mirrors possible stylistic links between the ceramics from the geographically separate sites, has wide ranging implications for the perception of Bronze Age society in the Peak District and, in particular, the role of farming communities such as those discovered on the Eastern Gritstone Moors. The highly distinctive, geographically widespread compositional signature that characterises the majority of ceramics analysed appears to have persisted for a long period of time, occurring as elaborate Early-Middle Bronze Age ritual vessels as well as largely undecorated Late Bronze pottery. Such unexpected continuity in ceramic practice during a period that is characterised by fundamental change in many other aspects of prehistoric society is highly significant and requires explanation.

## **Residue analysis of Mid-Byzantine coarse wares from Hierapolis/Pamukkale, Turkey**

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The ancient city of Hierapolis (modern Pamukkale) is located in a valley formed by the River Lykos, a tributary of the ancient Maeander River, in western Anatolia. The site has been the object of a long term research project run by the Italian Archaeological Mission at Hierapolis, presently directed by F. D'Andria (University of Salento). The site has Hellenistic foundations, and has had long standing use as a town, spanning across the Roman and Byzantine period until it became the Seljuk fortress and settlement. Excavations to date have uncovered large portions of the public, commercial and residential quarters of the Late Antique town, which was seriously damaged by an earthquake that took place in the 7th century AD.

Investigations carried out by the University of Venice in insula 104 (under the direction of A. Zaccaria Ruggiu), a residential quarter of Hierapolis, have recently brought extensive evidence for VIII-X century occupation to light. The associated ceramic assemblages reveal the prevalence of a distinctive Fe-rich micaceous fabric, highly resistant to thermal shock, associated with a new morphological and decorative repertoire, reflecting the changed socio-economic and cultural contexts of Hierapolis in the Early Middle Ages .

A programme of residue analysis has been carried out on the recovered Mid-Byzantine ceramics, in order to better define the functions of the various vessels (flagons, jars, pithoi/storage jars, cooking pots, small amphorae) found in this distinctive Mid-Byzantine micaceous ware. The organic residue analysis by GC-MS of samples from cooking pots indicate the saturated fatty acids, stearic (C18:0) and palmitic (C16:0), as the most abundant species with decreased amounts of oleic acid (18:1) in all cases. The high relative abundance of saturated species, especially stearic acid (C18:0), suggests that these lipids are of animal origin. Branched and odd chain fatty acids are also present in all of the pots, which further indicate a possible ruminant source for these lipids. The animal origin of the organic residue in the pots is also confirmed by the detection of traces of cholesterol in the sample US 732 inv. 6806 FT 2052. On the other hand, analyses carried out on samples of flagons revealed the presence of wine as their original content. These and similar results will be discussed, highlighting morphological and functional aspects of Mid-Byzantine coarse wares from Hierapolis.

## **Physicochemical characterisation of Byzantine ceramics found at excavation sites in Serbia: Ras, Reljina Gradina, Niš and Braničevo**

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Even though collections of archaeological pottery samples excavated in fortified towns, fortresses and monasteries in Serbia and dated as Byzantine ceramics are numerous and well described by archaeologists, there is only scarce information about Balkan ceramic manufacture and processing. Systematic archaeometric studies of ceramic provenance, production and decoration technology, specific characteristics of different workshops, as well as influences of neighbouring countries, have never been performed in this region. In a historical sense, the production of Byzantine ceramics in the Balkans is a missing link between the Greek/Roman and the Ottoman period; hence, archaeometric studies of medieval Serbian ceramic artifacts will lead to important knowledge in this area.

In this poster the results of a systematic investigation of pottery sherds from four archaeological sites, Ras, Reljina Gradina, Niš and Braničevo are presented. Ras is outstandingly important to the history of medieval Serbia and Stari (Old) Ras, which is an UNESCO World Heritage Site, was the first capital of the medieval Serbian state of Raška. Founded between the ninth and tenth century, and deserted in the thirteenth, Ras sat in the middle of the growing empire, on the crossroads between the Adriatic Sea and the state of Zeta, with Bosnia in the west and Byzantium in the south. The excavation site Reljina Gradina is a part of the Ras archaeological complex, while the excavation site Niš is located about 100 km east from Ras, and was the fortress at the border of the Serbian state in the twelfth century. Braničevo was one of the most important towns in medieval Serbia, particularly during the twelfth century, since it was located on the bank of the river Danube which was the border of the empire as well as an important trade route.

The primary aim of this study was to characterise pottery sherds in order to obtain evidence about local ceramic production, but also to analyse the results in the framework of economic and cultural exchanges between Balkan countries in the Byzantine period. The results will be used to build up a national database for the compositions of bodies, glazes and pigments from the different ceramic products.

16 archaeological pottery samples from Ras, 9 samples from Reljina Gradina, 10 samples from Niš and 6 archaeological pottery samples from Braničevo were investigated. The ceramic body of the artifacts was studied by a multianalytical approach, combining XRF, FTIR and Raman spectroscopies, XRPD and DTA. Data obtained by FTIR spectroscopy have been used for chemometric, principal components and cluster analysis. Utilisation of different experimental techniques allowed those methods which are most suitable for attaining specific information about the pottery samples under investigation to be established.

The results obtained confirm that ceramics from Ras, Niš and Braničevo are imported, and those from Reljina Gradina have a domestic origin.

## Provenance studies of black-coated pottery from Risan (Montenegro)

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Excavations in Risan (ancient Risinium) have been carried out by a mission from the Research Centre for Antiquity of South-Eastern Europe since 2001, directed by Professor P. Dyczek. The ancient town of Risan is situated in Montenegro on the northern edge of the Bay of Kotor, 11 km northwest of the town of Kotor. Ceramic sherds (25 fragments of amphorae and Gnathia-type pottery) recovered from excavation were submitted for archaeometric analysis and also local clay has been analysed (Daszkiewicz *et al.* 2007). Recently, Dyczek supplied 116 sherds of Hellenistic black-coated vessels recovered during the 2008 excavation season at the Carine VII site to M. Baranowski for the purposes of his undergraduate degree thesis. The small size of the sherds in many cases made attribution of the fragments by stylistic and typological analysis difficult. Laboratory analyses were therefore made to distinguish groups which were then described macroscopically to give precise fabric definitions for further field classification of black-coated pottery from Risan. For all 116 fragments measurements of ceramic properties (open porosity, apparent density, water absorption) and MGR-analysis have been done. 100 samples were chemically analysed by WD-XRF and for six selected samples thin-section examinations and measurement of changes of ceramic properties after refiring (so called K-H analysis) were also made.

Two samples have been attributed to Campana A, but for the rest of the samples archaeometric analysis only detected compositional groups, which, because of a lack of reference material, could not be attributed to provenances. The majority of the samples fall into one homogeneous group corresponding to the major group of the pilot series (Daszkiewicz *et al.* 2007). The geochemical characteristic of this group points to an east Mediterranean provenance. The rest of the analysed samples may have been produced somewhere on the Adriatic coast.

## **Late 5<sup>th</sup> to early 3<sup>rd</sup> millennium BC Transcaucasian wares: a technological and petrographic perspective**

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This paper focuses on the technological study of the Chaff Faced and Kuro-Araxe wares from the excavations of Ovçular Tepesi, an archaeological site located in the southern Caucasus (Autonomous Republic of Nakhichevan, Azerbaijan). The pottery in this study belongs to levels dated from 4300 to 2600 BC, with Chaff Faced Ware pottery attributed to the Chalcolithic 1 and 2 periods and Kuro-Araxe Ware to the Late Chalcolithic 3-Early Bronze Age 1. In the 4<sup>th</sup> millennium BC, the southern Caucasus had many links with the Anatolian highlands, sites such as Norshuntepe or Tulin tepe in the Elazig-Malatya plain and also with sites like Aratashen in southern Armenia. The aim of this study was to show the technological similarities between the ceramic productions of Nakhichevan a region hardly known until recently, northern Mesopotamia and the northern region of southern Caucasus, i.e. Armenia.

The project, combining macroscopic and petrographic analyses, aimed at reconstructing the production sequences used in the production of both wares as well as establishing their provenance. The macroscopic observation of surface features, indicative of specific methods of production, revealed that these wares were made using different techniques, mainly pinching and coiling, and, to a lesser extent, coiling combined with wheel shaping. The latter attests to the use of the fast wheel as early as the 4<sup>th</sup> millennium BC for a small percentage of pots. Thin section petrography of 50 samples has been successful in characterizing the types of clays used in the production of these wares and enabled the observation of the clay paste technology. Petrographic data revealed that 98 % of the pottery was produced locally or within the vicinity of the site. Only one sample may be imported, from the northwestern region of Iran. Overall, the results provide a good understanding of the skills and knowledge of the potters working at or near Ovçular Tepesi and contribute to the study of the role that pastoralism or transhumance played in the evolution and the diffusion of this Transcaucasian culture.

