

Cultural Heritage and Sciences

M. Isabel Prudêncio

The "Cultural Heritage and Sciences" (CHS) research group is mainly directed to the **protection, conservation and enhancement of the Portuguese cultural patrimony**, through the application of scientific approaches. The use and development of nuclear and related techniques consists on a basis of achievement the objectives.

The analytical methods associated to the CHS group are unique in Portugal, namely the **instrumental neutron activation analysis (INAA)** - comparative method, **radiocarbon dating** and **luminescence dating** units (TL-OSL, in installation). The good performance of these laboratories is a major objective, with the maintenance of excellent quality in the results obtained to serve the national and international communities.

The chemical characterisation by **INAA using the Portuguese Research Reactor** is the main support of most of the research work developed by the CHS group. The analytical methods associated to this group (instrumental neutron activation analysis and absolute dating) allow the chemical characterisation of materials and the chronologies establishment, consisting on the research-working basis. Detailed studies of geochemistry (especially of trace elements) and mineralogy of geological materials (clays and rocks) applied to cultural assets (ceramics and monument stones, for instance) consists on the essence of the CHS group scientific research.

Beyond financed **research projects** in collaboration with other national laboratories and universities, a significant part of the research activities of the CHS group are directed to the end users through the **ITN-IPA protocol** as well as **contracts/services** made with other private or public institutions (IPPAR, EDIA, Valorsul, Petrolgal, etc).

The ITN research activities of the CHS group can be divided in the following main domains:

- (a)- **Movable Cultural Assets**
- (b)- **Absolute Dating**
- (c)- **Immovable Cultural Assets**
- (d)- **INAA - Development and applications**

The multidisciplinary character of these research domains is traduced by the diversity of know-how of the team - chemists, geologists, physics, geographers and archaeologists.

In the field of **movable cultural assets**, the **archaeometric research** in ITN aims to obtain a better knowledge of the production technologies through time. On the other hand ITN will become the only laboratory in Portugal able to date archaeological and geological materials in a large range of dates serving the archaeological and Quaternary geological communities. Since 1999, a protocol between ITN and the Instituto Português de Arqueologia (IPA) has played a very important role in the increment in Portugal of the ancient ceramics studies for several chronologies as well as in the development, implementation and application of dating units.

The identification of the causes and mechanisms of degradation of stones by the CHS group contributes to the protection of **historical buildings and monuments** made of igneous rocks. Especial attention will be paid to the study of the interaction between the stone, the building materials, the pollutants and the percolating solutions.

Final Remark: A very significant increase of financed projects especially within the ITN-IPA protocol and services occurred in 2000. This was only possible and well accomplished with the very significant and efficient work of the non-permanent staff (70 % of the team; permanent staff: 2 researchers and 2 technicians). **The consolidation of the scientific research and its application to the conservation and enhancement of the Portuguese cultural heritage is a long-term goal of the CHS group, as well as the increase of the interaction between ITN and public institutions to solve problems of cultural assets.** Within this purpose an effort has been done in 2000, promoting an archaeometric workshop in ITN and publishing a review of our capabilities and the work developed so far in this field [1]. However, it should be noted that the maintenance and increment of those activities **will only be achieved with the assurance of the increase of the permanent staff, by contracting the already trained competent grant-holders** (post-doctoral and technicians).

- [1] Prudêncio, M.I., Soares, A.M., Araújo, M.F., Gouveia, M.A., Dias, M.I., Waerenborgh, J.C. & Alves, L.C. Ciências aplicadas à arqueologia: trabalho desenvolvido no Instituto Tecnológico e Nuclear. Trabalhos de Arqueologia da EAM, Portugal, Vol. 4/5 (2000) 8 pp.

Research Team

Researchers

- M. Isabel Prudêncio (Principal researcher) (**Group leader**)
- M. Ângela Gouveia (Principal researcher)
- M. Isabel Dias (Post-doctoral- PRAXIS XXI)
- Mohamed Nasraoui (Post-doctoral-PRAXIS XXI)
- Antoine Zink (Post-doctoral -PRAXIS XXI)
- Daniel Richter (ITN contract)

Technical Personnel

- Luis Fernandes (technician)
- António Amaro (technician)
- Rosa Marques (Graduated, ITN grant)
- Dulce Franco (Undergraduate, ITN grant)
- Guilherme Cardoso (Undergraduate, ITN grant)

