

# Cultural Heritage and Sciences

## Introduction

“Cultural Heritage and Sciences” research group is mainly dedicated to the valorization and conservation of the Portuguese cultural heritage, through the application of scientific methods and approaches, particularly nuclear methods of analysis, geochemistry, chemistry, crystal chemistry and mineralogy.

This group derives from the reorganization in September of 1998 of the “Applied Chemistry to the Earth and Environmental Sciences” and the “Archaeometry” groups.

The analytical capabilities of this research group are rather unique: (1) the neutron activation analysis (developed by members of this group in Portugal since the seventies) based on the use of the nuclear research reactor (unique in the Iberian Peninsula), and (2) the environmental isotopes laboratory - radiocarbon dating, which is also unique in Portugal.

Neutron activation analysis combined with other techniques, have been applied in studies of cultural heritage, particularly concerning the degradation and conservation of the Portuguese built patrimony (granitic and volcanic rocks) through the application of low-temperature geochemistry and mineralogy know-how of this research group. A significant contribution has also been done in studies of pollution monitoring and modelling, sedimentary dynamics and natural resources. The work developed in the archaeometry domain includes: radiocarbon dating, provenance studies, studies of ancient technologies, studies of monetary history, and scientific examination of works of art. Environmental isotopes (C, O, H) have been applied to study and characterize present and ancient environments, namely in the fields of palaeoclimatology and palaeoceanography. As a consequence, these particular capabilities have led to an active engagement of the staff of this group in several research projects in partnership with national and international teams from Universities and Research Laboratories.

## Research Team

Researchers –	6*	( PhD or equivalent)
Research Students –	2	( 1 MSc Students)
Undergraduate Students –	1	
Technicians –	2	

\* 2 post-doctoral; 1 from IPA; 1 retired

## Publications

Journals –	2	in press
Proceedings –	3	
Conf. Commun.:	2	

	10 <sup>3</sup> PTE
<b>Expenditure:</b>	<b>5 502</b>
Missions:	2 166
Other Expenses:	2 874
Hardware & Software:	418
Other Equipment:	44

		10 <sup>3</sup> PTE
<b>Funding:</b>		<b>8 536</b>
External	1997	-340
Projects:	1998	7 432
Others		1 444

## Determination of Rare Earth Elements in Geological Reference Materials: a Comparative Study by INAA and ICP-MS

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### Abstract

Data was obtained for the rare earth elements (REE) by instrumental neutron activation analysis (INAA) and inductively coupled plasma-mass spectrometry (ICP-MS) in twenty geological reference materials. In general the precision obtained by ICP-MS is better for the light REE, decreasing with increasing atomic number. This is partly a result of the heavy REE occurrence at low concentrations. The precision of the data obtained by INAA is good (<5% RSD). The data obtained also showed that for the elements determined by both methods, the accuracy is similar for the light REE and better for the middle and heavy REEs by INAA. Higher uncertainty is achieved by ICP-MS mainly for elements at very low concentrations, occurring at about ten times the chondritic values.

*Geostandards Newsletters* (1998) (in press).

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## Contribuição da Análise Química para a Identificação de Falsificações de Moedas Visigodas

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### Abstract

Results of analyses of 44 Visigothic tremisses, 38 of which admittedly forgeries, using X-ray fluorescence spectrometry without any abrasion, are presented. It was shown, by comparing them with the results obtained in the analyses of 238 genuine tremisses representing the coinage of 18 Visigothic rulers from Leovigild to Roderick, by the same method, that the determined gold and copper concentrations are generally different from those which characterise the respective genuine tremisses. It was thus proved that chemical analysis is an excellent method for identifying forgeries of these coins. Five new varieties of forgeries are presented.

*ANEJOS AEspA* (1998) (in press).