## **Chemical characterisation of Portuguese faience from the sixteenth to eighteenth century: a preliminary neutron activation study**

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Important centres of early Portuguese faience manufacture from the sixteenth to the first half of the eighteenth centuries have generally been differentiated by stylistic features. Among the most common stylistic groups like 'aranhões' (spiders), 'rendas' (lace) and 'contas' (beans), all from oriental inspiration, there are also others, including some specifically made for foreign markets like the Portuguese communities in Antwerp and Hamburg.

In this project ceramic sherds from Portuguese faience (PF) from Lisbon and Coimbra, centres of several stylistic groups, were studied in order to establish chemical patterns for these production centres, and eventual correlation of the chemical and stylistic features. The establishment of 'signatures' to define each production centre could be usefully applied in future provenance studies of similar ceramics, namely to identify faience exported to areas outside Portugal.

Chemical composition of faience pastes was obtained by INAA in the Portuguese Research Reactor, Sacavém, Portugal. Chemical elements considered for this study were the following: Na, K, Sc, Cr, Zn, As, Ga, Rb, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Hf, Ta, Th, U.

The results obtained so far clearly differentiated Lisbon and Coimbra productions, especially by the higher contents of REE Th and U present in Coimbra productions. Faience with 'rendas' (lace), usually attributed to Coimbra production, but also found in Lisbon sites (even with different tones of blue, white, yellow and brown), presents a geochemical similarity with other Lisbon products. So, chemical composition appears to confirm that this decorative style was also produced in Lisbon, imitating Coimbra productions. Within the Lisbon faience sherds studied, two main chemically differentiated productions were identified during the same chronological period. A good chemical identification of Coimbra production has been achieved.

These results confirm former assumptions based on the appearance of the faiences from Lisbon and Coimbra, and help to determine, in a more precise way, several productions.

## The real thing and the replica

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The ceramic objects which were found on the archaeological site Vörs-Máriasszonysziget were presumably made of clay originating from near-by deposits.

There is an active clay mine next to Vörs, at Battyánpusztá. The clay (Upper Tertiary, so-called Pannonian clay layers) may be the same as the one used by the Neolithic people in ancient times to make vessels. Earlier we did some experiments with commercially available artists' clay. We adapted this experiment to the clay mined from Battyánpusztá. If this was the clay used in the Neolithic period, we would see this in the images of the thin sections of the new ceramics samples.

In the clay mine of Battyánpusztá, two kinds of clay can be found, a sandy, yellow one and a compact, grey variety together with peat layer.

In accordance with the experience of the active brick factory, the yellow, sandy clay is unusable on its own. For this reason, the factory mixes it with the grey clay in a 2:1 proportion to produce building bricks.

After the appropriate preparation of the clays we made samples from the two material types, and the 2:1 mix, and fired them under the same conditions as the earlier experimental pieces (3 hours firing, at 500 °C, in the electrical kiln).

By the end of the experiment we can decide which is the best material or material mix to make vessels. As a final step, we make a replica of the characteristic Neolithic bowl type, a pedestal bowl, from this clay, fired using almost the original techniques.

## **Archaeometric investigation on Punic lamps from Ibiza Island (Spain)**

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Some twenty samples of shell-shaped Punic lamps, preserved in the archaeological museum in Ibiza (Spain), have been taken into consideration for an archaeometric study, in order to inform their archaeological interpretation. The ceramic artifacts represent the furniture of several tombs; they were either never used, or just used for a short time, for their typical functions. The shell-shaped lamps were present in Ibiza for almost five centuries, from the seventh to the second century BC, and gradually evolved a more closed shape and a flatter base. Two-spouted (Bilicni) lamps are associated with the first generation of Phoenician settlers on the island.

The samples have been investigated by means of different analytical techniques. Microstructural observations were conducted by optical microscopy in thin section; chemical analyses were carried out by inductively coupled plasma emission spectroscopy, while the crystalline phases were determined by XRPD. In addition, the content of organic substances contained in the ceramic paste of some lamps was also investigated by gas chromatography.

The ceramic paste is always fine, but its chemical composition is very variable from sample to sample, according to the presence of different amounts of small crystals of calcite. The presence of calcite and the corresponding high I.L. value indicate a low firing temperature, not more than 850 °C. The content of organic substances is very scarce (or absent), according to the votive use of the artifacts. The organic substances seem to be represented only by saturated fatty acids, possibly animal fats. Contrary to what was expected, this result allows us to exclude the use of olive oil. The intended destination of the lamps is probably the reason for their poor quality, as the generally low firing temperature would indicate. In addition, the variability of the composition and the firing temperature indicates that the artifacts were produced with different local raw materials by non specialised workshops.

## **Reassessing the Oswald-Plicque samian ware collection (University of Nottingham Museum)**

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The Oswald-Plicque samian ware collection housed in the University of Nottingham Museum is one of the most important collections of samian pottery in the UK. Felix Oswald, an early pioneer of Roman pottery studies in Britain, established a collection of samian ware from his excavations at Margidunum (Nottinghamshire) and also acquired a substantial collection from the French antiquarians Albert-Edward Plicque and Georges Chenet. A recent re-assessment of this collection highlighted the wide variety of the forms, decorative motifs and stamps, fabrics and potters represented by this material. This information is available in a searchable on-line database ([www.nottingham.ac.uk/museum/samian.php](http://www.nottingham.ac.uk/museum/samian.php)).

This paper presents the initial results of an analytical study of this material using an electron microprobe to examine the chemical composition and microstructure of the fabric and slip of a selection of samian ware sherds originating from Southern and Central Gaul. By investigating the raw material selection and preparation, decorative techniques and firing practices this study aims to address the technological traditions used in samian ware production of these areas and complement previous analytical studies that have used an examination of raw materials and production processes to characterise the different production centres (for example Picon and colleagues 1971, 1975, 2002). In addition, the paper introduces the first phase of an on-line hand-specimen fabric series (based on images taken at x20 magnification) that represents the common samian fabrics found in UK assemblages. Created using specimens from the Oswald-Plicque collection, it is now a resource for Roman pottery researchers ([www.nottingham.ac.uk/~aczsamia/database/display\\_fabric\\_images.php](http://www.nottingham.ac.uk/~aczsamia/database/display_fabric_images.php)).

## **Experiments with double chamber sunken up-draught kilns**

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Kilns are a subject often discussed in the archaeological literature (Kingery 1997, Vitelli 1997, Gosselain and Smith 1995), and their experimentation was among the first subjects of experimental archaeology.

Although it seems to be a closed subject, experimentation with this pyro-instrument can reveal new data, depending on the topic of inquiry.

The two chamber sunken up-draught kiln emerges during the fifth millennium BC in the Near East, as well as in the Western Pontic area. Its basic technical principle, common to a large family of contemporary pyro-instruments, is the filtration of the air (Gheorghiu 2007a), this being one of the first questions addressed by experimental study.

Other questions were about the relationship between an efficient shape of the vase chamber and the fire box, and about the methods used to construct them. The building of the platform with flues was another question.

During the experimental process a series of details was revealed to be very important, including the thickening of the ceramic walls of the kiln, which improves the quality of the firing process over time .

Last but not least, experiments helped to determine the spatial relationships of the operator and the instrument, i.e. the kiln proxemics (Gheorghiu 2007b).

To conclude, the experiments also helped to refine the chaîne-opératoire of this complex instrument.

## **Use of petrographic and petrologic tools to investigate the inter-island pottery network in the Aeolian archipelago**

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Forty ceramic samples from Capo Graziano (Early Bronze Age-Middle Bronze Age 2) and Milazzese (Middle Bronze Age 3) levels have been analyzed using a polarizing microscope (qualitative and modal analysis) and SEM in order to identify petrologic and petrographic markers to distinguish between the different workshops on the islands of the Aeolian archipelago (Lipari, Filicudi, Stromboli, Panarea, Salina). This could provide useful knowledge from which to investigate the inter-island pottery production and exchange network.

While plagioclase, pyroxene and olivine are widespread in all of the samples, those from Lipari are typically characterised by the lack of hydrated mineral phases (biotite, amphiboles), and by the presence of pumices, glass shards and volcanic rocks with a high degree of crystallization. On the other hand, samples from Filicudi show a greater variability: one group is characterized by hydrated phases (biotite, amphiboles), glass and a red birefringent matrix, a second group contains basaltic lavas and a black isotropic matrix, while a third one, which consists of decorated pots, appears very similar to the Liparian samples (pumice, glass shard, rocks with a high degree of crystallization). In Strombolian samples, there was one group with microcrystalline lavas containing phenocrysts of plagioclase, scoriae and a black isotropic matrix, and in another group there were hydrated phases (amphiboles, biotite) and a red matrix. As to the classic modal distribution (100 points per thin section) the lava/glass ratio is a distinguishing marker, which provides positive results in Strombolian samples and negative in Liparian ones. Samples from Filicudi, instead, follow a bimodal trend. The decorated samples, which appear to be petrographically similar to the Liparian samples (pumices, glass shards and rocks with a high degree of crystallization), show a negative lava/glass ratio too.

