

## Movable Cultural Assets

### Pre-historic pottery technology and provenance in the upper Mondego valley (central/northern Portugal)

M. I. Dias, M. I. Prudêncio, M. A. Gouveia,  
A. Jorge<sup>1</sup>, A. C. Valera<sup>2</sup>, P. Day<sup>1</sup>, F. Rocha<sup>3</sup>, C. Capitão-Mor<sup>3</sup>

#### Objectives

This archaeometric study essentially comprises two research fields, one related with technological procedures during the manufacture process of making the pots, and other with its provenance. This kind of scientific approach (geochemistry and mineralogy) contributes to emphasis on continuities or innovations in ceramic production and on raw materials resources of populations through the third millennium BC in the upper Mondego basin at a local/regional scale.

#### Results

This project concerns the study of early ceramic technology and provenance from the Upper Mondego Basin (Central Portugal) comprising PhD Thesis in archaeology and graduation students. Three main methodological approaches were done to ceramics and potential raw materials (clays): neutron activation analysis (INAA), thin-section petrography and X-ray diffraction.

The proposed research allowed exploits the potential of an integrated, archaeologically contextualised, ceramic analytical study on prehistoric pottery from a region of Portugal. It involves pottery assemblages from 10 settlements: 3 from the Early Neolithic, 3 from the Late Neolithic, and 4 from the Chalcolithic to Early Bronze Age.

Such approach emphasises the combination of stylistic, macroscopic, micro-structural, mineralogical and chemical data concerning ceramics.

Some important issues achieved and/or under progress:

- 'cultural influences' and long-distance exchange: the social and cultural processes and mechanisms underlying Neolithisation, and the wide distribution of specific ceramic styles such as Beaker pottery during the Chalcolithic/Early Bronze Age transition;
- settlement, mobility and social boundaries: study of these issues on the basis of technological variability of pottery assemblages recovered from various domestic contexts;
- regional/local clays characterization: the mineralogical composition of the bulk sample, enhance dolerites as the most clayey samples, presenting the higher levels of iron oxides and pyroxenes. Clay fraction mineralogy shows that kaolinite is the most abundant phase in samples with granite affinity; dolerites have the greatest

mineralogical diversity with considerable amounts of smectite, chlorite and interstratified minerals. In chemical point of view clays derived by weathering of granite and dolerite can be respectively distinguished by their Na and K contents (alkali feldspar and plagioclase) and other elements with geochemical affinity to ferromagnesian minerals, such as Cr, Co, Sc and Fe (Figure 1). The weathered schist is detachable from the other materials by a much higher La/Yb ratio in both whole and clay fraction.

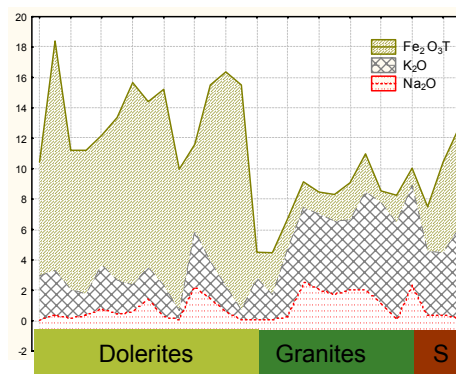


Fig. 1.  $\text{Fe}_2\text{O}_3$ ,  $\text{K}_2\text{O}$  and  $\text{Na}_2\text{O}$  distribution of regional clay materials

#### Published, accepted or in press work

1. M.I. Dias, A.C. Valera, M.I. Prudêncio. Pottery production technology through out the 3<sup>rd</sup> millennium B.C. on a local settlement network in Fornos de Algodres, central Portugal, *Proceedings of 7<sup>th</sup> European Meeting on Ancient Ceramics*, Lisboa, Portugal (in press)
2. J.P.M. Day, A.C. Valera, M.I. Dias, M.I. Prudêncio. Ceramics, style and exchange in the early Neolithic upper Mondego basin: a technological approach, *Proceedings of 7<sup>th</sup> European Meeting on Ancient Ceramics*, Lisboa, Portugal (in press)

