THE OLD POTTER'S ALMANACK

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EDITORIAL

Dear Reader,

This September issue of *The Old Potter's Almanack* presents two papers. The first, by Andreja Kudelić, is an experimental, scientific and archaeological study of middle and late Bronze Age pottery from north-western Croatia. The second is a detailed scientific study by Diego Tamburini *et al.*, on the chemical characterisation of organic materials used for the manufacture of plaster and mortar in the Champa civilisation in Vietnam (*ca.* 4-14th centuries AD).

Kudelić's paper focuses on how difficult it is, both macroscopically and petrographically, to distinguish between plant and dung temper and between tempering with dry clay pellets and with grog (recycled pottery, chamotte). Tamburini *et al.* highlight the necessity of using multiple techniques (optical microscopy, UV light and GC-MS) to identify organic binders, i.e. resins, in order to understand the brick temple construction.

Sarah Dillis *et al.* review the Early High Technology Ceramics Meeting, which took place in April at the UCL Institute of Archaeology.

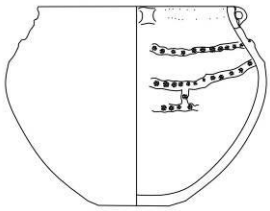
Patrick Quinn and Ian Freestone present a short history of the Ceramic Petrology Group.

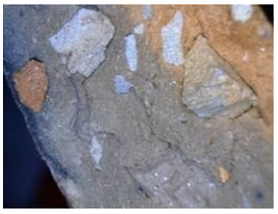
Finally, I am very pleased to mention the publication of a Special Issue of *Journal of Archaeological Science: Reports*, Spataro, M. and Tomber, R. (eds.) *Contextualising science: Advances in ceramic production, use and distribution*. This volume includes a wide variety of case studies on ceramics, from the Neolithic to the present day, from Asia, through Europe and Africa, and from scientific, ethnographic and theoretical perspectives. For more details, please see https://www.sciencedirect.com/science/journal/2352409X/16

I hope you will enjoy this issue.

Michela Spataro

IN THIS ISSUE





PREPARATION AND COMPOSITION OF CLAY PASTE IN BRONZE AGE POTTERY FROM NORTH-WESTERN CROATIA: THE ROLE OF EXPERIMENTS

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Introduction

This paper presents the preliminary results of two sets of experiments conducted as part of research into Bronze Age pottery production technology in north-western Croatia. A study was carried out on 7891 pottery fragments recovered from five Bronze Age settlements situated in the river valleys along small streams in the Turopolje and Podravina regions (Figure 1). The pottery was attributed to the early phase of the Central European Urnfield culture, dating to the period between the 15th and 13th c. BC (Kudelić 2015, 2016). The results presented in this paper consider the research conducted on the manufacturing processes of the clay paste and firing conditions of the Bronze Age ceramics and experimental briquettes. The experiments were aimed towards finding a recipe similar to that used for the Bronze Age pottery. Clay materials were collected from the vicinity of Bronze Age settlements and were used to produce 82 experimental briquettes according to various recipes (organic, grog and clay pellet temper) and firing conditions. The recipes were documented using a digital microscope (magnification x20-60) observing fresh fracture surfaces of the briquettes and Bronze Age pottery.

Technological characteristics of Bronze Age pottery from north-western Croatia

Pottery production in the north-western part of Croatia was abundant during the end of the Middle and the beginning of the Late Bronze Age, which resulted in a huge number of ceramic fragments being recovered from archaeological sites. The wide variety of vessel forms pointed towards a low degree of form standardisation (Figure 2). According to macroscopic observation, the pottery was hand-made and of low quality (highly porous and low-fired), which meant that the recovered fragments were poorly preserved. Potters used several forming techniques, such as modelling a clay lump by drawing and pinching, although the main technique was coiling and slabbing (Figure 3). Horizontal traces from using rotation in the vessels' final forming stage were recorded on the rim and the base areas of several fragments. The surface was smoothed (over 60% of the overall pottery sherds), and occasionally burnished (1–4%) during the vessels' final processing stages. Traces of slip coating have also been recorded from macroscopic observation of the pottery and these show high colour contrast between core and surface of the fresh fractures and peeling of layers from the surface. Vessels were usually fired under a reducing atmosphere, or in an incomplete oxidising atmosphere, which resulted in a predominantly dark grey colour of the core, while the surface retained a dark brown, greyish-brown or yellowish-brown colour.

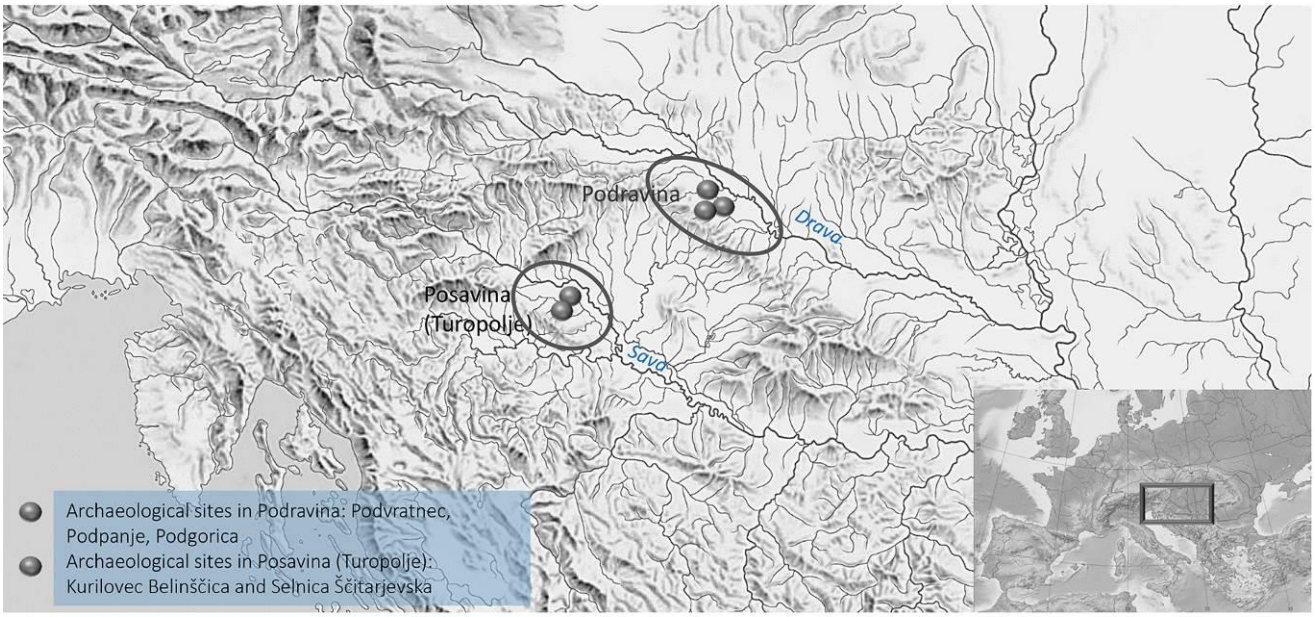


Figure 1. Location of the Bronze Age sites in north-western Croatia.

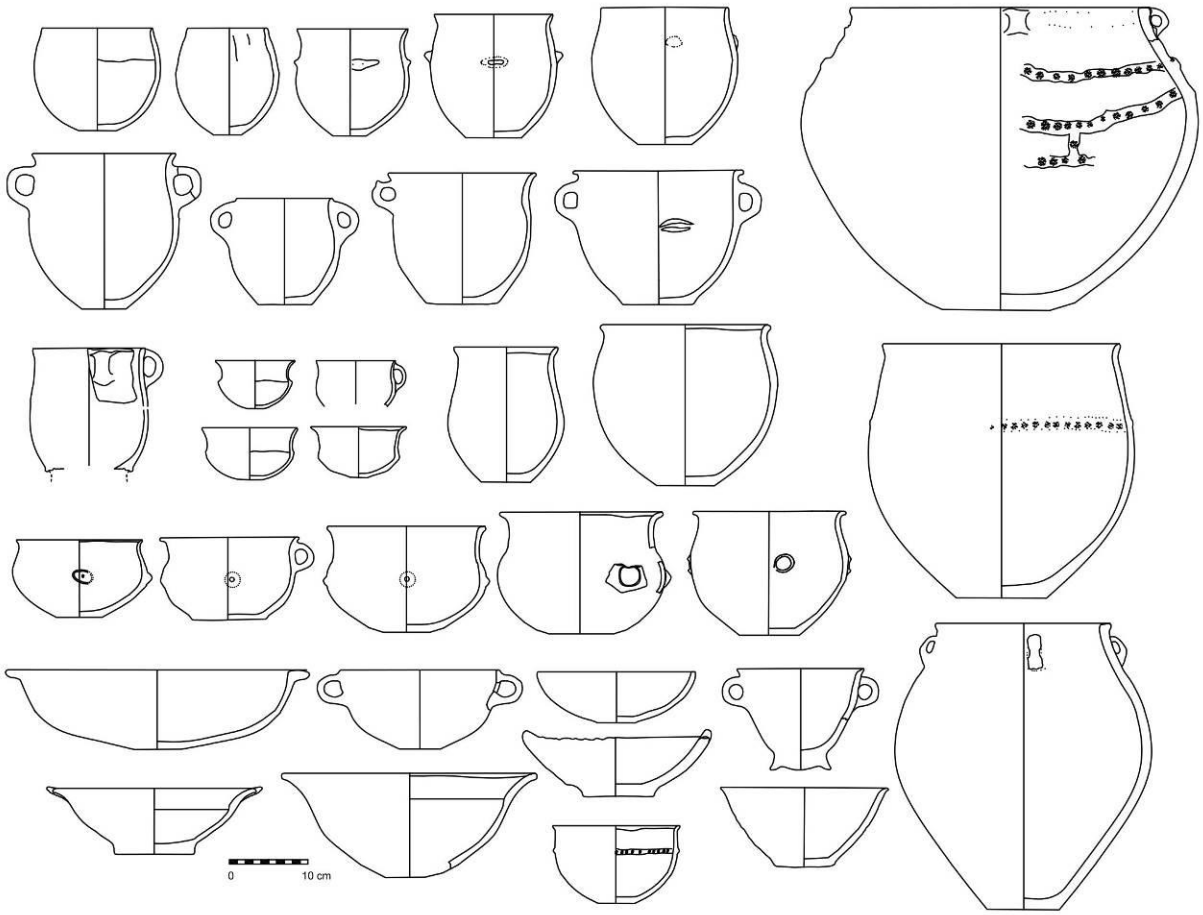


Figure 2. Basic vessel forms dating between the end of the Middle and the beginning of the Late Bronze Age in north-western Croatia (drawing by A. Kudelić).

Figure 3. Bronze Age site of Kurilovec-Belinščica: traces of forming techniques indicating coiling and slab building on the interior surface of the vessels (arrowed) (photgraphed and drawn by H. Jambrek and A. Kudelić).

Archaeometric analyses (XRPD and thin section petrography) of the clay samples and ceramics showed that the raw material used for the Bronze Age pottery was collected from the vicinity of the settlements, as the local alluvial clays (clayey silt and silty clay) were of sufficient quality for use in pottery shaping (Kudelić *et al.* 2017). Petrographic analysis showed that potters prepared the clay pastes by adding crushed pottery (grog), and probably an organic temper (Figure 4; Kudelić 2015; Kudelić *et al.* 2017). From the high number of tiny pores and voids present in the microstructures of the pottery, it is assumed that the organic temper was very fine. Grog was added to the clay material of all types of ceramic vessels in different amounts, and this was determined by macroscopic analysis to be between 5% and 40%.