Analyses on clinopyroxenes and glass have been carried out using an SEM. For both analyzed phases we observed a Liparian double trend, a separate Strombolian cluster, while the decorated Filicudian samples overlap with one of the two Liparian trends. Moreover, some of the glass which was analysed had resulted from the fall-out from the volcano (high potassium trachytic glasses) and Lipari's (rhyolitic pumice glasses) paroxysmal volcanic phenomena. The coexistence of these two kinds of glasses represents a regional marker.

This preliminary test shows the great potential in the combined use of petrography and petrology to investigate the Bronze Age pottery network. Some clear local and regional markers have been established. The first ones provided information with which to define the inter-island exchange network, while the second ones allowed us to identify the finished products imported from external areas. Both glass and pyroxene, major elements in the composition, are useful tools to differentiating between the provenance of the clasts. The Filicudian samples which are characterized by a low lava/glass ratio can be attributed to the Liparian decorated production.

## **Mayapán: a ceramic petrographic analysis**

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The technological study of ceramics can give information about strategies of pottery production and political-economic organisation of ancient potters. In particular, petrographic analysis can be used to form compositional groups, which research has shown can usually be associated with pottery producers. The number of prehistoric pottery producers is usually taken as a reflection of a society's degree of homogenisation, centralisation, or competition. Therefore, changes through time in ceramic composition can give insight into changes in those societies. When compositional analyses are combined with existing research on the effects of different tempering materials, changes can also be explained in terms of increasing efficiency of mass production, reducing costs in a competitive society, or improving a material's performance.

This research employed a combination of petrographic analysis (38 samples) and X-ray diffraction (4 samples), with a review of existing research on the physical characteristics of calcite-related tempers to investigate compositional groups and tempering materials, at Mayapán, the last Maya capital, located in the northern Yucatán Península (an exposed marine platform made of sedimentary calcareous rocks), México. Mayapán, which was abandoned less than one century before the Spaniards arrived, presents ceramic remains that are clear indication of changes in Mayan society during the last pre-Hispanic period. The nature of those changes is not clear.

The prevailing notion among archaeologists considers that the political fragmentation found by the Spaniards and demonstrated by the less spectacular archaeological remains of this last period indicate that Mayan society was in the midst of a total collapse. On the other hand, official letters and other documents written by Spaniards during the conquest present a picture of large towns, thriving markets, entrepreneurial people, and organised retail and long-distance trade, indicating to some that Mayan society had changed from an emphasis on monumentality and elaborate objects into a more egalitarian and pragmatic mercantile society. If the mercantile view of the last pre-Hispanic period is right, then there was probably also more competition and more ceramic producers than in previous periods.

The research results presented here indicate the presence of more compositional groups than in previous periods, agreeing with the notion of a more competitive and mercantile society. The results also suggest that potters engaged in the selection of a reduced number (when compared to previous periods) of technologically advantageous materials, concurring with the notion of a more pragmatic society probably intensifying production through efficiency and simplification. These results take us closer to an understanding of the state of the Maya during the century immediately before the arrival of the Europeans.

## **Technical ceramics and metallurgical secrets: the Prehispanic workshop of Rincón Chico (NW Argentina)**

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Recent research continues to highlight the crucial role played by technical ceramics in past metallurgical operations. Furnaces, crucibles, tuyeres and moulds had to meet a range of technical requirements such as refractoriness, thermal shock resistance, toughness and tensile strength, which required ingenious metallurgists to optimise the properties of the clays available to them. The suitability of ceramics was an essential requirement for a successful metallurgical activity, and all of these technical constraints have sometimes led scholars to assume that there was relatively little freedom for cultural variation in their production and use.

The prehispanic metallurgical workshop of Rincón Chico, however, challenges some of those assumptions. Archaeological excavations in the last two decades have documented extensive remains of copper smelting and casting activities taking place between the 9th and the 16th century AD, but the technical assemblage of the ceramics continues to raise questions due to its originality and variability. Numerous fragments of crucibles and moulds have been recovered, most of which are lined internally and externally with a fine white paste. In addition, some crucibles show a hole at their base, which was apparently blocked with a ceramic plug. Furthermore, crucibles often have an extremely fine perforation running along their rim that suggests that they would have been held or hung using a metallic wire.

This paper presents the results of analytical work employing optical microscopy, SEM-EDS, XRD and FTIR, aimed at understanding the nature and properties of the technical ceramics and the white paste, as well as the utilisation of these peculiar ceramics in the metallurgical system. It is possible to demonstrate that the technical ceramics were coated with extremely finely crushed bone ash that could have acted as a parting layer; furthermore, we reveal other dimensions of the selection and processing of clays for technical ceramic manufacture and use. While some of these aspects can be explained by reference to technical requirements, in others choices appear so convoluted and labour-consuming that they can only be understood as results of cultural choices made by the metallurgists. As a potential explanation for this complex technology, we argue that metallurgists deliberately kept their craft as an unnecessarily sophisticated technology in order to prevent public access to their knowledge. This would allow them to preserve their role as essential and revered specialists in a social context.

## **Late Halaf pottery production in Syria: a technological approach. Evidence from Tell Halula (Euphrates Valley)**

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The pottery production from Tell Halula that belongs to the Halaf period shows the economic and social complexity of Neolithic communities in the Near East. The site is located on the right bank of the middle Euphrates river valley, in the region of Djerablus in northern Syria. The site, 360 m by 300 m and 11 m high, includes two cultural horizons with anthropic deposits with an archaeological sequence from the Pre-Pottery Neolithic B, with continuous stages to Pottery Neolithic levels (Pre-Halaf and Halaf) with a timeline covering from 7,900 to 5,300 Cal BC. Late Neolithic levels (HLVII) at Tell Halula date from 5550-5300 Cal BC.

Ceramic assemblages from the several excavations that have been undertaken at the site between 1996 and 2007 have been analysed and all the chaîne opératoire processes can be recognised in several archaeological contexts. This work followed a global approach which enabled the identification of several pottery traditions intra-site and in the region.

The aim of this study of pottery assemblages is to reconstruct the systems of production and to understand the organisation of society beginning with the information from the pottery sources. Using ethnoarchaeology, experimental archaeology and archaeometry it was possible to assess the importance of several kind of productions used as objects in daily life activities. The morphology, ceramic technology and typology of these productions are also considered and the current findings from the study of the Halaf culture in its final stage, known as Late Halaf, are presented.

## Archaeometric investigation of Celtic graphitic pottery from different archaeological sites in Hungary

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The use of graphite in making pottery had already started in Neolithic times, but the importance of graphite grew considerably from the early La Tène period. Production of ceramics containing graphite as non-plastic inclusion reached its peak between the end of the fourth century BC and the middle of the first century AD in the form of the classical Celtic 'graphitic ware', which became a substantial part of the Central European Celtic pottery. The term 'graphitic ware' is commonly used for a special typological group of ceramics, the most characteristic form of which is the situla-like pot.

Extended (long-distance) trade in Celtic times is evidenced by the widespread occurrence of graphite-bearing ceramics, far away from restricted graphite sources. The reason behind preparing graphite-bearing vessels, as well as the determination of the exact provenance (i.e. mine or mining district) of graphite and its dominant form of transportation (i.e. raw graphite, clay mixed with graphite or finished graphite-bearing vessels) constitute significant topics in Celtic research.

Graphite-bearing and non-graphitic ceramics were investigated from two Celtic archaeological sites, Dunaszentgyörgy (LT B2-C1) and Bátaszék (LT D) in southern Hungary. The sites are situated along the Danube about 40 km apart. The aim of the research was to compare the characteristics of the graphitic raw material as well as their host vessels found at the two sites and to provide a preliminary outline about the possible provenance of graphite. The ceramics were analysed by optical microscopy, XRD, X-ray fluorescence spectrometry and electron microprobe analysis.

Graphitic ceramics from Dunaszentgyörgy contain graphite fragments and clasts of graphitic (para)gneiss consisting of quartz, K-feldspar, muscovite, sillimanite, kyanite and graphite, rarely amphibole and tourmaline. The chemical and mineralogical comparison of non-graphitic and graphite-bearing wares from Dunaszentgyörgy indicates that local clays were used to produce both types. Graphitic vessels from the Bátaszék show graphite, granitic clasts and graphitic rock fragments containing quartz, mica, graphite and sometimes amphibole. The granitic rock fragments originate from the granitic intrusion of Carboniferous age outcropping near Bátaszék and confirm that graphite-bearing wares (as well as non-graphitic pottery) were produced from local clays. The firing temperature of graphitic wares is similar at both sites: the absence of Ca-silicates indicates firing below 800 °C and sometimes below 650 °C.

Graphitic rocks with the above-mentioned mineralogical composition cannot be found in outcrops in the territory of Hungary. Their possible provenance is the Bohemian Massif. According to the mineralogical composition, the potential source for graphitic (para)gneiss found in the Dunaszentgyörgy ceramics can be restricted to the Variegated unit of the Moldanubicum zone. The results presented support recent archaeological assumptions according to which the trade of raw graphite (with the host rock) is predominant in the La Tène period.