<sup>1</sup>University of Sheffield – Department of Archaeology and Prehistory, England

<sup>2</sup>GAFAL archaeologist (C.M. F. Algodres), Portugal  
Era Arqueologia S.A. Portugal

<sup>3</sup>Departamento de Geociências da Universidade de Aveiro

## Movable Cultural Assets

### Chemical characterization of archaeological ceramics

#### ITN-IPA Protocol

M. I. Dias, M. I. Prudêncio, M. A. Gouveia, A. Gomes<sup>1</sup>, V.O. Jorge<sup>2</sup>, A. Carvalho<sup>3</sup>

### Objectives

The ITN-IPA protocol continues to play an important role in the national application of projects in the field of archaeometry research. This year seven projects regarding chemical characterization of ceramics from pre-history to modern times were approved. Each of those projects has specific objectives, but in general the main contribution of chemical characterization of ceramics regards production technology and provenance. So, an important contribution to a better establishment of main trade routes and regional impact of each site is presupposed, as well as, possible relationships, raw materials exploitation strategies and spatial vs chronological assessment of ceramic production.

### Results

Analytical data already obtained for projects from “Castanheiro do Vento. Vila Nova de Foz Côa” (pre-history), “Quinta das Longas. Elvas” (roman), and “Castelo de S. Jorge, Lisboa” (islamic), allowed the differentiation between local productions and imported ones.

Regarding “Castelo de S. Jorge” ceramics, it was settled the utilization of Lisbon kilns (near the castle, in R. Correeiros) to their production, mainly with two different types of raw materials. Also interesting was the differentiation of all the red painted ceramics from the others type of ceramics from the site, with similar chemical composition, pointing to an importation from the same production center.

The roman villa of Quinta das Longas (Elvas, Portugal) comprise an intense rural occupation in roman epoch, certainly directed to the provincial capital, *Augusta Emerita*. Besides ceramics, a notable marble sculpture collection was found. Important results enhance the importance of this site in privileged routes to products circulation during roman period, specially the amphorae ones, when compared with production centers of *Lusitania* and *Betica*.

Considering the suspicion that some of the materials – fine pottery – may have had an *emeritense* origin, together with the collaboration with Spain (Casa de Velázquez, National Museum of Roman Art of Merida and the Merida-Consortium, Historical, Artistic and Archaeological Ciudad Monumental), a set of fine

pottery originating from the production centres located in Merida was also selected for analysis.

Quinta das Longas ceramics present a chemical heterogeneity, as expected, pointing to different provenances of food products. However, a few groups may be defined, with a certain chemical similarity within them. Among the elements analysed, Rb, Cs, Th and REE are the ones that better discriminate groups. Chemical comparison between Qta. Longas ceramics and production centers (Fig. 1) shows: (1) A group of ceramics clearly presents chemical similarity with Tagus and particularly Sado estuaries production centers; (2) A few ceramics are related with Martinhal and Qta. Lago production centers of Algarve; (3) Two outliers are defined (Almagro 51C and common ware).

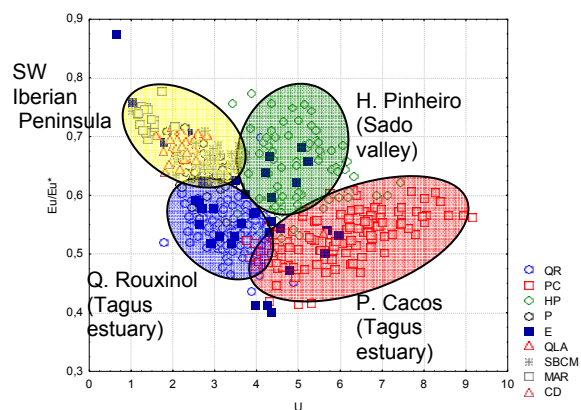


Fig. 1. Production centers of *Lusitania* and *Betica*. Q. Longas (E) ceramics provenance.