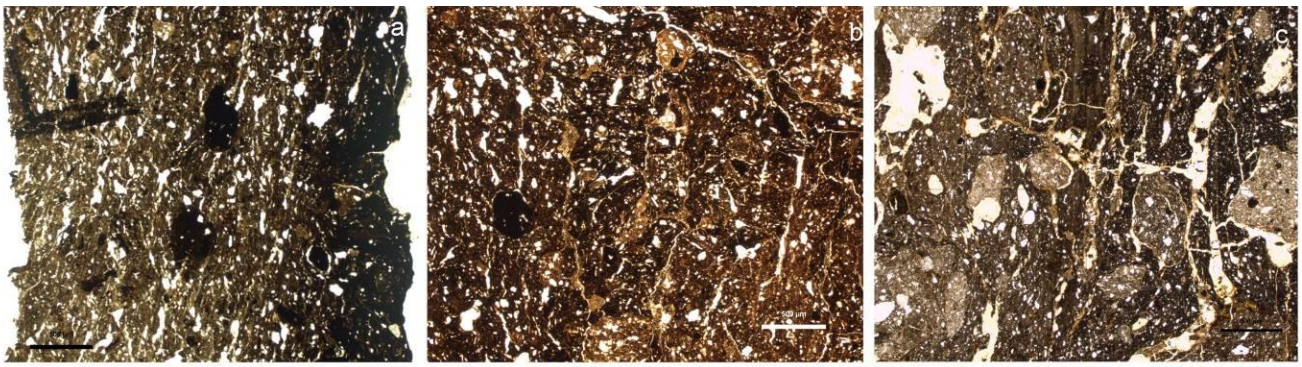


Figure 4. Photomicrographs of thin sections of Bronze Age pottery (scale bar = 0.5 mm): a) and b) pottery from the site of Podgorica; c) pot from the site of Kurilovec-Belinščica (by M. Mileusnić, modified by A. Kudelić).

According to macroscopic analyses, the Bronze Age samples were divided into six main fabric groups. Pottery fabrics were determined by type, size, and frequency of the temper (grog grains), where the grains were identified using a digital microscope and analysing the images of the fresh fracture surfaces of the pottery. 99% of the 182 analysed pottery samples contain grog (Kudelić 2015). However, the results of the microscopic analysis did not provide sufficient evidence to fully characterise the preparation of this paste - such as the amount of grog or types of organic temper. Experimental research was therefore undertaken to provide answers to these questions.

First set of experiments

Collecting clay material

Field survey has shown that easily accessible clay material of good quality is located in the immediate vicinity of the archaeological sites. Clay samples were collected from these areas as potential sources for the raw material used in the Bronze Age. These were used for archeometric analyses (Kudelić *et al.* 2017) and to produce experimental briquettes. Three clay samples were selected from different deposits located near the remains of a Bronze Age settlement in Turopolje (Table 1). The first deposit is located in a brickyard, four kilometres from the archaeological site of Kurilovec-Belinščica. The sample acquired at this site was a mixture of clay types (sample M, Table 1). Due to the size of the clay mine, and the depth of the exploitation pit, the well-stratified clay layers within the profile provide valuable insight for geologists, and assure a precise clay deposit analysis. The other two deposits were found by chance. The first deposit is located 600 m to the north-east of the archaeological site (labelled G, Table 1) and the sample was collected from the depth of more than one metre from the surface. The second deposit is located 500 m to the south-east of the site (sample K, Table 1) and the sample was collected from a much shallower depth of 40 cm from the surface and it was used in the second set of experiments. Clay material was also collected in the Podravina region, in the river Drava valley (samples P.Pv and P.Pg, Table 1) in the immediate vicinity of the remains of two Bronze Age settlements, and used in the second set of experiments.

The clay material was extracted by drilling 30-70 cm deep cores from the deposits. Sampling locations were recorded using GPS (Table 1). Collected clay samples were manually cleaned of larger inclusions such as gravel, leaves or similar unwanted organic material. Physical properties of each clay sample were observed: plasticity and its effects on shaping, drying time, and ease of manufacture in relation to the addition of different types and quantity of temper.

This first set of experiments was initiated before archaeometric analysis was undertaken.

Grog and organic tempered briquettes

Thirty-five briquettes were produced using different recipes in order to better understand preparation processes to be compared with the freshly fractured archaeological ceramics (Figure 5). In order to make a range of briquettes with different characteristics, grog was prepared using different available materials (brick, briquette and contemporary ceramics), and ground using a hammer (first a stone hammer, then a metal one) on a stone base which was used as a grindstone. It was noticed that grinding produced an extremely small amount of grog in relation to the initial quantity of raw material. Sieving was necessary to separate the grog grains from the powder obtained by grinding, because the dust severely dried out the clay paste. Two sieves of different sizes were used in the process to separate powder, grog inclusions up to the size of 1 mm, and the inclusions up to 2.5 mm, the latter being recorded in Bronze Age ceramics. Chaff was added as an organic temper, along with straw cut with scissors. The amount of grog added to each briquette was measured by weight in relation

Clayey sample label	Region (NW Croatia)	Coordinates	Distance from the archaeological site	Macroscopic description	Mineralogical determination
M	Turopolje	45.657977 16.084164	4 km	brown-yellow	clayey silt
G	Turopolje	45.700522 16.063316	0.6 km	grey-brown	silty clay
K	Turopolje	45.690340 16.071262	0.5 km	grey-brown	silty clay
P.Pg	Podravina	46.181544 16.892333	30-70 m	grey with yellow spots	silty clay
P.Pv	Podravina	46.221772 16.848861	30-70 m	grey-brown	silty clay loam

Table 1. List of clayey materials used for the experiments discussed in the article.

Figure 5. Temper used in the briquettes showing chaff with straw and grog grains in two sizes (photographs by A. Kudelić).

to the weight of dry clay to which it was added (5-10%), while the organic material was measured by volume (Figure 6). The amount of grog added to the paste was an estimation of the percentage area visible in the sample fresh fracture (Quinn 2013, 82).

In the drying process, the resistance of clay material to relatively fast drying was documented. In order to simulate quick drying conditions, the briquettes were dried with the help of a heating device. Heating response was dependent upon clay types and temper used. It was noticed that sample G shrank noticeably in the course of drying, and that it dried out more slowly than other briquettes.

Two copies of experimental briquettes were made from clay samples M and G (Table 2). The aim was to establish characteristics and differences visible on fresh fractures of experimental ceramic samples made using different recipes and fired under different conditions (Table 3), and to compare them with the Bronze Age pottery. One set of briquettes was fired in an open fire in incomplete oxidising conditions at a maximum temperature of 730°C, the other set in an oxidising atmosphere in an electric kiln at the same temperature (Table 3; Kudelić 2013). The firing in both cases lasted 5-10 minutes, after which the briquettes were removed. The briquettes fired in the fire the soaking time was short, approximately 5-10

Figure 6. Cup with volume markings of clay and temper used in the experiments with cow dung, grog and clay pellets (photographs by A. Kudelić).

	Clayey sample	**Recipe**		**Fired briquettes**	**Firing conditions**			**Unfired briquettes**
					Bonfire		Electric kiln	
First set of experiments	M; G	0	without temper	3			+	
	M; G	1	5% grog	6	+		+	
	M; G	2	10% grog	6	+		+	
	M; G	3	chaf and straw	4	+		+	
	M; G	4	chaf and straw and 5% grog	4	+		+	
	M; G	5	sand 10%	6	+		+	
	M; G	6	5% sand and 5% grog	6	+		+	
					Pit firing (A)	Bonfire (B)	Electric kiln (C)	
Second set of experiments	K; P.Pg; P.Pv	1	without temper	9	3	3	3	3
	K; P.Pg; P.Pv	2	dung 50%	9	3	3	3	3
	K; P.Pg; P.Pv	3	dung 30% and grog 20%	9				3
	K; P.Pg; P.Pv	4	clay pellets 20%	3	3	3	3	6
					0	0	3	
	K		clay pellets	2	2			
Total number of briquettes	**82**			**67**				**15**

Table 2. Summary of experiments discussed in the text.

minutes after which the briquettes were taken out of the fire. The briquettes fired in the electric kiln, after 10 minutes of soaking time, were left in the kiln to cool for approximately 2 hours. The study showed that the local clay has properties of sufficient plasticity for vessel shaping, and withstands rapid drying. However, the briquettes made of clay sample G, regardless of the recipe, were damaged during firing in an open fire. Defects in the form of fire spalls were recorded on two briquettes, where such defects are normally associated with evaporation of water from the clay during a rapid rise of temperature. Considering that sample G demonstrated a slow discharge of moisture during the drying process, it was assumed that the clay contained minerals that were subject to swelling. However, subsequent archaeometric analyses showed that the clay, just like clay sample M, does not contain such minerals (smectites and vermiculite), but that clay is of good quality for pottery production as it contains a mixture of illite, kaolinite, chlorite and abundant quartz. It was also confirmed that the presence of chaff temper in the clay paste significantly affects the colour of the core of the ceramic sample, as well as the firing conditions (Table 3).

Second set of experiments

The second set of experiments focused on aspects of organic temper, and on the raw material from which grog was made. Forty-seven experimental briquettes were made (Table 2) using three different clays (samples K, P.Pv and P.Pg), and following four distinctive recipes (marked with numbers: 1, 2, 3, 4). The first group did not contain temper, and it was used as a reference (Table 4). The second group was tempered with cow dung (50%); the third group with cow dung (30%) and grog (20%); and the fourth group with clay pellets (20%). Briquettes were made in three series (marked with letters: A, B, C,) using different firing conditions (Table 5).

Cow dung and grog

The first set of experiments suggests that straw needed to be chopped up with a sharp tool in order to properly prepare it as temper. However, although chopped straw was added to the clay samples, the temper appeared differently in the briquette microstructure compared to that of the Bronze Age pottery (Table 3). The Bronze Age pottery fabrics had abundant tiny pores and voids suggesting that the organic temper was very finely processed.

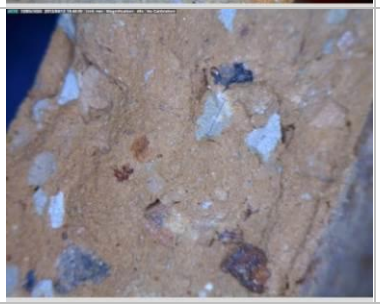
Recipe	Macrostructures of the fired briquettes		Firing conditions
	M	**G**	
No temper			Electric kiln max. 730°C
5-10% grog			incomplete oxidation max. 730°C 
5% grog, chaff and straw			
chaff and straw			
chaff and straw			Electric kiln max. 730°C
5-10% grog			Electric kiln max. 730°C

Table 3. Fresh fractures of briquettes from the first set of experiments.

Recipe	Firing conditions		
	A (Pit firing - incomplete reduction, max. 640°C; soaking time 20 min.)	**B** (Bonfire - incomplete oxidation, max 730°C; soaking time 10 min.)	**C** (Electric kiln - incomplete oxidation max 650°C; soaking time 10 min.)
K1		*damaged during firing*	
P.Pv 1	*damaged during firing*		
P.Pg 1		*damaged during firing*	

Table 4. Fresh fractures of untempered briquettes fired in different conditions (empty boxes: briquettes were severely damaged during firing).

Therefore, it was concluded that chopped-up straw was not used for manufacturing the early Urnfield pottery. Because of the high number of tiny pores and voids found within the Bronze Age pottery fabric, organic temper seemed to have been very finely processed (Figure 4). As mentioned above, the amount of organic temper in some ceramic samples was up to 40% (Figure 4). As temper of plant origin chopped so finely can be found in cow dung, and it requires no tools for its preparation.

Therefore, dry cow dung was added as experimental temper. Pieces of dung were easily crumbled with fingers to the required size, although, as with grog preparation, it was necessary to sieve the dust and separate larger dung pieces from the rest. Such temper can be easily mixed with clay, even though water must be added to facilitate mixing by maintaining sufficient plasticity of the clay paste when more than 30% by volume has been added. 50% of cow dung temper was the maximum amount that could be added to a clay without losing all the plasticity (Table 5).

In the third group of briquettes, grog (20%) was added with cow dung (30%). Grog was made of waste produced in previous experiments and, unlike grog made from ceramic building material, these inclusions were more rounded and porous.