## **Blowin' in the wind – thermal efficiency of pyrotechnical ceramics**

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Recent studies of Bronze Age metallurgical ceramics from the Aegean and from Cyprus, such as smelting furnaces and crucibles, revealed that one of their most outstanding material properties appears to have been their low thermal conductivity. This was achieved through a high level of porosity, presenting furthermore a particularly suitable material texture with elongated pores oriented perpendicular to the heat flux. Apparently the heat flux through the furnace or crucible structure was thus suppressed. As for the crucibles, it has to be considered that, like the furnaces, they were heated from their interior at this early stage of metallurgy. Therefore it can be assumed that the common idea was the reduction of heat transfer into the environment, which is the equivalent of energy loss. The fabrication of ceramics with heat insulating properties was thus related to thermal efficiency of the structures.

The influence of different parameters and particularly the texture and microstructure of ceramics on their thermal conductivity have already been assessed by means of computer modelling. The models were developed on the basis of textural characteristics of metallurgical ceramics that were the subject of different case studies. The present work constitutes a further step, comprising actual measurements of the thermal conductivity of the metallurgical ceramics fragments which have been used in the modelling. In this way an objective evaluation of the modelling results can be achieved which will enable their application in cases where the actual measurement of conductivity would not be possible. At the same time they provide more accurate data, which can be used for complete models of the heat balance in smelting furnaces and crucibles. Finally, the results of the material tests were included in a refined heat balance models of different ceramic structures which allow for the estimation of fuel consumption during metallurgical operations. It will be demonstrated that thermal efficiency and fuel economy were factors which could have been controlled by craftsmen and it is suggested that they should be considered during the reconstruction of ancient metallurgical processes.

## **On the track of the leopard**

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The Austrian excavations in the eastern Nile delta at 'Ezbet Helmi have revealed a large variety of pottery finds from the second millennium BC. The stratigraphically rich layers from the palatial area from the end of the Middle Bronze phase/beginning of the Late Bronze Age period (Late Hyksos period/early New Kingdom), where Minoan frescoes have also been found, contained a large number of imports and luxurious wares, which are the focus of interest. Besides a group of Cypriot and Canaanite material, which have already been studied, some typologically unparalleled vessels were also discovered.

One of them shows a painted representation of a leopard. The style of representation has been postulated to show connections with the Aegean world, as well as possible Syrian origins or origins in the nearby region of southern Canaan.

Multiple analytical data have been used to study the provenance, which have been gained by EPMA, ICP-MS and petrography. NAA was also carried out for comparison.

The aim was to trace the origin of such vessels, in order to get a closer idea of the cultural complexity during the early Late Bronze Age in the south eastern Mediterranean.

## Raman microscopy study of glazed Byzantine ceramics excavated in Serbia

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Medieval Serbian ceramics are well documented by the archaeologists and art historians but the study of ceramics provenance, technology of preparation and pigments used, as well as influence of neighbouring countries and specific characteristics of different workshops is still missing from this research. Therefore, in order to distinguish artifacts from different manufactures, non-destructive spectroscopic methods were used to investigate glazed medieval Byzantine ceramics from various excavation sites in Serbia.

A great number of ceramic sherds glazed on one or both sides and decorated by means of the sgraffito, champlévé and painting technique with zoomorphic compositions of wild animals and birds, or only glazed, or sometimes imitating a marble surface, provided a good choice of samples for analysis, using a combination of micro Raman and EDXRF spectroscopy and SEM.

It was found according to the EDXRF analysis that the main component of the investigated glazes is lead with the addition of Ca, Cu and Fe. Minerals and pigments of the glazes were identified by their characteristic Raman signatures.

For classification of analysed glazed ceramics the approach proposed by Colombari *et al.* (2006) was applied, utilising Raman spectroscopy for the identification of different types of glasses, pottery and jewels based on their composition. In the Raman spectra of glazes of all investigated samples the band with the highest intensity originates from the Si-O stretching mode at between 800 and 1200 cm<sup>-1</sup>. This behaviour is observed in glassy networks containing a large amount of lead (lead-rich silicates) which breaks Si-O links so that the resulting structures are characterised by isolated and poorly connected tetrahedra. The degree of polymerisation of SiO<sub>4</sub> units expressed by the area ratio of the bending and stretching envelopes was in the range from 0.3 to 0.5. These low values of the polymerisation index mostly correspond to lead i.e. a fluxing agent fired at a lower temperature. The corresponding families, with similar value of polymerisation index, were identified in literature as Byzantine glazes from the sixth to eleventh century and medieval Ifrikiya glazes. Deconvolution of bending and stretching bands and analysis of the compositional components provides information about particular workshops, including their possible location and the time frame in which they were active.

Spectra of analysed glaze samples frequently exhibit additional Raman peaks due to the pigments or crystalline precipitates which were also analysed. In the majority of spectra the 473 cm<sup>-1</sup> component is associated with un-dissolved quartz traces characteristic to engoba deposited below the glaze. The presence of Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>, TiO<sub>2</sub> and SnO<sub>2</sub> was also detected.

Reference:

P. Colombari, A. Tournie, L. Bellot-Gurlet, *J. Raman Spectroscopy*, 37 (2006) 841-852

## **The production and consumption of traditional tablewares in eighteenth-century South Yorkshire: a macroscopic and petrographic approach**

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At the beginning of the eighteenth century, traditional tablewares, notably, Slipwares, Late Blackwares and Mottled Wares emerged as popular products in the repertoire of most potteries in England. Today, however, they tend to instil a defeatist complex in pottery studies for a number of reasons. Firstly, a high degree of standardisation based on visual characteristics alone has been noted with respect to these ware types and therefore, difficulties frequently occur in identifying the source of specific products recovered from consumption sites. Secondly, insufficient research into production sites and their products proves a major disadvantage to any attempt in matching wares to their place of origin and to any hope of delineating their life history. As a result, it is not uncommon to find published archaeological reports with little detail on Early Modern Pottery and under this rubric Traditional Tablewares are described according to ware type based on decoration and form.

Recent laboratory analyses of Slipwares, Late Blackwares and Mottled Wares recovered from the excavation of an eighteenth-century pottery kiln at Silkstone, South Yorkshire (White, 2007), have demonstrated that several forms of traditional tablewares from this site can be characterised compositionally. South Yorkshire boasts a number of other archaeologically attested production centres of this style of pottery such as Bolsterstone, Midhope and Swinton, for which ample historical information is available. Continuing the research started at Swinton, analysis has been undertaken to determine whether the similarly decorated wares manufactured at these contemporary production sites can be distinguished from one another and identified in consumption contexts.

The results of this analysis have revealed significant intra- and inter-kiln variation in the composition of traditional tablewares from South Yorkshire. A system of fine-scale macroscopic and petrographic criteria has been developed to identify the products of the various Sheffield potteries. This has been successfully applied to provenance of eighteenth-century ceramics from a recently excavated consumption site in nearby Sheffield. The origin of this material challenges preconceived notions with respect to the distribution of traditional tablewares in the South Yorkshire region and clearly demonstrates the value of a detailed compositional approach to later historical ceramics, when combined with traditional typological criteria and documentary evidence.

## **‘Trial by fire’: studying Roman cooking wares produced in the region of Rome**

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A well-known geographical area where archaeologists have encountered substantial problems in the sourcing and characterisation of local Roman-period cooking wares is the city of Rome and its environs. The two principal reasons for this are the uniform volcanic geology of central Italy and the estimated size of the population supported by local pottery workshops. Hence, the differences between workshops can be recognised only through nuances in vessel mineralogy and geochemistry. Moreover, the demand for earthenware cooking vessels resulting from a population that quite possibly exceeded one million urbanites during the reign of Augustus obviously promoted a craft practised either in large factory-like production units or in numerous small workshops. While the former mode of production is not yet supported by archaeological evidence of Roman pottery workshops located in this area, which is also rather scarce in general, the most convincing proof of the existence of a substantial number of production centres is the heterogeneity shown by local cooking wares themselves.

This paper examines, describes and interprets this issue through the study of some 7,500 west-central Italian cooking ware vessels recovered from various contexts dated to AD 50–550 in the excavations of a late Roman domus on the northeastern slope of the Palatine Hill in Rome. After preliminary macroscopic analysis of the assemblage, the number of west-central Italian cookware fabrics thus identified topped a hundred – an obvious excess, even with respect to the large research area and relatively long time span. For this reason, an additional research program has been carried out with the aid of thin-section petrography (c. 130 samples) complemented with EPMA.