### Published, accepted or in press work

1. M.I. Dias, M.I. Prudêncio, F. Rocha, J. Albergaria, A. Jorge, A.C. Ramos, S. Melro, Barris ibéricos no SW peninsular. Resultados preliminares de um estudo arqueométrico. *O Arqueólogo Português* (in press).
2. M.I. Prudêncio, M.I. Dias, A.M. Arruda. Amphorae in Sellium (Portugal) from Ist century to Vth century – importation and regional production, *Proceedings of 7th European Meeting on Ancient Ceramics*, Lisboa, Portugal (in press).

<sup>1</sup> IPPAR

<sup>2</sup> Universidade do Porto

<sup>3</sup> Câmara Municipal de Cascais

## Non-Metallic Portuguese Resources

### Inventory, chemical and mineralogical characterization of clay materials

M. I. Dias, M. I. Prudêncio, M. A. Gouveia, M. J. Trindade, F. Rocha<sup>1</sup>

#### Objectives

This research aims to make an inventory of availability of potential raw materials for ceramic production in the southern and occidental Portuguese borders, followed by an evaluation of chemical and mineralogical transformations of clay materials of different nature, during ceramics production processes, and its implications on provenance and technological procedures studies of archaeological ceramics.

Specific Objectives:

- geochemical characterization of clay deposits from different origins
- mineralogical characterization of clay deposits from different origins
- clay fraction specific studies (chemical, mineralogical and technological)
- archaeological ceramic provenance based on non-metallic resources distribution patterns (applied to case studies)
- experimental studies simulating different technological procedures with different proportions of diverse raw material (physical-chemical properties according with temperature and atmosphere conditions reached upon heating process)

#### Results

This work is in course being part of a PhD thesis program.

Detailed field-work was carried out, including exhaustive sampling campaigns in geological formations of Algarve region (Fig.1). Chemical (INAA) and mineralogical (XRD) analysis were carried out.

Preliminary results already obtained clearly distinguish geological formations of different ages, and also the various levels of the same age. Different chemical and mineralogical composition was noted, like important variations in Ca, Mg and REE, which able to establish geochemical fingerprints for the main geological levels, specially the clayey ones, with more importance for ceramic production (Fig.2).



Fig. 1. Red clays (Jurassic) with a dolomite level.

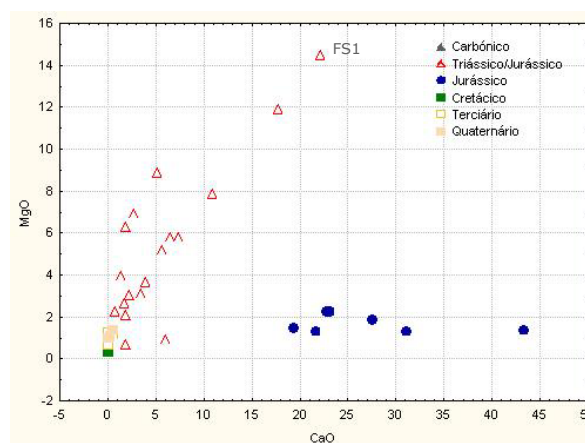


Fig. 2. CaO vs MgO plot of different clay materials from Algarve region.