As well as to recreate the appearance of temper in the briquettes and determine the amount of cow dung required to replicate the Bronze Age ceramics, another objective was to determine to what extent such temper affects the colour of the ceramic core in cross-section during firing under different conditions. Since the research is still in progress, these results are based upon the experiments of three groups of briquettes fired under different conditions. The first group of un-tempered briquettes and two tempered groups totalled 30 briquettes (Tables 2 and 5). One group of briquettes was fired in a pit with a partially reducing atmosphere (series A) using dry branches, dry grass and cow dung as fuel. The firing lasted almost 5 hours and the highest temperature achieved was between 600°C and 640°C, and was maintained for about 20 minutes. Unfortunately, the samples were not completely fired because the experiment was interrupted by rain. It is likely that two more hours of firing would have been sufficient for completion and to reach at least 700°C. The second group was fired in an open fire (series B) in incomplete oxidising conditions at a maximum temperature of 730°C. The fuel used was wood and

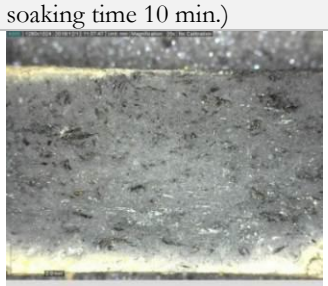
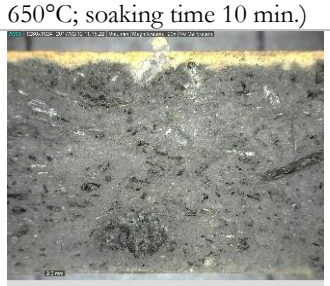
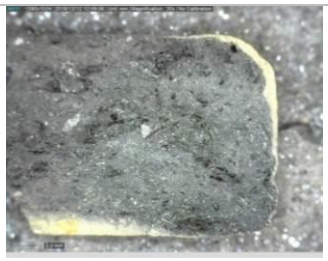
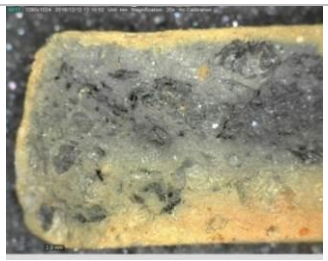
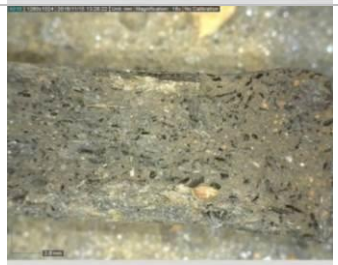
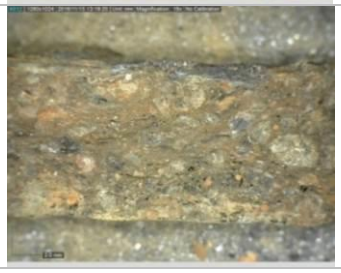
Recipe	Firing conditions		
	A (incomplete reduction max 630°C; soaking time 20 min.)	**B** (incomplete oxidation max 730°C; soaking time 10 min.)	**C** (incomplete oxidation max 650°C; soaking time 10 min.)
K2 50% cow dung			
K3 20% grog 30% cow dung	*damaged during firing*		
P.Pv 2 50% cow dung			
P.Pv 3 20% grog 30% cow dung			
P.Pg 2 50% cow dung			
P.Pg 3 20% grog 30% cow dung			

Table 5. Fresh fractures of briquettes from the second set of experiments.

cow dung. The firing lasted between 35 and 40 minutes with a short soaking time, approximately 5-10 minutes, after which the briquettes were removed from the fire. The third series (C) of briquettes were fired in an electric kiln at 650°C for 25 minutes with a short soaking time (10 minutes) after which the samples were removed from the kiln.

Clay pellets as tempering material

The first experiments showed that a relatively large amount of raw material for making grog turned to powder, which is not effective for use as temper. In this experiment an alternative variant of temper with similar characteristics was tested: dry lumps of clay were prepared as pellets, by grinding and sieving. One of the research goals was to determine the properties of this temper, and whether, after firing, there are visible differences between the grains of temper added as grog and those added as unfired clay pellets. One series of nine briquettes tempered with clay pellets was fired in the electric kiln and two samples were fired in the pit (Table 6).

Preliminary results

The fresh fracture of experimental briquettes, regardless of firing conditions, demonstrated that cow dung significantly influenced the colour of the ceramic samples' core. The cores are dark grey with sporadically distributed pronounced black smudges. Apart from the colour, the organic temper also appears in the form of well-distributed pores of oval or elongated shapes, ranging in size between 0.3 and 1.0 mm. One sample (Table 5, sample P.Pg 2A) shows a predominant number of black oval or circular voids which occurred when the fine plant seeds combusted and burned out during the firing process. Fractured briquettes tempered with cow dung and grog, share common physical characteristics with a high number of Bronze Age pottery sherds (Table 7). In contrast to the grog produced from contemporary ceramics during the first experiments, the clay pellets added to the briquettes (Table 6), display more rounded (softer) shapes and porous structures and are also very similar to the grog of the Bronze Age ceramics.

The results of the archaeometric analyses of the Bronze Age ceramics indicate that the maximum firing temperature was around 700°C (Kudelić *et al.* 2017); the experimental firing conditions reached a similar temperature and the colours indicated both oxidising and reducing atmospheres with relatively short soaking times (Table 7).

With the exception of two briquettes tempered with dried clay pellets that were fired in a pit at a maximum temperature of 650°C, three additional briquettes made of the same recipe were fired in an electric kiln (series C) at the same temperature with a short soaking time (10 minutes). Visible on a fresh fracture of a fired briquette, pieces of the original dried clay pellets show diffuse or rounded edges, i.e. the grains are partially fused with the matrix (Table 6). However, in most cases the grain edges are partially angular and clearly separated from the matrix (Table 6), therefore fully corresponding to the appearance of grog. According to the literature and the already established morphological characteristics, the fired grains from clay pellets have rounded edges while grog has partially angular grains (Whitbread 1986; Quinn 2013, 84; Albero Santacreu 2014, 62). The results of these experiments need to be checked in a larger number of samples.

Discussion

This experimental research confirmed hypotheses about finely fragmented organic temper of vegetal origin which appears to have been used in the preparation of the early Urnfield culture clay pastes. Moreover, the experiments suggest the possibility that the Bronze Age potters used cow dung as organic temper, in addition to grog (and/or clay pellets?).

In many cases temper has a functional purpose, although there are notable reasons of cultural or ideological nature for the use of grog (De Boer 1974, 336; Smith 1989, 61; Chapman 2000; Brück 2006; Kreiter 2007). The tradition of using cow dung in pottery production (as fuel as well as a temper) has been recorded in ethnographic sources (Sillar 2000; Gosselain 2008, 34; Albero Santacreu 2014, 70), although there are indications that it was also used in the past (Albink 1999, 134). Non-plastic temper material (grog, sand, etc.) as well as organic tempers (straw, chaff, bones, shells, etc.) are added to the clay paste in order to reduce its plasticity, facilitate the forming and drying of the vessel, and ensure a good level of heat resistance during the firing process and during the vessel's use (Velde and Druc 1999, 83; Gibson and Woods 1990, 27; Skibo *et al.* 1989). The main function of a highly-tempered clay paste in open-fired pottery is to open the body, allowing the water to evaporate during the early stages of firing (Gibson and Woods 1990, 207). It is therefore important to determine the type and characteristics of temper, as its properties directly affect aspects of vessel production and use. For example, a relatively low firing temperature (550°–700°C) and selection of firing atmosphere (reducing or incomplete oxidation), appear to be closely linked to the specific temper used in clay pastes. Paste rich in organic matter has a much higher rate of sustaining fractures when slowly fired. Rapid firing is a more appropriate method for a paste tempered with an organic material and such paste might serve as an indicator of the use of low firing temperatures (550–650°C) (Albero Santacreu 2014, 99).

Recipe	Firing conditiones	
	C (incomplete oxidation max 650°C; soaking time 10 min.)	
	Fresh fracture	Surface
K4		
P.Pv 4		
P.Pg 4		
	(incomplete reduction max 650°C; soaking time 20 min.)	
K4		

Table 6. Fresh fracture of experimental briquettes tempered with clay pellets (black arrow: grains are partially fused with the matrix; blue arrow: angular grains).

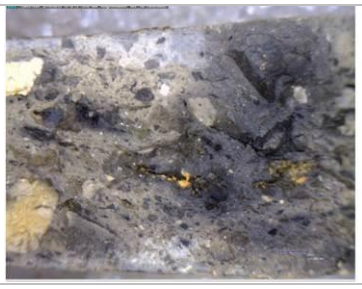
Recipe and firing conditions	Experimental briquettes	The Bronze Age pottery	
P.Pg 3A			
P.Pg 3B			
K2A			
P.Pg 2C			
M chaff and straw			

Table 7. Fresh fracture of experimental briquettes and Bronze Age ceramics (made by A. Kudelić).

In addition, another advantage of this type of paste is that its porous wall can absorb an additional wet layer of clay added to the vessel in the form of a slip (London 1981, 194). Due to the fact that some of the examined Bronze Age pottery fragments have traces of slip, it is possible to consider the function of fine organic temper and its relationship with final surface treatment techniques.

Conclusion

Bronze Age early Urnfield pottery in north-western Croatia was hand-made and of low quality, being highly porous and low-fired.

The temper added to the Bronze Age clay pastes was primarily grog and fine organic material. Grog is recorded in almost all studied vessel types sometimes

in large quantities (30-40%), which suggests that a large amount of ceramic waste was produced from the settlement. Experiments showed that during grog preparation, grinding and sieving produced an extremely small amount of grog in relation to the initial quantity of raw material indicating a need for a relatively large amount of source material. Furthermore, this may be an indication of special treatment of the ceramic waste in a settlement or household by collecting and storing it, either by potters or the community. The extent of this type of recycling material is not easily measured. This will hopefully be investigated by future research. On the other hand, there are instances in which dry clay pellets were probably deliberately added as well as, or instead of, recycled pottery.

Experiments were conducted on briquettes made from locally collected and relatively good quality clay, which was an easily available raw material in the Bronze Age. The experiments were aimed towards finding a recipe with added temper, similar to that found in the Bronze Age pottery. Fractured briquettes tempered with cow dung and grog, share common physical characteristics with a high number of Bronze Age pottery sherds. However, the experiments point to caution in interpreting temper selection because deliberately added dry clay pellets in the unfired clay, appear to look similar to grog in the freshly fractured ceramics.

The frequent presence of fine porosity in the archaeological samples seems to suggest the possibility that ruminants' dung or a highly crushed temper of plant origin was added. It was shown that producing temper from cow dung requires grinding and sieving. This might be also associated with surface finishing techniques, such as the application of slip. However, other archaeometric research shows that slips were applied to well-burnished vessel surfaces, e.g. in the Neolithic of the central Balkans (Spataro 2016).

Research is still ongoing. The results of these studies should certainly be supplemented by analysis in thin section of selected experimental briquettes in order to gain a better insight into porosity, as well as other characteristics of the clay pastes.

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CHEMICAL CHARACTERISATION OF THE ORGANIC MATERIALS USED FOR THE CONSTRUCTION OF THE TEMPLES AND BUILDINGS IN MỸ SƠN (VIETNAM) FROM THE CHAMPA KINGDOM

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Introduction

The archaeological site of Mỹ Sơn hosts a series of abandoned and partially ruined temples related to the Champa civilisation (4th-14th centuries AD). The site is situated in the Quảng Nam Province (Duy Xuyên district) in Central Vietnam and represents a unique example of interchange between Indian and South-Asian cultures. The temples show the typical Hindu architecture and were dedicated to the worship of the god Shiva. In 1997 the Mỹ Sơn Conservation Project started with the aim to safeguard the archaeological site and in 1999 UNESCO recognised Mỹ Sơn as a world heritage site. In the framework of this project, research focused on understanding the engineering principles and technological skills used for the buildings, the original materials used and their compatibility with modern materials to be chosen for conservation. The Mỹ Sơn temples are classified into ten principal groups, each consisting of multiple temples. For purposes of identification, letters were assigned to the groups: A, A', B, C, D, E, F, G, H, K. Within each group, numbers were assigned to the edifices (Hardy *et al.* 2009). Figure 1 shows a schematic map of the site and an image of one of the temples. Most of the temples were made of red bricks, generally fired at low temperatures (less than 850°C). However, the mortar/binder used to join the bricks has almost completely degraded and is mostly not visible today, although remains of the mortar are found as greyish/dark residues (Table 1). Nevertheless, the towers and the temples have remained stable, creating one of the most fascinating "mysteries" of the site. Among the hypotheses around the materials used as binding agents in the mortar of the bricks, a vegetable resin probably from

Figure 1. A schematic map of the Mỹ Sơn site and an image of one of the temples.

an autochthonous plant of the Dipterocarpaceae family (*Dipterocarpus alatus*) seemed to be the most reasonable option. This kind of resin is still used today and it is called dầu rái. Its main modern uses are wood lacquering, water-proofing of boats and traditional medicine. Some chemical analyses, mainly FTIR, seemed to support the hypothesis that dầu rái resin was used in the bricks' mortar, most likely to increase the adhesive properties of the material (Hardy *et al.* 2009). Dark residues are sometimes present on the surface of the bricks as well, suggesting that a coating material was applied.