As the characterisation of individual fabrics is beyond the scope of this presentation, the paper will deal with broader issues related to Roman-period cooking ware production in the study area. Therefore, the geology of Rome and its environs will be discussed in relation to the raw materials – including both clays and other sediments – used for local cookware production during the Roman period. Secondly, the data on archaeologically known Roman kiln sites will be used to strengthen the conclusions based on mineralogical and geochemical evidence. Finally, the date ranges of the identified fabrics as well as the form and the size of these vessels will be used to describe and explain the change and stability observed in Roman cookware production in the region of Rome.

## **The Temperament of the Inca State: on the source and significance of andesite tempered pottery from Cuzco**

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Rowe (1944) defined the Cuzco Inca pottery series by a number of characteristics. This paper offers a refinement of Rowe's pioneering work by providing a detailed description of one important group of Inca style pottery that can be identified by the distinctive addition of andesite temper to the fabric. The analysis of assemblages of pre-Inca and Inca period pottery from excavations and surface collections in the Cuzco region has allowed a series of fabrics to be identified and these have been further refined and characterised through petrographic analysis. Through this work one specific fabric used to make Inca style pottery can be characterised by the consistent addition of a high proportion of andesite to the clay matrix. Some aspects of this pottery technology show continuities with immediately pre-Inca fabrics (especially Lucre) and styles (especially Killke). The Inca andesite tempered fabric has a consistent composition and this combined with the quality and style of the Inca form and decoration support the suggestion of significant state intervention in the production of this pottery. Further petrographic analysis of rock samples taken from andesite outcrops in the area show that this temper originates from Rumicollca Formation andesites. Andesite from these formations has also been characterised from samples of stone used for high-quality Inca constructions including Coricancha, the 'temple of the sun', and it is suggested that the debitage created by state stonemasons was selected to temper the state pottery. Identifying the source of this andesite links its use to wider debates over the control of the quarry sites and the organisation of production within the Inca heartland during the final stage of state development and expansion of the Inca Empire.

## **Ceramic landscapes in the Late Neolithic Mondego Plateau, Portugal**

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In western Iberia as elsewhere in Western Europe, megalithic monuments dominate the landscape of the second half of the fourth millennium BC. In some regions, they represent the only vestiges of occupation during this period, the evidence of settlements being much more elusive. When identified, settlements generally consist of hearths, pits and/or small huts and are seen to have been inhabited by small groups. In their role as collective burials and places of ritual focus, dolmens, on the other hand, are thought to have the ability to draw people and objects from potentially wide surrounding areas. Yet, such arguments have often remained speculative, not least due to common post-depositional disturbances and lack of preservation of organic materials such as bone. More resilient materials such as ceramics appear to offer little additional information for the development of more complex interpretations; pottery is relatively unvaried morphologically and decoration is almost absent.

Ongoing research in the Mondego Plateau aims to provide new evidence to substantiate discussions about the role of these megalithic tombs in local and regional spheres of interaction during the Late Neolithic period. Reconstructing ceramic technology and provenance, the project compares funerary and non-funerary neighbouring sites of the same period. This paper focuses on the results of the comparative study of three pottery assemblages from the dolmen of Fiais da Telha and the two small settlements of Ameal and Murganho 2. In total, 93 samples corresponding to an equal number of vessels were analysed by optical microscopy and neutron activation analysis.

The results obtained so far show that: (i) the majority of the pottery is characterised by the use of similar clays without addition of temper; (ii) the pottery is overwhelmingly 'local', the Tertiary clay-rich sediments available throughout the Middle Plateau being the probable clay source; (iii) a few samples indicate the use of clays derived from metamorphic and amphibole-rich igneous rocks, the nearest outcrops of which are found between 10 km and almost 40 km from the archaeological sites. This analytical study is revealing not only of an overall homogeneous Late Neolithic ceramic tradition, but also the transport of a small number of pots from unexpectedly distant areas. Such results provide new insights into the geographical networks of prehistoric communities in the region.

## **Insights in manufacturing techniques of ancient pottery: industrial X-ray computed tomography as a tool in the examination of cultural material in museums**

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Since its first application in ceramic studies in the 1930s, X-radiography has been a powerful tool for the visualisation of manufacturing details and for reconstruction of pottery techniques. To a lesser degree it was also used to investigate pottery fabrics and to detect former restorations. The development of a three-dimensional imaging system, named computed tomography (CT), in the early 1970s has had an immense impact on medical diagnosis. Although most common in medicine, CT has always played an important role within non-invasive archaeology in the investigations of cultural historic objects, such as mummies.

Aside from these mummy-projects, there have been successful uses of CT in pottery studies, such as in the Allard Pierson Museum at Amsterdam. The technique was generally used for two purposes, for providing more accurate vessel-profiles, particularly of closed shapes, and for insights into ancient pottery techniques. A very interesting aspect of the Amsterdam project was the attempt to use the variations of the grey tones of a CT-scan, which are mainly due to different chemical compositions of the ceramic material, for the comparison and determination of pottery fabrics. The further development of medical CT to industrial X-ray computed tomography for non-destructive material testing established a technology, which enables a much closer examination of the object, due to high local resolution. Within research on Greek pottery, industrial CT has recently been applied to the investigation of single objects, but the results have been analysed only to a moderate extent regarding ancient pottery techniques or materials.

A cooperation between the Landesmuseum Joanneum at Graz and the Austrian Foundry Research Institute at Leoben made it possible to evaluate industrial CT as an archaeometric method in pottery studies, especially regarding aspects like manufacturing techniques or pottery fabrics. The Landesmuseum Joanneum at Graz provided its Greek vase collection to this investigation. Although the emphasis was on the different manufacturing techniques and on clarifying the inner structures and hidden parts, the results of this project show the considerable potential of industrial CT for the classification of pottery fabrics. Diagnostic features such as voids and inclusions can be analysed in frequency, size, sorting, rounding and orientation.

Dealing museum objects, the project had to address the issue of preservation of integrity and of the degree of non-destruction of the ceramics. The first results of this project will show that industrial CT is an important tool especially for the examination of objects in museums. A careful examination of the various details of manufacturing techniques relates to the reconstruction of the pottery production process and may lead to a better understanding of the ancient potter's craft.

## **Hispanic terra sigillata productions documented on the Catalan coast, some unexpected results and new issues**

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Traditionally, Hispanic terra sigillata (HTS) had been considered as a minor production that was just distributed in those places where Italian and/or Gaulish sigillata were not traded or were poorly commercialised. However, this view changed over the last few years thanks to the discovery of a large number of new workshops, and to the consideration of the Andújar and Tricio complexes as large production centres, on archaeological grounds. However, there is no clear understanding of the role played either by these two large production centres, nor by any of the small ones, even those found in the Catalan area, regarding the HTS that has recently been identified in archaeological sites on the Catalan coast.

To shed light on the provenance and exchange patterns of Hispanic terra sigillata on the Catalan coast a large number of samples from the sites of Emporion, Baetulo and Tarraco have been analysed by means of XRF and XRD analyses. A selection of them have been further analysed using SEM in order to get information about their technology. Moreover, several small HTS centres located in Catalonia have also been characterised. The results show, on the one hand, that almost all samples analysed from these sites can be attributed to Tricio. On the other hand, not one sample could be assigned to the small HTS workshops from the Catalan area. The massive presence of Tricio products in that area was unexpected on archaeological grounds, but even more, the lack of evidence of the products of the Catalan workshops in these nearby consumption centres raises new issues about the role of these production centres, as well as about the nature of the HTS exchange network on the Catalan coast.

## **Archaeometrical study of Roman amphorae of Port Vendres 4 shipwreck: new data on wine trade from Hispania Tarraconensis (northeastern Spain) to Gallia Narbonensis (southwestern France).**

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The Port Vendres 4 shipwreck was found off the coast of the Pyrénées-Orientales, southwestern France. Its cargo included an assemblage of wine amphorae that can be dated to the second half of the first century BC, and attributed to different origins from an archaeological/typological point of view: Pascual 1 amphorae from SE Spain, Dressel 1 and Lamboglia 2 amphorae from Italy (Tyrrhenian and Adriatic areas, respectively).

Archaeological data suggest that the shipwreck may represent a redistributive trade of Italian wine, associated with Spanish wine, from the Catalan area (in ancient Tarraconensis province) to Narbo Martius (Narbonne), capital of the Roman Narbonensis province (southwestern France).

A multidisciplinary archaeometrical study has been carried out on the different types of wine amphorae from the shipwreck. Thin section and XRF chemical analyses confirm the previous provenance hypotheses. The comparative study of reference databases allowed a better precision in the localisation of the production areas. XRD and SEM-EDS analyses were also applied in order to identify the weathering processes occurring in pastes during deposition in a maritime environment, which must be taken into account in the elaboration of chemical data.