#### Published, accepted or in press work

1. F. Oliveira, M.A. Sequeira Braga, M.I. Prudêncio, M. Delgado, M.A. Gouveia. The non vitrifiable red slip ware found in Braga (Northwest of Portugal). A mineralogical and chemical characterization., *7<sup>th</sup> European Meeting on Ancient Ceramics*, Lisboa, Portugal
2. M.I. Dias, J. Albergaria, A. Jorge, A.C. Ramos, S. Melro, M.I. Prudêncio, F. Rocha. Ceramic productions of Late Iron Age archaeological sites of the left bank of Guadiana river, Portugal, *7<sup>th</sup> European Meeting on Ancient Ceramics*, Lisboa, Portugal

<sup>1</sup>Universidade de Aveiro

## Immovable Cultural Assets Historical Buildings and Monuments

M. I. Prudêncio, J. C. Waerenborgh<sup>1</sup>, M. A. Gouveia, C. A. Alves<sup>2</sup>

### Objectives

Different types of anthropogenic pollution can contribute to the alteration/contamination and degradation of historical buildings and monuments. The evaluation of the prevailing degradation state of the stones, the identification of decay patterns, and the identification of different pollution sources, is the first step to the establishment of well-defined and scientifically based conservation strategies. This research has been supported by FCT.

### Results

The detailed characterization of the stone decay mechanisms, and the study of pathologies in the Church of Torre de Moncorvo and Braga historical buildings is an ongoing task.

The geochemical study of soils in the Évora region has proceeded to complement the evaluation of the *Sé de Évora* (Fig. 1) stones degradation.



Fig. 1. Sampling in the Sé de Évora (cloister).

A collaboration project with the University of Minho - Department of Earth Sciences, including a Masters Thesis (MSc), is in course concerning the effects of different pollution sources in the decay of igneous stone monuments of the north of Portugal, including the detailed study of the coatings of the monument stones and the chemical characterization of soils of the surrounding area of selected monuments, as well as a

detailed study of the particles found in monument façades in order to identify the main pollution sources.

In the frame of an investigation on Monument stone damage by fire, analyses of samples collected at Lisbon Cathedral Cloister (Fig. 2) and of limestones most likely used as the building materials was undertaken.



Fig. 2. Lisbon Cathedral Cloister

Chemical and mineralogical analyses, including clay mineralogy through X-Ray Diffraction (XRD) and Mössbauer spectroscopy, colour and porosity characterization were performed. This study suggested that the heat-induced colour modifications were mainly due to transformation of goethite into hematite and increase of hematite single crystalline domains. The temperature range at which Cathedral stones were submitted during the urban fire which occurred in the 18th Century was probably lower than 350°C.

### Published, accepted or in press work

1. A. Dionísio, M. Rodrigues, M.A. Sequeira Braga, H. André, J.C. Waerenborgh, D.P. Rojas, M.J. Basto, M.J. Matias, L. Aires-Barros, Study of heat induced colour modifications in monument limestones. *Lectures and Proceedings of the 6th International Symposium on the Conservation of Monuments in the Mediterranean Basin*, Lisbon, Portugal. Eds. L. Aires-Barros, F. Zezza, A. Dionísio, M. Rodrigues, (2004) 237-242

<sup>1</sup> Solid State Group of ITN

<sup>2</sup> University of Minho



## Absolute Dating - Radiocarbon Unit

A. M. Soares, M. I. Prudêncio, R. Marques

### Objectives

This absolute dating unit supports the Portuguese scientific community (archaeologists and Quaternary geologists) to solve chronological problems. Besides several samples from archaeological projects financed by the Portuguese Institute of Archaeology (ITN-IPA protocol), others were processed from marine cores and peat deposits. Also some samples were processed in a service basis.

It must be stressed that the approach to the scientific and the student communities continue through the “Ciência Viva” program, numerous visits to the laboratory from secondary schools and universities and also lectures in some universities.

During this year about one hundred samples of different kinds, such as bone, charcoal, wood, marine shells, peat and mud were dated. A new liquid scintillation spectrometer entered in operation in October, increasing in this way the capacity of processing samples of the laboratory.

### Results

More than 60 samples of different types (Fig. 1) were processed, namely as human and animal skeletal bones, coal, mud, wood, peat, shells (in majority) and water.