Natural resins are produced by many varieties of plants. From a chemical point of view, plant resins are a complex mixture of mono-, sesqui-, di- and triterpenes, which have respectively 10, 15, 20, and 30 carbon atoms per molecule. The mono- and sesquiterpenes are both present in most resins. The di- and triterpenes are rarely found together in the same resin, thus terpenic resins are divided into diterpenoid and triterpenoid resins (Scalarone and Chiantore 2009). The mono- and sesquiterpenoids are rarely found in ancient samples because of their high volatility, except when they have been

conserved in very particular conditions (Hamm *et al.* 2004). On the other hand, diterpenes and triterpenes are useful to identify the resins and sometimes assess their botanical origin (Evershed *et al.* 1997). Plant resins and resinous materials played a prominent role in ancient times, as their intrinsic properties meant that they were used as adhesives, hydro-repellents, coating and sealing agents (Charters *et al.* 1993; Pollard and Heron 1996; Ribechini *et al.* 2009; Robinson *et al.* 1987; Serpico and White 2000).

The Dipterocarpaceae family consists of 17 genera and nearly 500 species. All Dipterocarpaceae species produce the so-called triterpenoid resin "dammar" that has been traded for centuries and therefore had, and has nowadays, an important economic role in Southeast Asian countries (Burger *et al.* 2011; Burger *et al.* 2009; Lampert *et al.* 2002). Because of the chemical complexity of resinous materials especially in archaeological findings, analytical procedures for chemical analysis are normally based on chromatographic and mass spectrometric techniques (GC-MS, DE-MS, Py-GC-MS) (Burger *et al.* 2009; Evershed 2008; Lampert *et al.* 2003; Lluveras *et al.* 2009; Ribechini 2009).

In this work, microscopic observations of cross sections and GC-MS analyses were performed to investigate some samples of the organic materials used in the construction of the temples and buildings in the archaeological site of Mỹ Sơn (Vietnam). In particular, attention was focused on the possible presence of organic residues in the mortar used to join the bricks and in the plaster used to caulk them. The results of this investigation are presented in this article.

Materials and methods

Samples

A sample of dầu rái resin, supposed to be produced from *Dipterocarpus alatus* and used in conservation practices of the temples, was used as reference material and prepared as fresh resin produced locally from the plant.

Three fragments of mortar (samples G, G1 and G1a), four fragments of plaster (samples G1b, A1, A1a and E7) and a whole brick were collected from various Mỹ Son temples and samples taken from these were analysed for possible organic residues. The fragments were *ca.* 2 cm in length. The dimensions of the brick were *ca.* 25 cm length, *ca.* 10 cm width and *ca.* 8 cm height (Table 1). The samples are named with the same identification letters that are assigned to the Temple groups, thus corresponding to the building they were taken from (A, E and G). Table 1 contains the sample descriptions. All of the samples showed some greyish/dark residues on the surfaces.

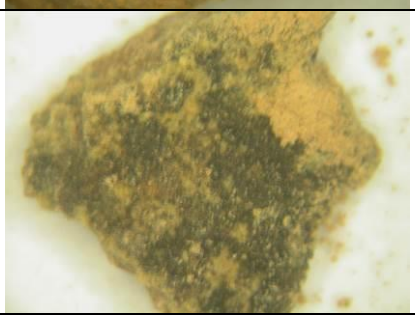
Microscopic investigations

Cross sections were prepared by embedding fragments of samples A1, A1a, G1a, G1b and E7 in an epoxy resin. The polished cross sections were observed using an Olympus System Metallurgical Microscope BX51M coupled with an Olympus Reflected Fluorescence System U-RFL-T.

Analytical GC-MS procedure and instrumentation

From all samples, *ca.* 2 mg of the superficial layers (dark or greyish areas) were sampled and subjected to an analytical procedure for the analysis of lipids, waxes and resinous materials by GC-MS (Lluveras *et al.* 2009). Samples were subjected to saponification by adding 400 μL KOH/MeOH (10% w/w) and 600 μL H_2O and putting them in a water bath at 60°C for 3 h. Neutral organic components were extracted with n-hexane (3 × 200 μL) and, after acidification with trifluoroacetic acid, the acidic organic components were extracted from the residual solution with diethyl ether (3 × 200 μL). The extracts were combined and an aliquot for each sample was derivatised with N,O-Bis(trimethyl)-silyl-trifluoroacetamide (BSTFA) containing 1% trimethylchlorosilane (TMCS), using isooctane as a solvent. 2μl were analysed by GC-MS using hexadecane and tridecanoic acid as internal standards.

The analyses were performed using a gas chromatograph 6890N GC System (Agilent Technologies, Palo Alto, CA, USA) coupled on-line with a 5975 Mass Selective Detector (Agilent Technologies, Palo Alto, CA, USA) single quadrupole mass spectrometer equipped with PTV injector (split/splitless mode, 280°C). The MS transfer line temperature was 280°C; the MS ion source temperature was kept at 230°C and the MS quadrupole temperature was 150°C. For the gas chromatographic separation, a HP-5MS fused silica capillary column (5% diphenyl/95% dimethyl-polysiloxane, 30 m x 0.25 mm i.d., 0.25 mm film thickness (J&W Scientific, Agilent Technologies, Palo Alto, CA)) with a deactivated silica precolumn (2 m x 0.32 mm i.d. (J&W Scientific Agilent Technologies, Palo Alto, CA)) was used. The carrier gas was used in the constant flow mode (He, purity 99.995%) at 1.2 mL/min. The chromatographic oven was programmed as follows: initial temperature 80°C, isothermal for 2 min; 10°C/min up to 200°C, and

Sample name	Brief description	Image
R	*Ca.* 5 g of fresh natural resin used for restoration (dầu rái resin from *Dipterocarpus alatus*)	
G	Sample taken on 22.01.2011 from the G Group: it is from the mortar between two bricks	
G1	Sample taken on 21.04.2011 from the G Group: it is from the mortar of G1 *cella*	
G1a	Sample taken on 21.04.2011 from the G Group: it is from the mortar of the entrance of G1 *cella*	
G1b	Sample taken in June 2013 from the G group: it is the plaster of G1 *cella*	
A1	Sample taken on 21.04.2011 from the A1 *cella*: it is the plaster on the bricks	

A1a	Sample taken on 22.04.2011 from the A1 architectural stone block: plaster	
E7	Sample taken in June 2013: plaster	
Brick	Whole brick dated back to 12th century. A sample was taken from the surface, corresponding to the plaster.	

Table 1. List of the samples analysed.

isothermal for 3 min; 10°C/min up to 280°C, and isothermal for 30 min.

Results

Microscopy

The making of the cross sections was sometimes difficult, as the bricks and mortar had porous and fragile structures. Figure 2 shows some images obtained from sample G1a, corresponding to a mortar sample. Some very faint fluorescence was observed under the UV light at the edge of the sample, but the material mostly appeared relatively homogeneous.

Figure 3 shows some images at different magnifications obtained from the cross section of sample A1, corresponding to a plaster sample. In this case, multiple layers were applied on the brick.

The exact number is difficult to ascertain from these images, but at least three layers were visible on the left hand side of the cross section. Under UV illumination, the middle layer produced an intense yellow fluorescence, which was a clear indication of the presence of organic material. Nevertheless, natural resins usually produce a yellow-greenish fluorescence, thus the results suggested that some other organic material was likely to be present.

Figure 4 shows some images obtained for sample G1b. This sample also had multiple layers and at least three were noticed. The whitish top layer on the surface revealed a greenish fluorescence when exposed to UV light. Another slightly fluorescent layer seemed to be present under the surface, showing that the organic material might have been applied in more than one step.

Figure 5 shows the images of the cross section of sample E7. Although the quality of the cross section was not as good as the previous three, due to the porosity of the structure, also in this case a slightly fluorescent superficial layer was visible under UV light.

The remaining four polished samples did not show specific stratigraphy or fluorescence. However, these results suggested that the mortar and plaster were applied differently on the surface of the bricks, the former as a relatively homogeneous paste and the latter in layers.

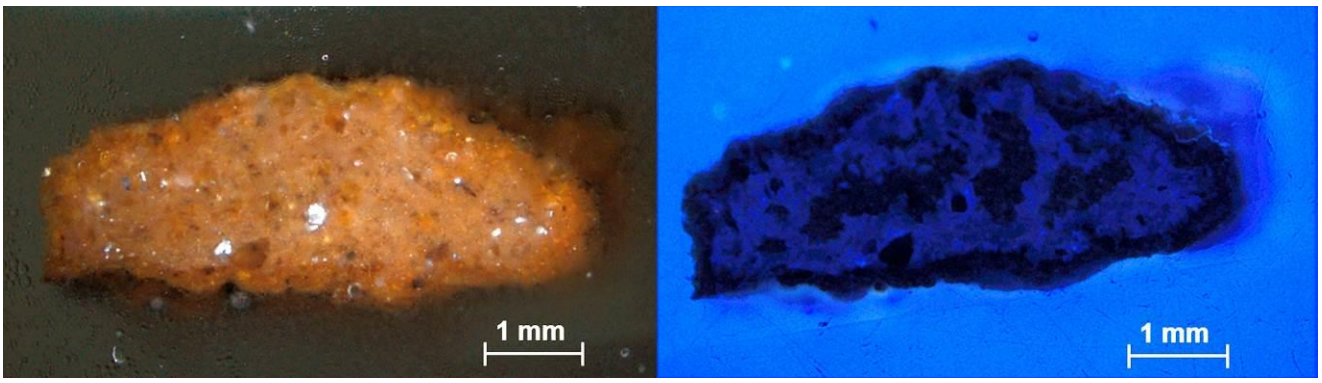


Figure 2. Cross section images of sample G1a. Left: dark field, magnification 5x; right: UV light showing very faint fluorescence, magnification x5.

GC-MS analysis

GC-MS analysis of the fresh resin sample used as a reference material showed a chromatographic profile typical of a dammar-like triterpenoid resin (Figure 6). The freshness of the resin was evident as sesquiterpenes were present with high relative abundances at low retention times. Triterpenes with dammarane, ursane and oleanane structures were identified at high retention times. The occurrence of dammarane, oleanane and ursane derivatives is a typical feature of dammar. In addition, the absence of monoterpenoids is described in the literature as a feature common to all Asian Dipterocarpaceae resins, thus in agreement with the provenance of the material (Burger *et al.* 2011).

The samples from group G (samples G, G1, G1a and G1b) were three mortars and one plaster sample. Figure 7 reports the chromatogram obtained for sample G, corresponding to a mortar sample. The results showed a high abundance of carboxylic acids, in particular monocarboxylic acids, dicarboxylic acids and hydroxycarboxylic acids. Triterpenoid compounds were also present in the chromatogram, in particular dammaradienone, 20, 24-epoxy-25-

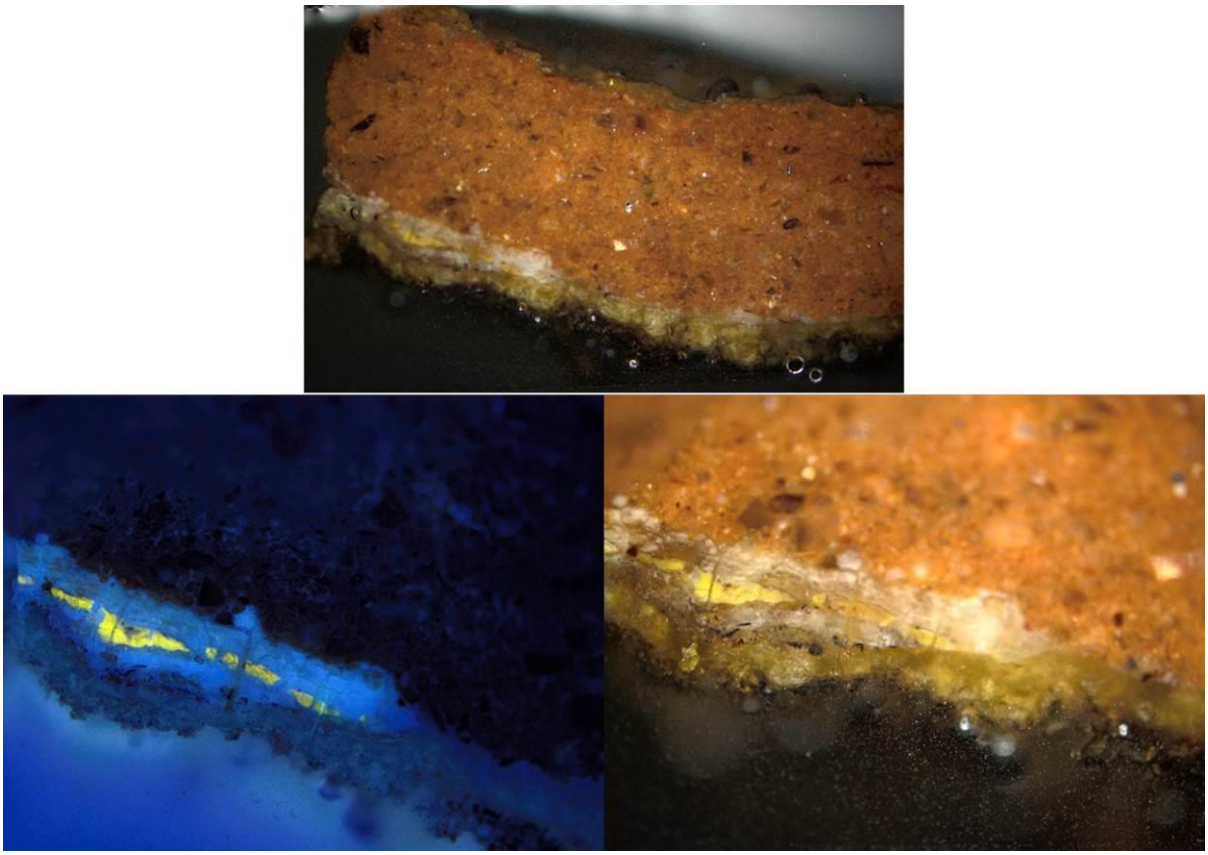


Figure 3. Cross section images of sample A1. At the top: dark field, magnification x5; bottom left: UV light showing yellow fluorescence of organic material in the surface layer, magnification x10; bottom right: same area, dark field, magnification x10.