## Use of Stable Carbon and Oxygen Mass Spectrometry and Neutron Activation Analysis in Determining Provenance of Some Roman Works of Art in Portuguese Museums

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### Abstract

Archaeological evidence of marble extraction has been observed in some quarries located in the Estremoz anticline (province of the Alto Alentejo, Portugal), indicating that these marbles were exploited on a large scale during the Roman period. They were extensively used in Lusitania and Baetica (southern and central Portugal, as well as central and southwestern Spain) for architectural decoration, epigraphic monuments and statuary.

A preliminary study of their chemical and isotopic characteristics has already been carried out by applying X-ray fluorescence spectrometry and stable isotopic ratio analysis, cannot unequivocally distinguish the marbles of all sampled quarries in Alto Alentejo, but they appear to provide distinctive signatures for telling Alto Alentejo quarries from Carrara.

Thus, it was decided to attempt to determine the quarry sources of some Roman works of art in Portuguese museums by means of stable carbon and oxygen isotope ratio measurements, coupled with neutron activation analysis.

This paper reports work in progress in this direction as well as new information regarding the characterization of Alto Alentejo marbles by neutron activation analysis.

Communication to: *Asmosia 1998, Fifth International Conference*, Boston USA 1998.

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## Radiocarbon Ages of Recent Volcanic Events from the Island of S. Jorge (Azores)

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### Abstract

Radiocarbon analyses were performed on 21 samples from Complexo de Manadas deposits, in the island of S. Jorge. The sampled materials include peat, wood, charcoal and paleosols. The dates indicate Holocene age for that unit. Nine or ten volcanic events dated by these radiocarbon ages, together with the historic events of 1580, 1808 and 1964, indicate that, at least, 12 or 13 eruptions occurred in the last 5600 years, separated by average dormancy periods of less than 470 to 430 years. However, an average recurrence interval between eruptions of the order of 200 to 300 years is probably more realistic.

*Actas do 5º Congresso Nacional de Geologia. Instituto Geológico e Mineiro. Sociedade Geológica de Portugal Comunicações, Tomo 84, Fascículo I, pp. A-189 a A-192. Lisboa 1998.*

## INAA Applications on the Study of Degradation and Conservation of Stone in Monuments

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### Abstract

The importance of the application of neutron activation analysis in geochemistry studies in general, is well known. The precise and accurate determination of numerous trace elements, covering a wide range of different geochemical behaviors makes this technique particular useful to characterize and differentiate rocks even of the same type. This detailed chemical characterization of rocks is very important in monuments studies since the identification of the quarries used to built the monuments is essential for the evaluation of the degradation processes of the stones in the monuments. Another advantage of INAA is the small size of samples required which is obvious when dealing with monument stones. Besides the identification of the quarry allows the possibility of laboratory tests with conservation products using large samples of the same rock of the monument.

In this work examples of INAA applications are given for monuments built of granitic rocks (megalithic dolmens, Alentejo) and volcanic rocks (churches in Azores Islands) from Portugal. Samples were collected of the monuments stones and from outcrops and quarries from the vicinity of each monument. The analyses were performed using a  $\gamma$ -ray spectrometer consisting of a 150 cm<sup>3</sup> coaxial Ge detector and a low energy photon detector (LEPD), connected through Canberra 2020 amplifiers to Accuspec B (Canberra) multichannel analyser were used. This system had a FWHM of 1.9 keV at 1.33 MeV (coaxial Ge detector), of 300 eV at 5.9 keV and of 550 eV at 122 keV (LEPD). The irradiations were carried out in the core grid of the Portuguese Research Reactor (Sacavém) at a flux of  $4.4 \times 10^{12}$  n cm<sup>-2</sup> s<sup>-1</sup> for seven hours;  $\phi_{\text{epi}}/\phi_{\text{th}}=1.4$  %;  $\phi_{\text{th}}/\phi_{\text{fas}}=12.2$ .

The results obtained indicated that the application of INAA in this type of studies is particularly useful. The chemical results, naturally complemented with mineralogical studies, may contribute largely for the identification of the sources of the stone monuments. Among the chemical elements determined, the rare earth elements group is a very important tool to be used as fingerprints of stone provenience.