## **Provenance of seventeenth and eighteenth century blue tin glaze and lustre pottery from Sant Bartomeu del Grau (Catalonia)**

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Sant Bartomeu del Grau is a small town located 90 km north of Barcelona. A Romanesque church built before the eleventh century was used until 1787, when a new church was constructed 700 m north from the older church. In 1810 the older church roof fell down, and the medieval church was consequently abandoned. Recent archaeological works at the medieval church recovered several fragments of lustre decorated and blue tin glazed pottery. These sherds correspond to a common Catalan ceramic production dating back to the seventeenth and eighteenth centuries according to their decoration and typologies. The aim of this project is to identify the production centres and the technology associated with the set of sherds. Previous studies have demonstrated that in the seventeenth and eighteenth centuries different associated workshops used the same clay recipe (calcareous clay), but several studies also indicate that the different workshops produced their own tin glaze, probably according to their own traditional recipes. Therefore, in order to achieve a better understanding of the ceramic commodities recovered in Sant Bartomeu del Grau, the provenance attribution involves both chemical paste analyses and microstructural glaze analyses. Twenty-five fragments of blue tin glaze and lustre pottery pastes were analysed by XRF and XRD. In addition, their glazes were analysed by SEM-EDX and LA-ICPMS.

Preliminary results indicate that blue tin samples were made in Barcelona, probably by potters corresponding to the BCN-SC group. Until now, blue tin glazed ceramics analysed from Barcelona were always grouped with BCN-DR. Thus, this could be the first evidence of BCN-SC blue tin glazed productions found in Catalonia. However, the two samples with lustre decoration correspond to the BCN-DR group, as well as the polychrome samples (blue and yellow decorations).

## **Social dimensions of pottery: a methodology to investigate ceramic provenance**

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The aim of this study is to establish methodological patterns to define strategies of acquisition and management of raw material related to pottery production in the Argaric communities (Ancient and Mid Bronze Age in southeastern Spain) as a means to explore ceramic tradition and analyse social dynamics. In order to achieve this goal the 'provenance postulate' was used, which tries to find a proved relationship between artifacts and the raw materials used to produce them, since variations will be bigger between different raw material sources than between artifacts derived from the same source.

Archaeometric approaches were used to confirm this relationship, through petrographic and chemical analysis on both pottery and raw materials. In this study, these techniques were used to investigate the pottery production of the Argaric Group between 2250 and 1550 Cal BC. The factors influencing the choice of technique to study both the characteristics of the artifact (ceramic paste, sample size available) and the properties of the techniques (accuracy, precision, sensitivity, cost, availability, amongst others) were evaluated. Previous research had shown different methodological approaches exist: while some research is based exclusively upon petrological analyses, some others only use chemical analyses. Finally, some studies have an integrated approach using both methods to infer provenance.

This fact led to the development of a methodological approach which focuses on composition of the artifacts above some other factors. As it focuses on a primary aspect of the pottery production, rather than characteristics of technique, this approach is applicable to any kind of social investigation of ceramic materiality.

Thus, the methodological proposal contains two steps. The first one is a mineralogical analyses of pottery pastes to establish compositional groups and select samples to study, together with a geological survey of the area to determine is a raw material study is possible. The second one presents the analyses of chemical compounds which are only applied if the mineralogical characterisation of pottery samples and clays is not sufficient to define provenance.

## **Provenance of regional ceramics in Pisidia (southwestern Turkey)**

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The characterisation of regional craft ceramic production and identification of its raw clay materials is of major importance for the understanding of ancient crafts and socio-economic interaction within a region. Different fabrics of locally produced pottery were recognised both at the excavations of the ancient Hellenistic to Byzantine city of Sagalassos (Pisidia, southwestern Turkey), and on surveys within its territory. Preliminary archaeometric data describe the studied area as a chain of different local and regional production entities during the Iron Age where the continuous use of the same fabrics over a relative long period can be observed, used for the whole functional spectrum of ceramics. These regional economies later developed into one unified centre of production for the mass produced (export) luxury tableware at the city of Sagalassos. In the late Roman period, however, cooking pots and storage vessels (e.g. local amphorae) are not as homogeneous in raw material as the tableware. The mineral resources show a broader variation. This led archaeologists to believe that again there must have been different production centres active in the territory in which large farms were responsible for the production of their own ceramic containers. This research tries to map the differences in raw materials for these late Roman coarse wares. An integrated approach of petrographical, mineralogical and geochemical (microscopy, main and trace element analysis, electron microprobe analysis, X-ray diffraction) methods is used to define the properties of the raw materials and the origin of the different ceramic fabrics. In this way, different production processes and possible exchange patterns in the studied area are described.

## **Alteration processes in lagoon environments: the case study of the Roman pottery from Aquileia and Olbia (Italy)**

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This research focuses on a study of how pottery buried in lagoon environments becomes altered over time. For this study, some Roman transport amphorae (Dressel 6B, funnel-neck amphorae) and *terra sigillata* (which showed evidence of chromatic turning based on their pristine colour), and some unaltered fragments of the same ceramic types were selected from the archaeological sites of Olbia (Sardinia Island, Italy) and Aquileia (north-eastern Italy) respectively, the burial conditions of which can be classed as a lagoon-type environment.

Each of these materials was analysed using a combination of microtextural, mineralogical and microchemical analysis, which indicated that the potsherds underwent different degrees of alteration from core to rim, showing a marked mineralogical and textural zonation. Secondly, mineral deposits in the potsherds from the two archaeological sites which were analysed provided different results. Amphorae from Aquileia were characterised by secondary calcite and euhedral microcrystalline pyrite, whereas the *terra sigillata* from Olbia displays framboidal microcrystalline pyrite, jarosite-natrojarosite and gypsum. These compositional and morphological differences between the two sites, can be related both to the different properties of the ceramic materials, such as pristine mineralogical composition and porosity, and to different environmental conditions. The formation of pyrite after pristine haematite, and subsequent crystallisation of jarosite after pyrite, were interpreted in terms of chemical-physical environmental conditions and their relative development over time. A post-depositional alteration model for lagoon-type environments was proposed.

## **Archaeometric contribution to the understanding of ritual ceramic production in the Moche society (north coast of Peru, AD 150-850)**

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The north coast of Peru provided many ceramic remains, testifying to the long and complex occupation of this region during prehistoric times. One of the most remarkable societies developed in this area is probably the Moche culture, which occupied this territory between approximately AD 150 and 850. Until the 1990s, the Moche were considered as a unified and centralised society, organised around the Moche and Chicama valleys. Today, it is known that, far from being organised around a unique political centre, the Moche were composed of several independent political organisations. Therefore, archaeologists are now trying to define the characteristics of the different regional expressions of this complex society.

One of the questions addressed in this paper is to establish whether technical characteristics of some Moche craft products can be used as a criterion to define these different groups. In other words, to what extent can one consider that the techniques used for manufacturing these objects reflect the identity of the group who produced them? From this perspective, some technical aspects of Moche ritual ceramics from the Jequetepeque valley were examined by means of archaeometric methods. These methods include optical examinations of sherd sections, SEM observations, chemical analyses using the energy dispersive X-ray spectrometer attached to the SEM, and analyses of the crystallographic composition of the samples by X-ray diffraction and Raman spectroscopy. The first results of this technical study will be discussed, emphasising the importance of taking into account, in the interpretation of the archeometric data, the information available in the archaeological record (excavation of workshops), and those provided by the ethnographic survey. These interpretations indicate that Moche potters, as did Moche metallurgists, used different techniques to create similar effects, underlining the existence of different technical choices. In the present phase of this investigation, it is not possible to claim that these choices are related to different technical traditions or territories. Nevertheless, it suggests that technical approaches of Moche craft goods need to continue and to be developed in a more systematic way.

## **Detection and Identification of Organic Residues in Bronze Age Cooking Vessels from Akrotiri, Thera**

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Akrotiri is one of the most important prehistoric settlements of the Aegean and it is located on the island of Thera. The first habitation at the site dates to the late Neolithic period (4th millennium BC), but the settlement mainly flourished during the Bronze Age, as least until the early Late Bronze Age, when the volcano erupted. The Akrotiri cooking vessel assemblage is well-represented in a variety of successive phases stretching across the Early, Middle and first phase of the Late Bronze Age. Changes in cooking pot morphology can be seen within the archaeological record. Additionally, variability in shapes and technological choices has been attested to by studies performed on the technology and performance of the pottery under discussion. Therefore, the morphological and material variability of the assemblage, as well as the excellent preservation, due to the volcanic eruption, make it highly significant?

However, the relationships between morphology, technology and use are complex, and should be approached from different viewpoints. Molecular analyses of cooking vessels from Akrotiri were undertaken as another means to determine the relationship between form, production technology and function. In addition, the detection and identification of residues from their use would enable an understanding of culinary practices/habits in the settlement through time. Therefore, 37 sherds representing the main shapes of cooking pottery (including tripod cooking pots, hearths, baking plates, pedestalled pots etc) dated from the Middle Bronze Age to the early Late Bronze Age have been sampled and were submitted for analysis using Gas Chromatography – Mass Spectrometry.