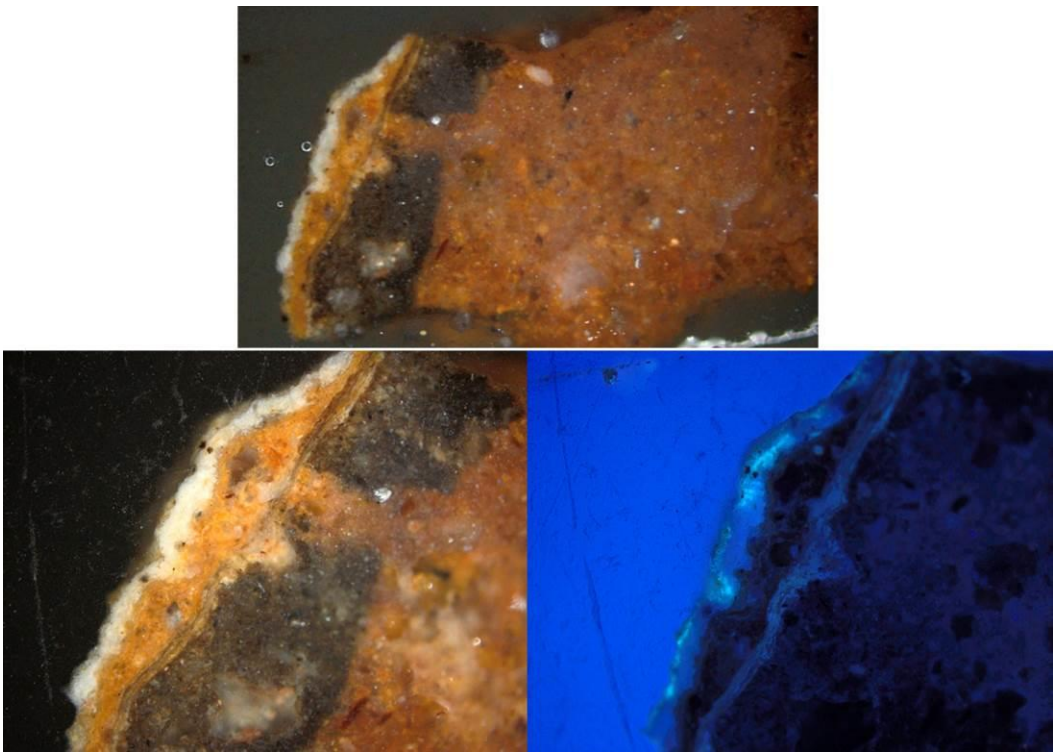


Figure 4. Cross section images of sample G1b. At the top: dark field, magnification x5; bottom right: UV light showing light-coloured fluorescence in the surface layer, magnification x10; bottom right: dark field, magnification x10.

hydroxy-dammaren-3-one, hydroxydammarenone and two unidentified triterpenoid compounds, which were also present in the reference resin sample.

Therefore, the results showed that a triterpenoid resin was present in this sample. It was not possible to ascertain if the resin was exactly the same as the reference, due to the degradation phenomena that has occurred, which resulted in a different profile of triterpenes. Nevertheless, the resinous material was definitely obtained from a tree belonging to the Dipterocarpaceae family. Furthermore, the results also highlighted that a lipid fraction was predominant in the sample. In addition to palmitic and stearic acid, aliphatic long-chain α,ω-dicarboxylic acids and ω-hydroxycarboxylic acids with dominant chain-lengths 16, 18, and 22 carbon atoms were present with significant relative abundance. These compounds are typically present in the bark of trees (Orsini *et al.* 2015; Ribechini *et al.* 2015), thus indicating that the resin was not the only organic material added to the mortar mixture. Identical results were obtained for sample G1a, also corresponding to a mortar sample

Sample G1, on the contrary, showed some differences in the chromatographic profile. Figure 8 shows the chromatographic profile of sample G1. Despite some qualitative differences in the relative abundances of the compounds, a similar lipid fraction was present in this sample compared to sample G and G1a, but no other compounds were identified. Therefore, the triterpenoid resin was not present in this sample. Very similar results were obtained for sample G1b, which corresponded to a plaster sample.

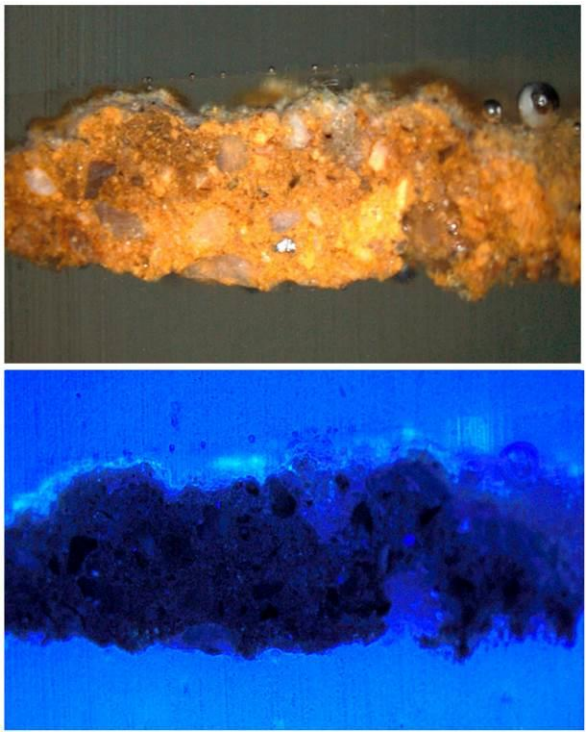


Figure 5. Cross section images for sample E7. Top: dark field, magnification x5; bottom: UV light showing faint fluorescence in the surface layer, magnification x5.

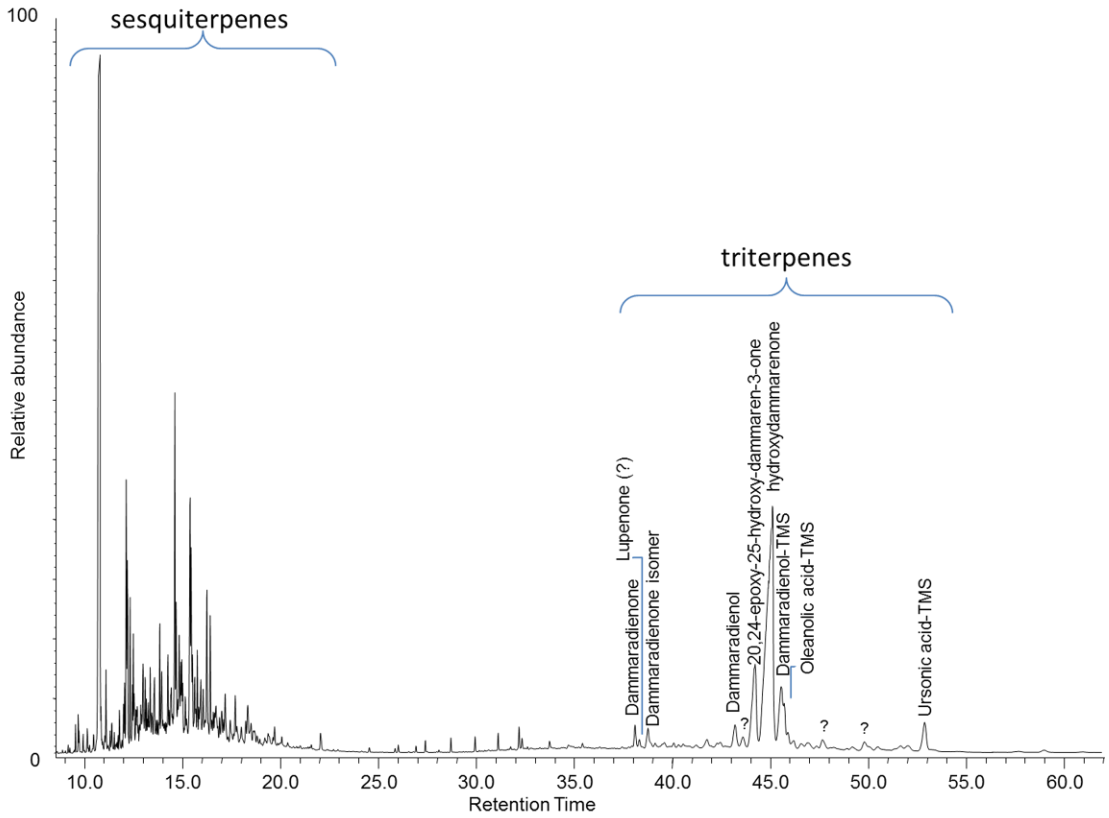


Figure 6. Total ion chromatogram (TIC) obtained by GC/MS analysis of the fresh resin showing characteristic compounds of Dipterocarpus alatus resin.

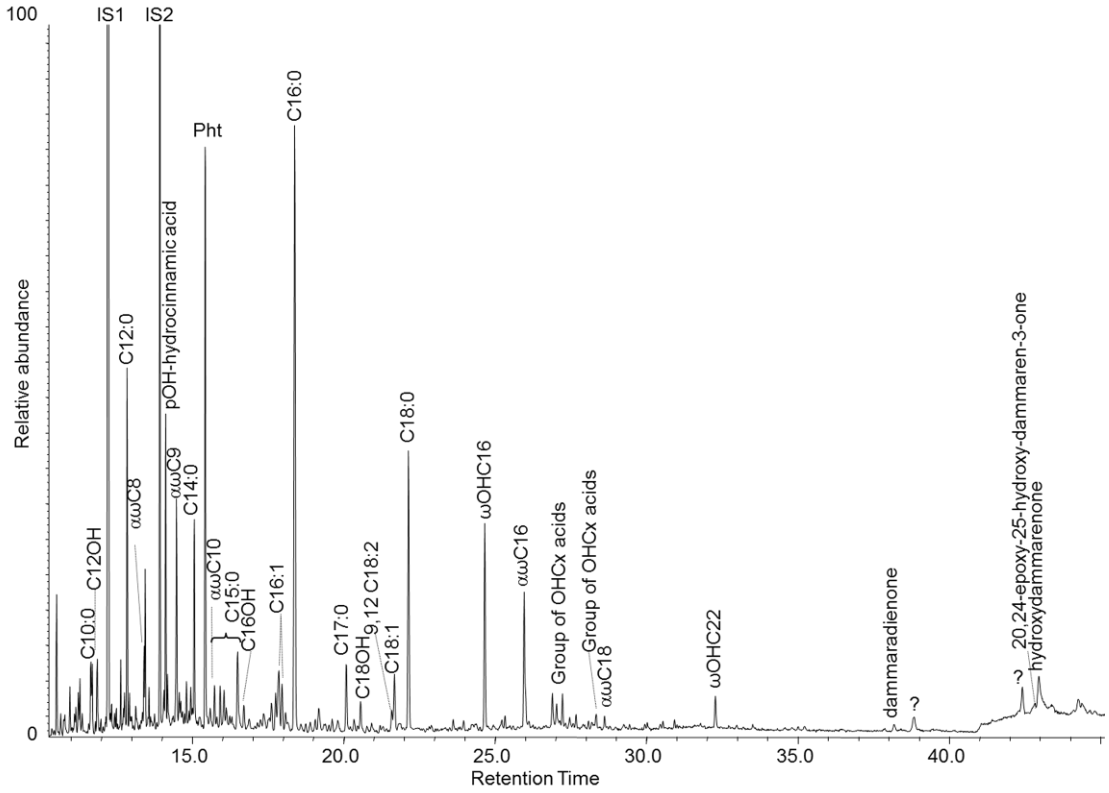


Figure 7. TIC obtained by GC-MS analysis of sample G (Internal standards: IS_1 = hexadecane, IS_2 = tridecanoic acid; Pht = phthalate present as contamination). The acidic and alcoholic moieties are present as TMS-derivatives. Cx:y: linear monocarboxylic acid with x carbon atoms and y unsaturations; CxOH: linear alcohol with x carbon atoms; αωCx: dicarboxylic acid with x carbon atoms; ωOHCx: ω-hydroxyacid with x carbon atoms.