Fig. 1. Dated shells.

Dates were obtained in a large range, between 2760±80BP till present. The analysed samples were included in services for private and public entities and institutions, graduation and PhD thesis and in collaboration with other ITN group.

An important number of samples were done in the frame work of the ITN-IPA protocol, comprising projects of different archaeological sites and chronologies (pre-history, proto-history and medieval age).

Nine projects were approved under the ITN-IPA protocol for this year, covering a wide range of chronologies and sites all over Portugal. Selection of materials to be studied is in course.

### Published, accepted or in press work

1. A.M.M Soares, A.C Sousa, Cronologia Absoluta. In “São Julião. Núcleo C do Concheiro Pré-Histórico”. Mafra: Câmara Municipal (2004) 73-82.
2. J.L. Cardoso, A.M.M. Soares, F. Reiner, A. Guerreiro, C. Barradas, R Costa, C., Carvalho, O concheiro de Salamansa (ilha de São Vicente, arquipélago de Cabo Verde): nota preliminar. *Portugália, Nova Série*, **22** (2003/ 2004) 221-231.
3. A.M.M. Soares, M.F Araújo, L.C. Alves, Análise química não-destrutiva de artefactos em ouro pré e proto-históricos: alguns exemplos, *Revista Portuguesa de Arqueologia* **7(2)** (2004) 125-138.
4. A.M.M. Soares, Identificação e caracterização de eventos climáticos na costa portuguesa, entre o final do Plistocénico e os tempos históricos – o papel do Radiocarbono, in A.A. Tavares, M.J.F. Tavares, J.L. Cardoso, Eds., *Evolução Geohistórica do Litoral Português e Fenómenos Correlativos (Actas)*. Lisboa: Universidade Aberta (2004) 171-199.

## Absolute Dating - Luminescence Laboratory

M. I. Prudêncio, M.I. Dias, G. Cardoso

### Objectives

The optimization of the luminescence dating laboratory using various techniques and materials is a general objective.

The promotion of this dating technique in national and international communities (archaeologists and geologists) and the increasing of the laboratory output is a main goal.

The application of luminescence technique for dating various kinds of samples of archaeological contexts was a major objective, which has been also supported by Instituto Português de Arqueologia (IPA) within the protocol ITN-IPA, allowing the archaeologists to date sites of the Portuguese territory.

### Results

The calibration results were found to be good to excellent.

Important dates were obtained within the running projects/services, namely OSL results for:

- (a) timing of glaciations in the Pyrenees (Andorra) from glaciofluvial deposits, and
- (b) two archaeological sites from the Lower and Middle Palaeolithic located in Spain: Ambrona and Bajada.

A significant number of samples of different geological and archaeological contexts were prepared during this year.



Fig. 1. Risoe D-15 Luminescence Reader of the luminescence laboratory.

During 2004, the project - "Paleoenvironmental reconstruction using Chemical Analysis and Single-Grain Luminescence Dating. A non-biostratigraphical approach" - was approved for financing by FCT, which will increase and diversify the laboratory capacities. Single grain luminescence will be used for palaeoenvironmental reconstruction of sediments from Quaternary deposits. This approach is independent of biostratigraphic markers, which often are not available, or their use as unequivocal proxies has to be questioned. Apart from the reconstruction of palaeoenvironments, the Portuguese chronology will be refined and data made available for the analysis of seismic hazards and pollution studies of various geological areas.