The results obtained to date show good preservation of residues, consisting of: a) aliphatic compounds (alkanes, alcohols, esters etc), which possibly derive from beeswax based on the compounds present and their respective distributions, and b) mainly fatty acids and acylglycerols that derive from plant and/or animal lipids. Samples prepared from hearths and baking plates, all dated to the earlier phase of the Middle Bronze Age, preserved relatively poor residues, whereas residues comprising aliphatic compounds are primarily observed in pedestalled pots/jugs. Residues, on the other hand, consisting of fatty acids and acylglycerols are preserved in samples prepared from deep bowls and tripod cooking pots

Although this study is still ongoing, it is expected that it could shed light on issues related to culinary practices and palaeodiet in the Aegean. The nature of the material, as well as the distinctiveness of these deposits offers a unique opportunity to carry out a detailed study of food preparation and consumption - through analysis of organic residues - in relation to technological and morphological characteristics of pottery.

## **Ceramic technology between Final Bronze and Second Iron Age in northeastern Italy: the case of Oppeano (Verona)**

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The archaeometric study of pottery from the proto-urban settlement of Oppeano (Verona, northeastern Italy) has shown important changes in the production technology between the beginning of the tenth and the fifth century BC.

The ceramic technology of the final Bronze Age is characterised, in several sites of the eastern Po plain, by the intensive use of temper, and in particular of grog. This material choice has been observed, not only at Oppeano, but also at several coeval sites of the provinces of Rovigo and Verona. These centres were located in areas characterised by sand-silt to silt-clay alluvial or glacial deposits, often covered by a thick clay-rich soil. Therefore, the choice to temper pottery with grog was probably determined by the paucity of pebbles and millimetric rock fragments in the alluvial deposits of these areas, as well as the absence of rock outcrops.

The use of grog in the ceramic production at Oppeano progressively decreased from the beginning of the Iron Age (ninth to eighth century BC), and even more dramatically from the sixth century BC. During the Iron Age the number of recipes used for ceramic production increased considerably. Moreover, the presence of trachyte 'key' inclusions in a few ceramic objects and their occurrence in Etruscan-Corinthian as well as Attic pottery indicate that ceramic materials started to be imported to the Euganean area (Padova, northeastern Italy), probably from Etruria and Greece, respectively. These important changes in the material culture were probably connected to increasing social complexity, to the introduction of new production techniques, such as the use of wheel and permanent kiln installations, mobility of artisans, domestic demand, and development of commercial trades. During this time span, Oppeano increased in extent, being in the Final Bronze Age a proto-urban centre (about 40 hectares) and becoming much more extensive (about 80 hectares) in the early Iron Age until its decline in the fifth to fourth century BC.

## **Seventeenth-century England: early attempts to make the 'Arcanum'**

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This contribution focuses on the investigation of seventeenth-century porcelain from the collection at Burghley House, Stamford, Lincolnshire, using non-destructive SEM-EDX. The glaze and body of three seventeenth-century objects, a small jar, its lid and a larger jar, were analysed by EDX using the variable pressure (VP) mode to allow the surface of the jars to be examined directly and without damaging these objects by the need to take samples. Both this new application of direct VP observation and analysis to ceramic vessels and the limits of the method are discussed, as well as the possibilities for obtaining results that are directly comparable to those acquired by standard methods that require intrusive sampling.

The EDX analyses of the bodies of the two jars suggest that they were produced using a similar paste, high in clay content, while analysis of the lid suggests that it was made using a different paste, perhaps at a different time or by a different artisan; this mismatch is supported by differences in decoration and the poor fit between lid and jar. The glaze analyses indicate variable concentrations of lead, which may partly derive from the pigments and variations in the thickness of the glaze.

The PCA results from the two jars suggest that the porcelain is different to Dehua as 'blanc de Chine' and to John Dwight's experimental material from Fulham which is currently under examination.

## **Petro-mineralogical and geochemical characterisation of Middle Neolithic Bükk Culture fine ware (Hungary)**

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The Bükk Culture is one of the 'industrial' prehistoric cultures in the Carpathian Basin (Middle Neolithic, c. 5300-5000 B.C). The core of the distribution area is located in northeastern Hungary and southeastern Slovakia. It is famous for its intensive role in lithic trade and even more famous for the artistic perfection of its pottery. Bükk pottery is claimed to have been traded over large areas far beyond the limits of the culture.

The authors wrote the first essay on the subject of Bükk pottery distribution and petrography in connection with a German-Hungarian Collaboration project centred on Early Neolithic pottery. As a valuable by-product, characterisation and provenancing of Bükk pottery was emerging, giving a basis for the continuation of the collaboration.

In the current project, a systematic and representative study of Bükk pottery products is initiated, in the first phase, in the core of the tribal area. The basic aim of the project is to compare Bükk fine ware from sites of the Bükk Culture from different topographic positions (e.g. caves, hill-tops, valleys) and to identify local or regional raw materials and production technology (and probable workshops). In addition, characteristic inlay of fine ware will be observed. Later it is intended to compare 'Bükk imports' that are found or claimed sometimes at a distance of several hundred kilometres from the territory of the Bükk Culture.

The framework of the project involves detailed petrographic (PM), mineralogical (XRD) and geochemical (XRF and PGAA) characterisation. By collecting these data on both archaeological finds and comparative soil/clay samples from the field, it will be possible to determine the applied special raw materials and/or special manufacturing techniques of Bükk fine ware. Raman microscopic analysis is planned to investigate the decoration. By creating the "fingerprint" of Bükk pottery, the possibility of long distance trading of vessels may be identified in the future.

## **First results on the archaeometric investigation of the Buda white ware (twelfth to fifteenth century, North Hungary)**

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There was a special white ware in Buda, the capital of the Hungarian Kingdom in the Middle Ages, which mainly consisted of table ware (bottles) with thin walls, sometimes red painting but more often engraved decoration. According to Holl (1963), these types of ceramics appeared during the thirteenth century and spread through the middle and northern part of the kingdom. It was his suggestion that the manufacturing happened somewhere near Buda in rural pottery workshops (domestic industry). However, contradictory evidence emerged during later research. This special pottery can also be found in pre-thirteenth century contexts. In the archaeological assemblages of the northern territory (present Slovakia) it is interpreted as an imported product, but there is no obvious raw material in the region of Buda for this kind of pottery.

The aim of this research is to obtain preliminary archaeometric data about this special white ware by microscopic petrographic observations and basic instrumental mineralogical investigations (XRD). The analysed fragments came from archaeological sites of the twelfth to thirteenth century and different distances from the capital. Processing these first results, will allow suggestions to be made about the possible sources of the raw material used.

## **Raw materials of Roman ceramics from Algarve (South Portugal): firing tests and mineralogical assembly**

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Several Roman ceramic production centres have been identified in the Algarve region (south Portugal) showing the economic importance of this activity near the coast. In order to better establish signatures of each production centre, a detailed survey of Algarve clays was conducted, including a mineralogical and geochemical characterisation.

In this study a compositional comparative study has been performed between pottery and clays. The aim is to identify mineralogical markers of different types of clays and further comparison with the mineralogy of local ceramics in order to find out the most probable raw materials. The Roman ceramics, mainly amphorae, of four archaeological sites from Algarve (S. Bartolomeu de Castro Marim – SBCM, Castro Marim – CM, Martinhal – MAR and Quinta do Lago – QLA), were found to be associated with ancient kilns, suggesting they are production centres; therefore the use of local raw materials is expected.

The mineralogy of 100 samples of ceramics was determined by XRD and then compared with the fired clays. Eleven samples of clayey materials representing the compositional variability of the region were selected for firing tests. Firing (300-1200 °C) of powdered clays was performed under oxidising conditions, using a firing cycle of 5 °C/minute and keeping maximum temperature for 30 minutes. The mineralogy of the original clays and fired specimens was also determined by XRD.

From this study information was obtained about the type of clays used and the range of ceramics firing temperatures. The results of the clay samples show that three groups of clays could be distinguished according to the type of newly-formed minerals: 1) non-calcareous clays, characterised by the presence of mullite at high temperatures; 2) clays with calcite that produced gehlenite, wollastonite and larnite, and 3) clays with dolomite, from which diopside originated, mellilite from the gehlenite-akermanite series, periclase, and forsterite, among others.

This work contributes for the identification of the clays used in each production centre: 1) in SBCM materials, the absence of carbonates and newly formed phases suggest clays from type one (without carbonates) were used, which may come from Carboniferous, Early Cretaceous and Cenozoic units. The absence of mullite indicates firing temperatures below 1100 °C; 2) MAR materials are generally rich in calcite and rarely contain newly formed minerals (gehlenite), indicating they were made of calcareous clays, as those frequently found in Jurassic and Cretaceous units, and fired to temperatures below 800-900 °C; 3) CM and QLA have frequent newly formed minerals (diopside, gehlenite-akermanite and less frequently anorthite) and sometimes calcite. Dolomite is rarely found. The raw materials used were probably clays from the Triassic-Hettangian age, which are usually rich in dolomite, and the firing temperatures were in general above 800-900 °C.