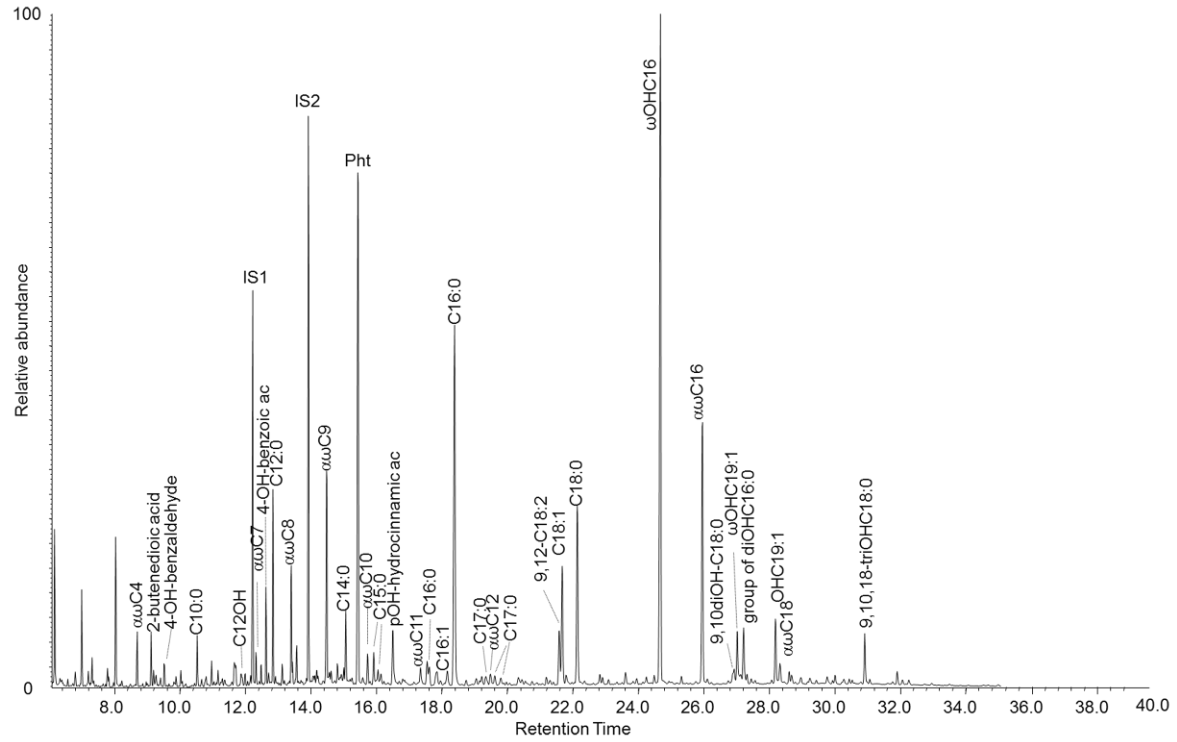


Figure 8. TIC obtained by GC-MS analysis of sample G1 (Internal standards: IS_1 = hexadecane, IS_2 = tridecanoic acid; Pht = phthalate present as contamination). The absence of triterpenoid compounds is highlighted. For the legend, see Figure 7.

The samples from the A group (samples A1 and A1a) were both taken from plasters. They showed a similar composition to each other and the chromatographic profiles revealed high abundances of saturated and unsaturated monocarboxylic acids, dicarboxylic acids and hydroxycarboxylic acids, as shown in Figure 9. With respect to the samples from the G group, a higher abundance of unsaturated and isomerised compounds was highlighted. The formation of unsaturations and isomerisation are sometimes indications of thermal treatments, thus the tree bark might have been exposed to high temperatures in these cases. Also for these samples, no traces of resin were found.

A general lower amount of organic material was detected in sample E7 (plaster) compared to the other samples, but the composition of the lipid fraction was again very similar (Figure 10). Triterpenes derived from the resin were not found. On the other hand, 4-hydroxybenzoic acid, 4-hydroxyhydrocinnamic acid, cinnamic acid, vanillic acid and ferulic acid were all detected with significant relative abundance. These aromatic compounds were generally detected in all samples and are commonly found in tree extracts. Therefore, they confirmed again the vegetable origin of the material. Nevertheless, monocarboxylic acids with odd-number carbon atoms were generally detected in all the samples. In particular, pentadecanoic, heptadecanoic and nonadecanoic acids were present, as well as their ramified and unsaturated forms in some cases. These compounds are generally ascribed to the presence of fats of animal origin (Evershed *et al.* 2002), but they can easily be the result of contamination from the burial site or the environment. In addition, minor amounts of moieties with odd-number carbon atoms have been identified in suberin from various species of plants (Ribechini *et al.* 2015). Therefore, the results concerning the possible presence of some animal-derived material in the samples are not conclusive

Finally, a further confirmation of the results was also obtained for the material found on the brick surface (Figure 11), which showed again a similar composition to the other plaster samples.

Conclusions

The microscopic observations and GC-MS analyses performed on the samples from Mỹ Sơn temples confirmed that organic materials were used in the formulation of the plaster and mortar of the bricks during the Champa kingdom.

The observation of the polished cross sections highlighted that the plaster was usually applied in thin layers, whereas the mortar was composed of a relatively homogeneous mixture of materials. The UV light produced fluorescence in most samples, ranging from bright yellow colours to faint green

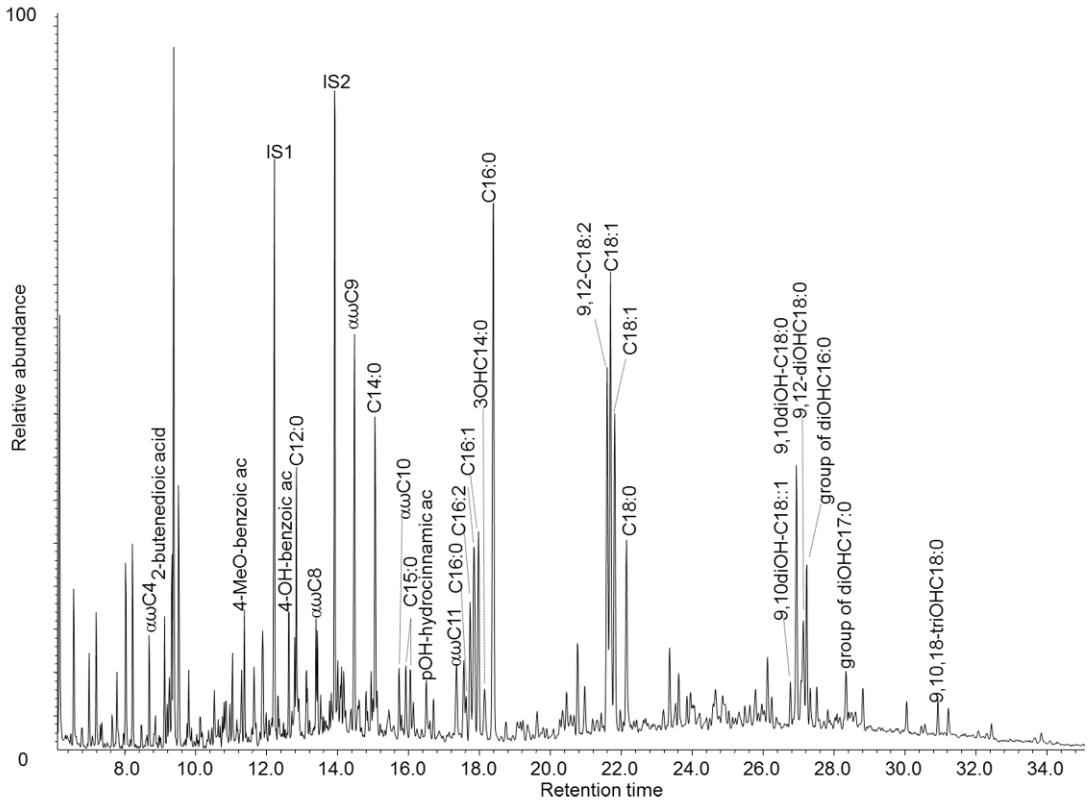


Figure 9. TIC obtained by GC-MS analysis of sample A1 (Internal standards: IS_1 = hexadecane, IS_2 = tridecanoic acid; Pht = phthalate present as contamination). In addition to the compounds detected for all the samples, a high abundance of unsaturated and isomeric compounds is highlighted. For the legend, see Figure 7.

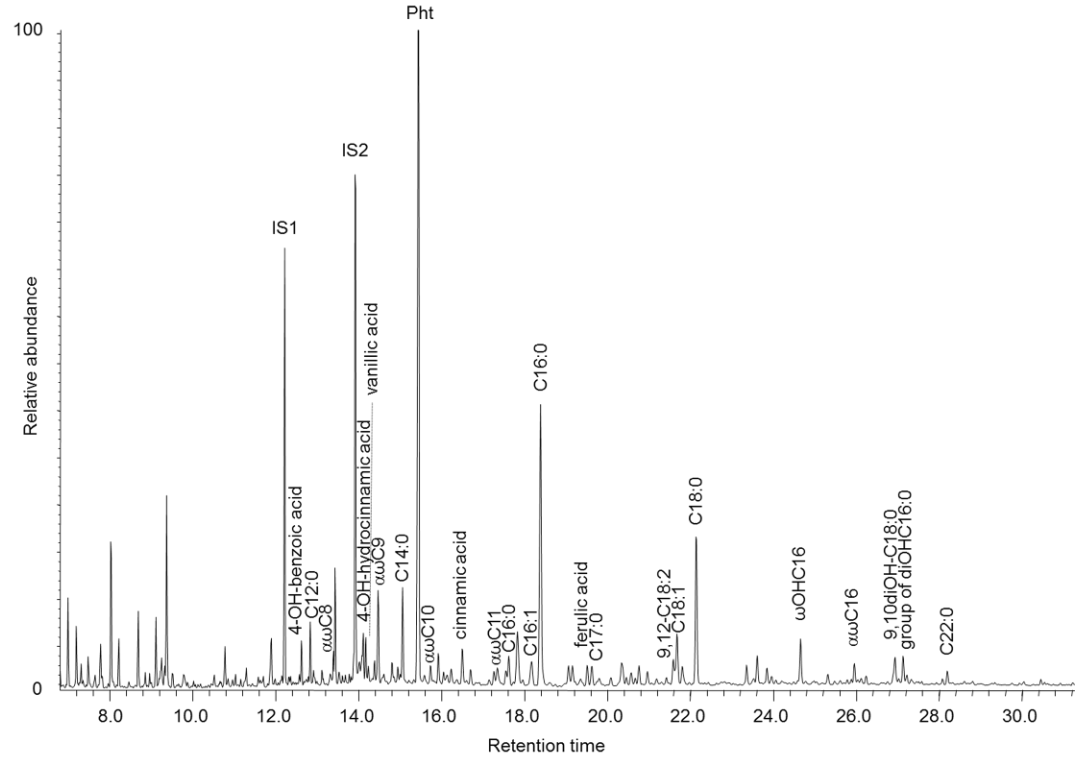


Figure 10. TIC obtained by GC-MS analysis of sample E7 (Internal standards: IS_1 = hexadecane, IS_2 = tridecanoic acid; Pht = phthalate present as contamination). A general low abundance of organic material is noticed. For the legend, see Figure 7.

shadows, indicating the presence of organic materials.