Students

- Ana Gomes (MSc student - Minho Univ.)
- Alexandra Gaspar (MSc student - Minho Univ.)
- Miguel Ângelo Gonçalves (Research Student - PRAXIS XXI)

Publications

Journals:	5 and 1 in press
Proceedings:	7 and 6 in press
Conf. Communications:	15
Book chapters:	1
Internal Reports:	1
Theses (MSc):	2

Funding

Research Projects: ^(a)	21 764
ITN: *	22 535
Services:	5712
TOTAL:	50 011

×10³ PTE

(a)

FCT

- Production and Technology of Roman Pottery: <i>Bracara Augusta</i> case. (PRAXIS/HAR/13047/98) - (1999 - 2001) (6000 × 10 ³ PTE → ITN/3163 × 10 ³ PTE) ITN/Co-ordinator: Isabel Prudêncio , Partners: Univ. Minho, C.M.V.N.F.	1800
- Pre-Historical Ceramics. (PRAXIS - Post-doctoral grant) Collaboration with GAFAL and Univ. Seville	—
- Causes and mechanisms of degradation of igneous rocks in monuments from Minho, Alentejo and Azores (PRAXIS2/2.1/CHS/254/95 - (1996 - 2000) (18 000 × 10 ³ PTE → ITN/6550 × 10 ³ PTE) ITN/Co-ordinator: Isabel Prudêncio , Partners: Univ. Minho, LNEC, IICT, CECRA	486
- Alteration processes and conservation methods of the built patrimony made of granite (PRAXIS 3/3.1/CEG/2516/95) - (1997 - 2001) (16 823 × 10 ³ PTE → ITN/8177 × 10 ³ PTE) ITN/Co-ordinator: Isabel Prudêncio , Partners: LNEC and Ec.Mines St. Étienne	3069
- Roman marbles in Portugal: artistic, petrographic, chemical and isotopic characterisation (PRAXIS 2/2.1/CHS/819/95) - (1996 - 2000) (10 000 × 10 ³ PTE → ITN/5050 × 10 ³ PTE) ITN/Co-ordinator: J.M. Peixoto Cabral , Partners: Univ. Coimbra, UNL, DG/UE	—
- Paleobiology and paleodiets from the Mesolithic to the Late Neolithic: the portuguese case. Contribution of the trace elements and stable isotopes. (PRAXIS PCNA/C/BIA/114/96) - (1997 - 2000) (11 164 × 10 ³ PTE → ITN/8148 × 10 ³ PTE) ITN/Co-ordinator: J.M. Peixoto Cabral , Partner: IAV (Eugénia Cunha)	2809
IPA	
- Archaeometry: characterisation of archaeological ceramics and dating Collaboration with J.D. Almada, I.P.Tomar, Univ. Lisboa, A.A.Tavira, C.M.C., IPA, C.M.V.N.F.	13 600

×10³ PTE

* Special funding for the equipment and installation of the TL-OSL Laboratory.

1. Movable Cultural Assets

Ancient Ceramics - Production, Technology and Provenance

M.I. Dias, M. I. Prudêncio, M.A. Gouveia, J.C. Waerenborgh¹, A. Valera²

Objectives

The movable cultural assets studied by the CHS group include mainly ceramics. The work consists on the chemical and mineralogical characterisation followed by detailed geochemical and phases transformation studies, aiming to define provenance and the production technologies used in the manufacture of the objects, i.e. where and how they have been produced. The results have naturally implications on the knowledge of the history of technology through time, the establishment of the population characteristics of the different sites, trades and the spread of cultural influences.

This research domain aims to contribute solving problems requested by the archaeological scientific community. Several chronologies of ceramics are studied, from the pre-history to the medieval times, particularly emphasising roman amphorae. In general our contribution consists on a detailed geochemical and mineralogical study of pottery and potential related raw materials aiming to establish trade patterns, manufacturing techniques employed and production organisation, sometimes crossing large chronological periods in order to establish continuity or discontinuity in ceramics production for a certain archaeological site.

Results

1.1 Pre-Historical Ceramics

A large set of chemical and mineralogical data was already obtained for ceramics of two archaeological sites (Castro de Santiago and Fraga da Pena), as well as for the related raw materials [1-4]. A database has been implemented concerning the macroscopic characterisation of the sherds, as well as its chemical composition. It is important to enhance that for the pre-historic period in Portugal only a very few works exists. So the work carried out in that period will also provide a solid basis of comparison to similar studies that can be done of the same chronologies in Portugal and the rest of the Iberian Peninsula. An important collaboration with the Univ. Seville assumed a significant role in the mineralogical and textural characterisation of those ceramics. A morphometric analysis of ceramic thin slides was done, which methodology evolves digitation of those thin slides with parallel and cross-polarised light, extraction of temper grains boundaries by digital image processing, measurement of size and shape of the temper grains, constructing granulometric curves (Fig. 1).