## **Merovingian pottery in the Mosan Valley: diffusion and consumption**

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During the transition from Antiquity to the Middle Ages, by combining Roman and German traditions, a new civilisation flourished in northwestern Europe. Amongst the many rich remains left by this culture, pottery survives in both dwellings and in burials, providing useful information about the economy and society of the Merovingians.

Pottery kilns have been found in two important Merovingian cities of the Mosan valley: Maastricht and Huy. A hundred and five thin sections from both places have been observed under the petrographic microscope and chemical analysis of one hundred ceramic samples have been performed with PIXE and PIGE techniques. Results have shown that though the production is very homogeneous in Maastricht, it is heterogeneous in Huy.

This previous characterisation of the Merovingian productions in the Mosan region has made it possible put into context the studies performed on five settlements subsequently excavated in this same area, which are the subject of this paper.

A number of significant samples have been selected according to archaeological criteria and the combination of this approach with the above mentioned analytical procedures has made it possible to conclude that the settlements' wares were imported from the cities of the Mosan valley, but also that they came from other production centres certainly situated in the Rhineland. Besides these two origins, it is believed that in some of the locations studied, pottery comes from workshops that are yet to be discovered.

## **A study of black pottery by Mössbauer Spectroscopy**

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Black pottery has been produced in many civilizations. The blackness is often due to the deposition of carbon black during firing, but may also be obtained by admixing graphite into the clay or in other ways. The detailed procedures by which black pottery was made in antiquity are often a matter of discussion.

We have investigated a variety of black ceramics by Fe Mössbauer spectroscopy at ambient temperature and at 4.2 K in order to find out what this method can teach us about the firing techniques used in making black pottery. The Mössbauer method is well suited to study the chemical and physical state of the iron in the pottery, which in turn gives valuable clues about the firing procedures used. The Mössbauer method was supported by XRD, thin section microscopy and SEM. Much of the studied pottery stems from Northern Peru and has been dated to the Formative Period (2000-800 BC) and the Sicán culture (AD 950-1050). A great deal of the studied material is from Celtic Europe (300-15 BC). Additional examples that will be discussed are Etruscan Bucchero blackware and contemporary blackware from San Ildefonso, New Mexico.

In most of the studied pottery, carbon black was deposited during a reducing firing step following heating to about 800 °C, during which the iron either dissolves in a vitreous phase or forms hercynite. In many cases, the iron was re-oxidised during the cooling phase, forming maghemite or hematite, or remaining dissolved in a vitreous phase containing enough trivalent iron to order magnetically below about 40 K.

## Early Islamic mixed alkali glazes in Central Asia

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The Islamic artisans and craftspeople are renowned for their skilled work in glass and glazed ceramics, producing some of the most beautiful objects ever made in these materials. Both glass and glaze making rely crucially on the availability of fluxes such as alkali oxides and lead oxide. Early Islamic glasses are mostly plant-ash based soda-lime-silicates, with very limited use of lead-rich glasses. In contrast, most early Islamic glazes are lead-silica based or a mixed lead-silica and alkali glaze. Pure alkali glazes seem to be less common. Near Eastern alkali glazes are mostly similar in composition to contemporary plant-ash based soda-lime-silica glasses (e.g. Mason *et al.* 2001; Paynter *et al.* 2004). In contrast, Middle Eastern and Iranian alkali glazes seem to have relatively more potash, but are still soda-dominated (e.g. Borgia *et al.* 2004; Pace *et al.* 2008).

Ongoing work on ninth to eleventh century AD alkali glazes from Tashkent, Akhsiket and Kuva (all Uzbekistan) and Merv (Turkmenistan) identified a wide range of soda to potash ratios, from a soda-rich 5, similar to contemporary glasses, to near 1, essentially mixed-alkali compositions. In contrast, contemporary glasses from these sites all fit the expected soda-rich plant-ash composition known from most Near and Middle Eastern early Islamic glasses, with a soda to potash ratio of 4 to 5.

This poster will present electron microprobe data on six alkali glazes from eastern Uzbekistan (Akhsiket and Kuva), three from Tashkent, and nine from Merv. All Uzbek glazes were found to have mixed-alkali compositions, with soda to potash ratios of 3 or less, while of the Merv samples, half are standard soda-rich glazes, while half have mixed-alkali ratios. We will explore the implications of this pattern, placing it into the context of the published literature and discussing the possible relationships and differences between ceramicists and glassmakers in the Near East and Central Asia, respectively.

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## The ways of the lustre: Egypt, Tunisia, Spain

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The recent discovery of Fatimid lustreware production in Sabra al-Mansuriya near Kairouan (Tunisia), in the French-Tunisian excavation directed by P. Cressier and M. Rammah, re-opens the question of the introduction of this technique in Ifriqiya. Although lustreware tiles dated back to the ninth century decorate Kairouan's great mosque, it does not seem that lustreware was produced in the region until a much later date. Besides, the Fatimid dynasties moved from Ifriqiya to Egypt to establish their capital in Fustat (Cairo). Technological connections with the well established Egyptian lustreware production might therefore have been expected. Tunisian lustreware might also have been a link in the transmission of the technique towards Muslim Spain. It is a new piece of the puzzle to understanding the diffusion of lustre technology in the Mediterranean regions.

Composition and microstructure of the bodies and glazes and micro- and nano-structure of the lustre layer are compared, to investigate the technological relationships between Tunisian, Egyptian and Spanish lustrewares.

## **Parallel developments in Chinese porcelain technology in the fourteenth century AD**

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In the fourteenth century AD two giant south Chinese kiln-complexes dominated the mass-production and export of high-fired wares in China – namely Jingdezhen in the Jiangxi province and the Longquan region of Zhejiang province. Jingdezhen's main production was blue and white porcelain, while Longquan wares typically used opaque porcellanous bodies, and smooth and thick, greenish celadon glazes.

Despite the obvious visual differences between the two wares, Jingdezhen porcelains and Longquan celadon wares were closely related technologically. Both used bodies based on micaceous porcelain stones with primary clay additions, and both used the advanced and stable style of lime-alkali glaze. However, when the origins of these body-types and glaze-types are considered the reasons for their adoption seem rather different. For example, the use of kaolin at Jingdezhen was probably related to resource-depletion, and the need to exploit reserves of non-kaolinised porcelain stone. By contrast, the addition of iron-rich primary clay to porcelain stone at Longquan was more likely to have occurred in the search for a visually harmonious body for the jade-like celadon glazes that were adopted there in the late twelfth century.

Lime-alkali glazes were preferred at Jingdezhen for their stability and transparency with underglaze decoration. At Longquan similar glazes were applied to much greater thicknesses, to exploit their similarity to jade. The fine and early (thirteenth century) bluish-green Longquan glazes were inspired by imperial Guan wares, which were themselves true successors to the imperial Ru wares of north China.

Thus a pattern of parallel technological development at Jingdezhen and Longquan in the thirteenth and fourteenth centuries is seen – but probably driven by rather different causes. Jingdezhen seems a simpler and altogether more local technological history that was entirely southern, and unconnected with the history of imperial-quality northern wares. Longquan by contrast adopted a glaze-type that had already seen many prestigious applications in north China – with its origins reaching back to the Yaozhou kilns of the early tenth century.

## Scientific analysis of sherds from Wuzhou Kilns in China

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Wuzhou (the ancient name for the area comprising Jinhua and Quzhou nowadays) is located in Zhejiang, the south-eastern part of China (Fig. 1). Wuzhou Kilns started to produce pottery as far back as Neolithic times and flourished on a large scale during the Tang and Song dynasties. More than 400 kilns were found in this area. Wuzhou Kilns, as one of the six most famous celadon-producing centres, are one of the least studied kiln sites among them.

This study attempts to analyse the chemical compositions of the bodies, glazes and inclusions of the ceramic sherds from Wuzhou Kilns and to profile their surface images using electron microprobe. 24 pieces of ceramic sherds collected or excavated from 9 different Wuzhou kilns were analysed. Most of these ceramic shards were produced during the Tang, Song and Yuan dynasties, which were the flourishing periods of the Wuzhou Kilns.



Fig. 1 The location of Jinhua and Quzhou in Zhejiang and the location of Zhejiang in China.

A clear chemical similarity is seen between the porcelain stones in Zhejiang and the bodies and glazes of Wuzhou Kilns, which indicates the possibly employment of this porcelain stone to make the ceramics at Wuzhou. There is no distinctive difference in chemical compositions between glazes of the same type in the north and south China, but a big distinction in different types of glazes because different fluxes were employed. Most of the glazes in this study were found to be lime glazes. Wood ash or plant ash was added to the porcelain stone in earlier eras to make ash glazes, while the limestone was added to make lime-alkali glazes during later periods.

The chemical similarity among the 24 sherds from Wuzhou Kilns is a probable indication of a mature ceramic production site, characterised by full-time potters who produced similar ceramic wares in different workshops and at different time periods. However, the fact that the majority of potters were connected with small-scale family workshop production outside the central government-controlled system meant that slight differences exist in the treatment of raw materials, which were freely altered by potters.