Communication (accepted) to: *Tenth International Conference on Modern Trends in Activation Analysis (MTAA-10) USA 1999.*

## New Data on Sixteen Reference Materials Obtained by INAA

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### Abstract

Instrumental neutron activation analysis results for 16 elements (Na, K, Fe, Sc, Cr, Co, Zn, As, Rb, Sb, Cs, Ba, Hf, Ta, Th and U) in sixteen geochemical reference samples, namely SDC-1, Sco-1, SGR-1, STM-1, RGM-1, SDC-1, BIR-1, MAG-1 and BHVO-1 from USGS, Soil-5, Soil-7 and SL-1 from IAEA, and GSS-1, GSS-4, GSS-7, GSR-2 and GSR-3 from IGGE, are reported and compared with literature values.

The analyses were performed using a  $\gamma$ -ray spectrometer consisting of a 150 cm<sup>3</sup> coaxial Ge detector and a low energy photon detector (LEPD), connected through Canberra 2020 amplifiers to Accuspec B (Canberra) multichannel analyser were used. This system had a FWHM of 1.9 keV at 1.33 MeV (coaxial Ge detector), of 300 eV at 5.9 keV and of 550 eV at 122 keV (LEPD).

Three IGGE reference rocks, namely GSS-5, GSD-9 and GSR-1, were used as standards. The irradiations were done in the core grid of the Portuguese Research Reactor (Sacavém) at a flux of  $4.4 \times 10^{12}$  n cm<sup>-2</sup> s<sup>-1</sup> for seven hours;  $\phi_{\text{epi}}/\phi_{\text{th}}=1.4$  %;  $\phi_{\text{th}}/\phi_{\text{fas}}=12.2$ .

The results were obtained with a precision: (a) better than 3 % for Na, K, Fe, Sc, Cr, Co, Zn, Cs, Hf, Ta and Th and (b) to within 3% to 5% for As, Rb, Sb, Ba and U. The comparison with recommended or proposed values showed an agreement (a) better than 3 % for K and Fe, (b) to within 3 % to 5 % for Zn, Hf and Th, (c) to within 5 % to 10 % for Sc, Cr, Co, Rb, Cs, Ta and U, to about 12 % for Ba, 13 % for Sb and 14 % for Na.

Communication (accepted) to: *Tenth International Conference on Modern Trends in Activation Analysis (MTAA-10)* USA 1999.

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## **Tecnologias de Produção e Proveniência de Matéria-prima das Cerâmicas Campaniformes da Fraga da Pena (Fornos de Algodres - Portugal)**

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### **Abstract**

O contexto arqueológico em que se insere este trabalho corresponde a uma rede de povoamento da Pré-História Recente na região de Fornos de Algodres. O âmbito geográfico é restrito, correspondendo à parte do rebordo sul do planalto da Nave, área sobranceira à depressão tectónica da “Bacia de Celorico” e à plataforma do Mondego. Esta rede de povoamento conta já com sete *habitats* identificados que abrange um período que vai dos finais do IV aos inícios do II milénio AC (Calcolítico e Início da Idade do Bronze).

Neste trabalho faz-se um estudo arqueométrico das pastas de cerâmica de um destes *habitats* (Fraga da Pena), com particular destaque para as cerâmicas campaniformes, através de uma caracterização química e mineralógica detalhada dando-se especial atenção aos elementos traço como elementos discriminantes de diferentes grupos de cerâmica. A análise química faz-se por activação com neutrões térmicos. A análise mineralógica e textural é feita por difracção de raios-X e estudos petrográficos.

Este estudo, associado à classificação clássica da cerâmica arqueológica, visa uma melhor caracterização das pastas e as tecnologias de produção. Além disso, estudar-se-ão do mesmo modo depósitos de argila locais e regionais com vista ao estabelecimento da proveniência de matérias-primas.

Communication (accepted) to: *3º Congresso de Arqueologia Peninsular*, UTAD, Vila Real, Portugal, 1999.

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