Chemical differences in ceramics allowed the definition of several pottery groups according to its composition and the establishment of a correlation between some of

the pottery analysed, its typological group (Fig. 2) and local clay samples. In some specific cases different origins for raw materials is suggested [5-6].

1.2 Ceramics from Roman to Medieval times

The ceramic production technology in roman ceramics form *Bracara Augusta* has been established, with the identification of several compositional groups and its relation with typological groups. A correlation with local clay deposits (sedimentary and residual ones) has also been established using mineralogical and geochemical fingerprints (especially trace elements), being able to settle provenance of ceramics [7]. Two master theses were fulfilled [8, 9].

1.3 Archaeometry: characterisation of archaeological ceramics - ITN-IPA Protocol

The running projects in 2000 (ITN-IPA protocol) were:

- 1 – “Excavations in the Historical Center of Tavira”. Leader: M. Maia
- 2 – “The Santarém "Alcáçova" during Iron Age and roman time”. Leader: A. Arruda
- 3 – “The evolution of cultural landscape in the Mondego Platform in the Later Pre-History (c.5000-550 cal AC): Characterisation of Neolithic archaeological ceramics” Leader: J.C. Senna-Martinez.

This research field includes projects submitted under the ITN-IPA protocol.

¹ Solid State Group, ITN.

² GAFAL archaeologist (Câm. M. F. Algodres)

The foremost target is the increase in Portugal of the archaeometric research on ancient ceramics for several chronologies in order to obtain a better knowledge of the production technologies through time, with the implementation of a wide database of ceramics associated to its chemical composition. Furthermore, this study will provide a solid basis of widespread comparisons between archaeological sites in Portugal and in other European countries, with which those communities could have traded.

The main results obtained from January 1999 until February 2000 were presented and discussed in the Workshop "Sciences Applied to Archaeology" held in ITN in April 2000 [10]. Several works were submitted to presentation and publication in international conferences in 2001.

Published (or in press) work

- [1] Dias, M.I., Prudêncio, M.I., Gouveia, M.A., Valera, A.C., Sequeira Braga, M.A., Alves, C.A. Pottery production technology through out the 3rd millennium BC on a local settlement network in Central Portugal: comparing results from Castro de Santiago and Fraga da Pena sites, *Proceedings of the 32nd. International Symposium of Archaeometry*, Mexico, (2000), in press.
- [2] Polvorinos del Rio, A., Dias, M.I., Gómez Morón, M.A., Sequeira Braga, M.A., Valera, A.C., Prudêncio, M.I., Gouveia, M.A., Alves, C.A., Archaeometry of the pre-historical Fraga da Pena fortified settlement (Central Portugal): morphometric, mineralogical and chemical analyses of ceramics, *Proceedings of the 32nd. International Symposium of Archaeometry*, Mexico, (2000), in press.
- [3] Dias, M.I., Prudêncio, M.I., Prates, S., Gouveia, M.A., Valera, A.C., Tecnologias de Produção e Proveniência de Matéria-Prima das Cerâmicas Campaniformes da Fraga da Pena (Fornos de Algodres – Portugal), *Actas do Congresso de Arqueologia Peninsular*, V.Real, Portugal (2000), in press.
- [4] Dias, M.I., Prudêncio, M.I., Valera, A.C., Sequeira Braga, M.A., Gouveia, M.A., Provenance and Technology of Pre-Historic Pottery from Fornos de Algodres (Portugal): the Fraga da Pena Archaeological Site, *Proceedings of the EMAC'99*, Athens, in press.
- [5] Dias, M.I., Prudêncio, M.I., Gonçalves, M.A., Sequeira Braga, M.A., Gouveia, M.A. Geochemical and mineralogical diversity of clay materials in Fornos de Algodres region (Central Portugal) and its implications on provenance studies of ancient ceramics, *Proceedings of the 1st Latin American Clay Conference*, Funchal 2000, Vol II (2000) 237-244.
- [6] Dias, M.I., Rocha, F., Prates, S., Fibrous clay minerals from a Tertiary Continental deposit (Malpica do Tejo, Portugal) - mineralogical and statistical analysis, *Proceedings of the 1st Latin American Clay Conference*, Funchal 2000, Vol II (2000) 49-56.
- [7] Oliveira, F., Prudêncio, M.I., Sequeira Braga, M.A., Delgado, M., Gouveia, M.A., Martins, M. The "Bracarense" ceramics from roman settlements of the north of Portugal and Galiza (Spain), *Proceedings of the 32nd. International Symposium of Archaeometry*, Mexico, (2000), in press.
- [8] Gomes, A., Cerâmicas pintadas da época romana: tecnologia, tipologia e cronologia. Master thesis, Universidade do Minho, 2000 (co-supervisor: M. Isabel Prudêncio).
- [9] Gaspar, A., Contribuição para o estudo de cerâmicas dos séc. V-VI DC de Braga. Master thesis, Universidade do Minho, 2000 (co-supervisor: M. Isabel Prudêncio).
- [10] Dias, M.I., Caracterização química de cerâmica arqueológica. Produção e proveniência, *Workshop Ciências Aplicadas à Arqueologia*, April 2000, Sacavém, Portugal.