Four projects began within the protocol ITN-IPA, and financed by IPA:

- "Pre-history occupation in the Bairro Alto area" (OPABA);
- "Anta 1 of Laje valley" - TEMPOAR II (Territories, settlements and mobility during Pre-history in the Alto Ribatejo -;
- "Megalithic Monument 5 of Jogada" - TEMPOAR II (Territories, settlements and mobility during Pre-history in the Alto Ribatejo -
- "Ribeira da Ponte da Pedra" - TEMPOAR II (Territories, settlements and mobility during Pre-history in the Alto Ribatejo -

The archaeological site of Bairro Alto (Lisbon) presents a few stratigraphic levels well dated by other methodologies and scientific approaches, which will provide an ideal base for an evaluating process by luminescence technique of absolute dating. Field-work is in course together with archaeological research with identification / selection of the various levels and monitoring / in situ measurements. This running project is in collaboration with an archaeological enterprise (Era Arqueologia) which is excavating the "Palacio dos Lumières / Andrades in the center of Lisbon, in the frame of a diagnostic process of the archaeological potential of the corresponding rehabilitation project. The chronology of the site is the Ancient Neolithic and the level in dating process is a paleo-soil deposit just above the Miocene clays ("Areolas da Estefânia").

## Geological environments

M. I. Prudêncio, M.I. Dias, J. C. Waerenborgh, M.A. Gouveia, E. Galán<sup>1</sup>, J. Duplay<sup>2</sup>

### Objectives

Geochemistry, crystal chemistry and mineralogy studies are applied to environmental and geological projects, with a view of the preservation of classified natural environments and valorisation of natural resources.

The characterization of the natural background is essential for the evaluation of the anthropogenic input in the geological environment. In this way, an important objective of the CHS group is the study of the geochemistry of the earth surface, particularly the behaviour of trace and major elements in secondary natural systems, and the alterations due to pollution actions.

The CHS running projects, concerning the quality control and identification of pollutants of geological environments, refer to lagoon environments of two main types:

A. volcano craters of Azores - Non-point Pollution in the Hydrosphere Due to Agricultural Practices: Source Characterization and Pollutants Mobility in the Vadose Zone (Lagoa das Sete Cidades, Fig. 1) (FCT – in collaboration with University of Azores, University of Lisbon).



Fig. 1. Lagoa das Sete Cidades (Azores).

B. coastal areas - COLASU – Sustainability of Mediterranean coastal lagoon ecosystems under semi-arid climate (EC project – in collaboration with University of Strasbourg, University of Seville, University of Tunis, University of Mohamed V-Agdal, Rabat, IRMCO).

### Results

Chemical results were obtained for sediments from the lagoon of Sete Cidades (volcano crater) and soils collected around the lagoon, contributing to the natural background knowledge and to evaluate the anthropogenic alterations. Among these a particular attention is paid to the fertilizers effect in the water quality of the lagoon (FCT project).

Two coastal lagoons in the north of Africa -Nador in Morocco and El Meleh in Tunisia (EC project).The chemical characterisation of lagoon sediments and soils around the lagoons was done by INAA, and the geochemical interpretation is in course. Zones in the lagoons environment with metals enrichment (Fig. 2) were identified and the origin of the anomalies is under study.

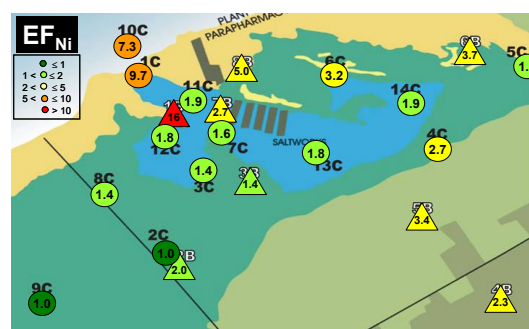


Fig. 2. Enrichment factor of Ni in sediments (circles) and soils (triangles) collected during the winter of 2003 in the El Meleh lagoon (Tunisia)

### Published, accepted or in press work

1. M.I. Prudêncio Biogeochemistry of trace and major elements in a surface environment (volcanic rock, soil, mosses, lichens) in the S. Miguel Island, Azores, Portugal., *Journal of Radioanalytical Chemistry* (in press).

<sup>1</sup> University of Seville, Spain

<sup>2</sup> University of Strasbourg, France