Some indications for the use of a dammar-like resin produced from a tree belonging to the Dipterocarpaceae family were obtained for two out of the three mortar samples (G and G1a). The comparison between the results obtained for the archaeological samples and those obtained for a fresh local resin produced from the plant *Dipterocarpus Alatus* did not allow us to ascertain the botanical source of the resin, mainly because of the degradation of the archaeological resin. Nevertheless, the same triterpenoid compounds, such as dammaradienone, 20,24-epoxy-25-hydroxy-dammaren-3-one and hydroxydammarenone, were detected in both the archaeological and the fresh resin, suggesting that the origin might be the same or closely related.

More interestingly, none of the plaster samples showed the presence of the resin, but all of them revealed a lipid fraction consisting of long-chain aliphatic monocarboxylic acids (saturated and unsaturated), dicarboxylic acids, and highly oxidised carboxylic acids, such as hydroxy- and dihydroxycarboxylic acids. Although some differences in the relative abundances, the distribution and nature of these molecules indicated the presence of suberin, which is a major component of tree bark. The presence of isomeric and unsaturated carboxylic acids with high relative abundances suggested that the material might have been submitted to vigorous thermal treatments (pyrolysis regime). In addition to the lipid fraction, most samples also contained aromatic acids such as ferulic, hydroxybenzoic, vanillic, cinnamic, caffeic acids, thus confirming the hypothesis of a plant origin for the organic material.

Considering the different functions of a plaster and a mortar – coating and adhesive material, respectively – it may be hypothesised that a tree bark-derived material was used in both the construction elements, whereas the resin was added only to the mortar, probably to increase its adhesive properties. The addition of thermally-processed bark might have increased the waterproofing and isolating properties of the plaster, in a similar way to the use of pitch on wood surfaces. The quantitative differences observed among the various samples might be due both to different production parameters (temperature and duration of the thermal treatments) used to process the bark, and to different plant sources possibly employed. Moreover, the possibility that several plants could be used at the same time should not be excluded. There is also evidence that resin extraction from some trees in South-East Asia is performed by firing the trunks of the trees. A similar process might

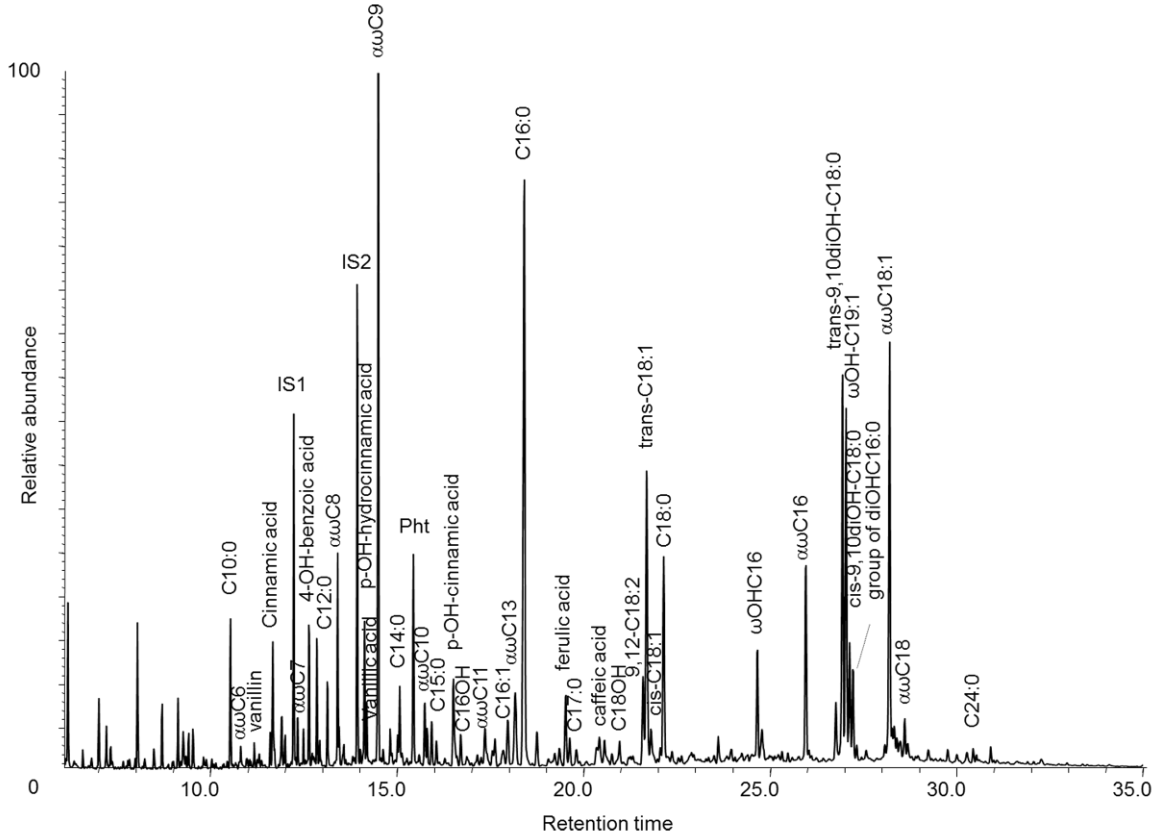


Figure 11. TIC obtained by GC-MS analysis of the surface of the brick (Internal standards: IS_1 = hexadecane, IS_2 = tridecanoic acid; Pht = phthalate present as contamination). For the legend, see Figure 7.

have been used by Champa people to produce a sticky material to apply on the bricks used in the construction of the Mỹ Sơn temples.

At the moment it is not possible to state the botanical source from which the "glue" was obtained and the transformations deliberately induced by man before the use of the material, but these results shed light on the actual composition of the organic adhesive, which was not just made of resin but in many cases of a composite mixture of ingredients including tree bark compounds in many cases.

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A POTTED HISTORY OF THE CERAMIC PETROLOGY GROUP

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The Ceramic Petrology Group or CPG was founded in March 1988 by several British academic and museum researchers using thin section petrology to analyse ancient ceramics. These included Ann Woods of University Leicester, Ian Freestone and Andrew Middleton of the British Museum, Peter Wardle from the University of Bradford and Ian Whitbread from the University of Southampton.

Ceramic petrology had grown in popularity since its initial application in Britain by David Peacock, Henry Hodges and others, with PhD projects being initiated at several departments during the 1970s. In response to this, the British Museum appointed its first petrographer (Ian Freestone) in 1979, followed by Andrew Middleton in 1984, and hosted two meetings dedicated to the approach in 1980 and 1987, which were published in key edited volumes Freestone *et al.* (1982) and Middleton and Freestone (1991). A natural next step was to form a group to bring together researchers applying ceramic petrology in order to share ideas and experience.

A steering committee met on 4 March 1988 at the University of Leicester to initiate and direct the activities of the newly formed group. It was decided to run the group for an initial trial period of two years. An important component was the production of a group newsletter, to include news, a report of relevant meetings and small research articles. CPG Newsletter No 1 from 1988 featured an article on the mineral staurolite, written by Ian Freestone and one on computer-aided data collection from ceramic thin sections by Ian Whitbread. The latter is a topic that is still being grappled with by researchers, nearly 30 years later.

In July 1988, an inaugural one-day CPG meeting took place at Leicester University. This was hosted by Ann Woods and cost £5 for CPG members and £2 for non-members. A second meeting took place in December the same year, at Sheffield University. This featured a microscopy session where participants examined glauconite inclusions in ceramic thin sections. Similar workshops on specific microscopic features took place at future CPG meetings, and covered carbonates (British Museum 1989) and lithic inclusions (Leicester 1990). These sessions were important given that very few courses on ceramic petrography existed at the time. They were summarised in CPG newsletters for those who could not make the meeting.

A themed CPG meeting was held at University Southampton in November 1989 by David Peacock and David Williams, focusing on amphorae. In addition to several talks on the petrology of this important vessel type by the two Davids and Roberta Tomber, then of the Museum of London, Southampton's extensive collection of amphorae slides was also shared with participants. Southampton was a leading centre for the scientific study of ceramics in the 1980s and 1990s, due to a succession of research students that included Ian Whitbread, Peter Day, Alan Vince, Roberta Tomber, Hilary Howard, Elaine Morris, and Tim Darvill.

Two years on from its inception, it was decided that the CPG had indeed been a good idea and should therefore continue. In CPG Newsletter No. 4 Ian Freestone reported that the fledgling group had been criticised for its lack of a detailed policy statement. In response, he pointed out that this avoided excessive paperwork. The rather loose and informal character of the group remains to this day and is one of its endearing features.

The idea of putting out a joint newsletter with the Experimental Firing Group and the Later Prehistoric Ceramics Research Group was put forward at a CPG meeting in Cambridge in 1991. The justification was that these UK-based special interest groups had many overlapping members with the CPG. The rather quirky title of 'The Old Potter's Almanack'

was suggested by Sue Pringle at a wine reception and 'OPA' Volume 1 appeared in March 1993.

At the Museum of London CPG meeting in 1992, a new steering committee was elected, consisting of Ian Freestone as Chairman, Susan Pringle as Secretary, Andrew Middleton as Treasurer, Anne Woods as Publications Officer and Peter Day and Roberta Tomber as Committee members. The Museum of London meeting was the only get-together in 1992, with a move towards annual meetings only in future years. Throughout the eighties and nineties, members of the steering committee would meet informally at Indian restaurant the 'Neal Akesh' on Hanway Street, which was then located just behind the corner of Oxford Street and Tottenham Court Road. The London meeting place was convenient for visitors from the British School at Athens (Ian Whitbread, Louise Joyner and Peter Day) and from further afield such as Rob Mason from Toronto and K. Krishnan from Baroda, India and committee meetings were sometimes timed to coincide with their visits. Policy decisions could be made over a vegetarian thali and a pint of Cobra before retiring to the BM labs to look at any novel or problematic thin sections that members had brought with them.

At the 1995 meeting, John Cooper of the Natural History Museum, London presented on the identification of shell in thin section and kindly wrote this up for publication in OPA 2(3).

The following year witnessed several developments for the CPG. Email address appeared for the first time in the OPA as this new technology started to be embraced by many members. Contributors were encouraged to submit their papers as a 'word processor file' on a 'floppy disk' (an early type of portable electronic storage device). Some members complained that computers were going to take over the world and replace ceramic petrographers. The floppy disk came and went and the petrographer still remains.

The idea of the CPG and the Prehistoric Ceramics Research Group (PCRG) producing a joint research framework was mooted in 1996. The PCRG published its own, but the CPG does not seem to have been included in this. At the 1996 CPG meeting at the British Museum several changes were made to the CPG committee with Louise Joyner, Sarah Vaughan and Alan Vince being elected. The meeting was attended by Patrick Quinn, a fresh-faced researcher from the University of Sheffield, who presented his initial findings on the occurrence and research potential of microfossils in archaeological ceramics.

In its heyday, the OPA appeared as many as three times a year, but with shorter issues than today. It received an International Standard Serial Number (ISSN) in 1999 and copies were deposited in the British Library. At the Museum of London meeting in that year, Andrew Middleton, who had organised printing and distribution of the newsletters since their inception (including filling envelopes and licking stamps!), committed to editing the newsletter for one more year. To keep Andrew replete with paper and floppy discs the cost of subscription went up from £5 to £7.50, the first increase in the CPG's history at that point! The Museum of London meeting in 1999 was attended by present OPA editor Michela Spataro, who had then began her research on south and south-eastern Neolithic European ceramics.

On the committee front, Roberta Tomber acted as CPG secretary between 1995-1999 and Chris Doherty was treasurer from 1997-1999. Ian Freestone stood down as long-standing chair of the group at the 1998 meeting at the British Museum and was replaced by Peter Day, who was not quite as long standing. Ian became a lowly committee member as did Elaine Morris of University of Southampton.

Abstracts of past CPG meetings appeared in the OPA from 1999, but did not remain a permanent feature. The research article was front-loaded in the 2000 volume at the expense of news and other announcements, thus signalling the OPA as a more serious publication compared to the casual newsletter that it started out as. The group caught up with the modern world in 2001 by setting up its own website. This was painstakingly programmed by hand in HTML by Alan Vince and housed on his own server. It featured a fancy rotating GIF logo, which was *de-rigueur* around the turn of the century/millennium. Alan had taken over from Peter Day by this time and Carl Knappet of the University of Cambridge was on the committee.

Despite embracing technology, the 21st century appeared to leave the CPG behind somewhat. The excitement surrounding ceramic petrography as the solution to the world's problems in the 80s and 90s had waned somewhat. The 2004 OPA was dominated by activity of the Prehistoric Ceramics Research Group (PCRG) with little reference to the CPG.

Meetings nevertheless took place in 2002 at the British Museum and Leicester in 2003. The 2002 PCRG conference at Bradford on 'Prehistoric

Pottery: People, Patterns and Purpose' was organised jointly by the CPG, though the 2004 follow up was a PCRG only affair. Group activity then ground to a halt for the next four years as Ian Freestone, Louise Joyner and then Andrew Middleton left the British Museum and Alan Vince became an independent archaeological consultant with less time on his hands.

Thankfully interest in ceramics and their analysis was reawakened with a realisation of the value of analytical data as a means of addressing topics beyond trade and exchange, which had been the main focus in the 80s and 90s. This led to new appointments at several UK institutions.

The 2008 meeting on 'Petrography of Archaeological Materials' at University of Sheffield captured this new wave, with participants from the UK, mainland Europe and North America presenting over three days. A volume inspired by the meeting, the first since 1990, appeared a year later (Quinn 2009).

The Sheffield workshop was supported by residual funds of the then dormant CPG and it hosted the first AGM for many years. The injection of new and enthusiastic researchers including Michela Spataro of the British Museum (OPA Editor), Alice Hunt from University College London (Secretary) and Edward Faber of University of Sheffield (Committee Member), alongside post-hiatus CPG stalwarts such as Caroline Cartwright (Treasurer) and Roberta Tomber (Committee Member) led to the reemergence of the group.

Annual meetings followed in 2009 (University College London), 2010 (Nottingham) and 2011 (Leicester). The OPA was also relaunched, with Michela Spataro handling editorial duties. She brought the publication up to date with colour figures and the use of pdfs that were emailed to members rather than posted.

Alan Vince sadly died in 2009. An obituary appeared in the 2010 OPA 15(1) to commemorate his contribution to the field. With his passing the CPG website also died, though it had always been difficult to find the resources to keep it updated. Several failed attempts were made to come up with a solution in the late noughties.

Roberta Tomber was acting President between 1999 and 2012 and presided over the change to non-subscription membership. In 2012 she was replaced by Louise Joyner, despite Louise having left archaeology for some years at that point! At the British Museum meeting in 2013, a committee of just two elected Ian Whitbread as President and Patrick Quinn as Secretary. It was decided to use the social media platform 'Facebook' as a means of communicating with group members and to serve as a sort of website and bulletin board.

With the launch of the Facebook page the CPG was able to reach and connect petrographers and ceramic analysts in all corners of the globe, keeping them up to date with the latest meetings and goings on. Membership fees were rarely collected at this point due to the use of pdf format for OPA issues, so were replaced by Facebook group membership, which rose to a high of 250. Email communication began to be used only for meeting announcements.

In 2013 Michela Spataro was offered the exciting opportunity of launching the OPA online on the website of the University of Heidelberg Library. This widened the distribution of the publication around the world. Nigel Meeks of the British Museum became production editor of the new online OPA.

The 2013 and 2014 CPG meetings at the British Museum and University College London were well attended by researchers from various parts of Europe including Italy, Germany, Spain, Greece, Belgium and Portugal. This signalled a tangible resurgence in the group and the popularity of ceramic analysis as a research tool. At both meetings Andrew Appleby from the Orkney Islands, Scotland entertained participants with his adventures in clay oven construction. A co-edited volume (Spataro and Tomber 2017) stemming from the 2013 meeting is now published as a Special Issue of the *Journal of Archaeological Science: Reports.*

Andrew Appleby was unable to convince members of the viability of a CPG meeting in Orkney, however the 2015 meeting did take place 'up north' in Durham UK, where Kamal Badreshany acted as host. This was followed in 2016 by the first ever non-UK meeting, organised by Natalia Donner and Dennis Braekmans at the University of Leiden, Holland. Taking CPG abroad was an obvious step with the increase in research activity in north-western Europe and Facebook membership around the world.

In 2017, some 28 years after its inception the Ceramic Petrology Group is thriving. Petrographic analysis is generally accepted as the primary analytical method for the study of the materials and technology of early pottery. The group has had to adapt with the times but has not lost its relevance as a means of tying together petrographers and ceramic analysts so that they can share research, information and skills.

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CONFERENCE REVIEW

Early High Technology Ceramics Meeting 27th April 2017, UCL Institute of Archaeology

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After a warm welcome and registration, Trinitat Pradell started the meeting by presenting the analysis of Jun wares by SEM and FIB with a particular focus on the role of nanostructures in areas of the glaze showing different colours and optical properties. Origins of colours and appearances were discussed in terms of chemistry and nanostructure. Scattering and absorption of light by different size nanoparticles and oxidation states of iron, titanium and copper give different colours. Differences between kilns were highlighted. The presentation ended with a question regarding how nanostructures influence the physical properties of fluids.

The next presentation was by Nigel Wood on SEM-EDS analyses of a life-sized lead-glazed *luohan* statue, found in a remote mountain cave in Yixian, China, and now in the possession of the State Hermitage in Saint Petersburg. He demonstrated a clear link with other statues from the cave and the Liuliqu kilns in Beijing which were already in operation in the 13th century and are still active today. The manufacturing technique was unusual as the life-size statues were hand-built and made on a structure of iron bars, much like those used in sculpting.

In the final lecture of the first session, Shan Huang described how transfer of knowledge and objects from Southern China to Northern China lead to a virtually 2-step evolution from the use of pure kaolinite clays with a greenish glazing, to colourless lead-glazing, finishing with colourless alkali glazing. Merging of technologies finally led to the birth of Chinese white porcelain.

The second session began with a presentation by Ian Freestone describing work carried out with Rita Gianinni on Qing dynasty enamelled porcelain. He explained that Chinese cobalt, which is high in manganese, gave a fine blue colour at higher temperatures (1300°C). However, at low temperatures (800°C) used for enamels, it turned to unwanted colours. Therefore, Chinese cobalt was used for blue underglaze, whereas European cobalt, which is low in manganese, was used for blue overglaze. European cobalt was first imported into China as smalt, followed by local porcelain production, after which much of the material found its way back into European markets.

Continuing with cobalt as a raw material, Moujan Matin characterised the cobalt pigments from the Kashan mines in Iran and compared preparation techniques described in Persian and Chinese texts. The data thus produced allows assessment of whether cobalt in glazes from the Islamic period came from Kashan or not. This concluded the morning session, which had provided a lot of stimulating ideas.

After the lunch break, Zahed Tajeddin started the afternoon session by presenting an ethno-archaeological study of faience beads from Iran. Following a general introduction on various production methods for faience, he showed how production technology was essentially unchanged since the Early Bronze Age, but that craftsmen had

recently changed to industrially produced raw materials. The element which had long been a trade-secret is dung which provides the chlorine needed to carry the cobalt to the surface. In addition, he also makes artworks in faience which were on display in the Manchester Museum until the 30th of June.

Continuing with the beads theme, Victoria Benson discussed a bracelet of glass beads from tomb 27 associated with the Harem palace in Gurob, originating from between the reigns of Amenhotep I and Tuthmosis III. The beads appeared to be Mesopotamian blue glasses (probably brought with one of the ladies of the Harem). A few quartz beads with a blue glazed surface layer, which were shown to be the same glass as the fully blue beads, were also part of the bracelet. An interesting discussion on the effect of the blue glass on the quartz ensued.

Marcos Martinón-Torres started the final session of the meeting with a presentation on a selection of gold-smelting crucibles from the colonial period in Colombia and showed that, apart from the known European crucibles used in Santa Cruz, there was an illegal gold market using local clays and crucible design. He encouraged further research on metalworking crucibles in the New World to understand why metallurgists from different places used crucibles imported from different locations in Europe and/or local crucibles.

The next presentation was given by Justine Bayley from the Historical Metallurgy Society and described the function and properties of ceramic crucibles for metallurgical use over a wide time scale. She illustrated the desirable refractory and mechanical features required, and special shapes of some crucibles depending on the hearth or furnace arrangements. Overall, the wide variety of crucibles that are found showed that in practice many shapes work and later domestic pots have also been used in metallurgy.

The final presentation was by Carlotta Gardner who described the trial and error process of reconstruction experiments which finally allowed her to produce a double layer ceramic test bar comparable to Roman metalworking crucibles which have an extra outer layer of a different clay. The tests showed an increased ductility and toughness at high temperature by the combination of two clay layers. The difficulty in obtaining a thermally functional 2-clay test bar illustrates the skill and knowledge of the Roman metalworkers in producing a practical solution for successfully handling molten metal.

This concluded a highly interesting meeting with excellent talks that stimulated discussion. We also appreciated how the different lectures followed a general narrative, with lectures on related subjects in each session.

In addition, the refreshment breaks also receive commendation as participants were well looked after during the entire day, and we look forward to attending the next meeting.

NEWS

Sixth release of FACEM
www.facem.at

December 6th 2016. It focuses on transport amphorae of the Bay of Naples, on the analyses of Italian terra sigillata and on pottery from Monte Iato in Sicily.

For more information about FACEM:

http://facem.at/project/about.php

CONFERENCE DIARY

Ceramic Petrology Group (CPG) Annual General Meeting
10 November 2017, UCL, Institute of Archaeology, 31-34 Gordon Square, London, UK

For more information:
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MetArh: Methodology and Archaeometry
30 November - 1 December 2017, University of Zagreb, HR

The scientific conference Methodology and Archaeometry is organised by the Department of Archaeology, Faculty of Humanities and Social Sciences of the University of Zagreb. The goal of the conference is to promote interdisciplinarity, critical thinking, new insights and approaches as well as new theoretical frameworks in contemporary archaeological science. Coverage of a wide spectrum of themes and scientific disciplines has resulted in papers and discussions that promote scientific issues in the fields of methodology, documentation and interpretation of archaeological data.

For more information:
http://www.ffzg.unizg.hr/metarh/

Restating Clay: making, learning, communicating & collecting contemporary studio ceramics
19-20 March 2018. Centre for Ceramic Art (CoCA), York Art Gallery, York, UK

This two-day international conference will bring together potters, artists, curators, academics, students, collectors, gallerists and enthusiasts from the UK and beyond, to share experience and knowledge about the issues that matter to the sector. An exciting and engaging programme of activities is being planned, including - discussions, object handling, demonstrations, talks, workshops, films, store and exhibition visits.

For more information:
https://www.centreofceramicart.org.uk/studio-ceramics-subject-specialist-network/conference-2018/

UISPP XVIII World Congress: International Union of Prehistoric and Protohistoric Sciences
3-9 June 2018, Paris

UISPP integrates all sciences related to prehistoric and protohistoric development, including archaeology, anthropology, palaeontology, geology, zoology, botany, environment, physics, chemistry, geography, history, numismatics, epigraphy and mathematics.

For more information:
http://www.uispp.org/

24th EAA Annual Meeting
5-8 September 2018, Barcelona

The Annual Meeting themes, as defined by the Scientific Committee, incorporate the diversity of EAA and the multidimensionality of archaeological practice, including archaeological interpretation, heritage management and politics of the past and present.

Topics include: theories and methods in archaeology; the archaeology of material culture, bodies and landscapes; Mediterranean seascapes; archaeology and the future of cities and urban landscapes; archaeology and the European Year of Cultural Heritage; museums and the challenges of archaeological heritage in 21st century.

For more information:
https://www.e-a-a.org/eaa2018

THE OLD POTTER'S ALMANACK

The Old Potter's Almanack is the joint letter of the Ceramic Petrology Group and the Prehistoric Ceramics Research Group. It is a venue for presenting current projects, research, reviews, information and topics of interest on all aspects of pottery, ceramics and refractory materials to the audience of scholars, experts, students, interested groups and individuals. The OPA is now published on-line with Heidelberg University and reaches a world-wide audience (see below for website link).

We welcome contributions focussing on any aspect of ceramics technology from any period, culture and geographic locality. Topics can cover materials from collections, museums, excavations and experimental work.

The deadline for copy of articles for the next issue of the OPA is 31st January 2018 (guidelines for contributors are available from the Editor). Copy and other information, news and events should be sent to the Editor, Michela Spataro (for details see below).

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