Further Work

- The chemical and mineralogical analyses will proceed on *Bracara Augusta* ceramics enlarging correlation with ceramics from well-known abroad production centres, in order to establish possible importation centres used by those roman communities.
- Concerning the Fornos de Algodres pre-historical settlement network, more studies will be carried out in other archaeological sites, adding more samples of sherds, as well as increment the raw materials survey. A project proposal was submitted to FCT for funding in order to enlarge the data for the several existing archaeological sites.
- Under the ITN-IPA protocol, six new projects of chemical characterisation of archaeological ceramics from pre-historical to islamic times will be running during 2001:
 - *Produção Oleira no arrabalde ocidental da Lisboa islâmica* - J. Bugalhão (IPA)
 - *Idade do Ferro no Alentejo Central* - o povoado da Herdade da Sapatoa - J. Mataloto
 - *Zona Megalítica de Vale de Rodrigo* - P. Kalb & M. Höck (UBI)
 - *Estudo e valorização da estação arqueológica de S. João de Perrelos* - F. Oliveira (C.M.V.N:F.)
 - *Muçulmanos e cristãos na Península da Arrábida: o Castelo de Palmela e a Ruralidade Envolvente* - I. Fernandes (C.M.P)
 - *Zambujalinho - Centro Produtor de Cerâmicas do Vale do Sado* - I. Fernandes (C.M.P)
 - *Ambientes Funerários no Povoado dos Perdígões* - M. Silva e A. Valera (ERA).

2. Absolute Dating

The good performance of the dating laboratories (Radiocarbon and TL-OSL) is a compromise assumed by ITN in 1999, within the ITN-IPA protocol. Funding from IPA has been attributed to the CHS

group to support archaeological projects concerning not only dating, but also chemical characterisation of ceramics and metal artefacts.

2.1. Radiocarbon Unit

M. I. Prudêncio, R. Marques

Objectives

The good performance of this dating laboratory is a compromise assumed by ITN in the ITN-IPA protocol. In this context IPA promoted in the archaeological community the use of the radiocarbon unit in ITN, financing some projects. Also the geological community is aware of the good performance of this laboratory incrementing during 2000 the request for analysis.

Results

The increase of the radiocarbon unit output was a major achievement in 2000, allowing processing all the samples for analysis in the laboratory. This was only possible due to the excellent work of two new collaborators (ITN grants: Rosa Marques; Guilherme Cardoso).

2.2. Luminescence Dating Laboratory

D. Richter, A. Zink, M. I. Prudêncio

Objectives

The objectives are the construction and establishment of a Laboratory devoted to Luminescence Dating. This will provide the archaeological and geological community on the Iberian Peninsula and elsewhere with chronometric dating methods based on luminescence (TL, G-OSL, IRSL, B-OSL). Furthermore, fundamental studies on luminescence properties on various minerals and the development of new techniques are anticipated, which will make use of the already present equipment and expertise at ITN.

Results

The laboratory was designed and constructed, the equipment selected and most items purchased. Apart from the focus on the laboratory design, projects (see below) for the future works in the laboratory were developed. For example a study on the luminescence properties of quartzite was started. The new unit was presented at several conferences and subsequently new projects were initiated. Fieldwork and preliminary dosimetry was carried out at several archaeological sites, in order to collect samples for dating in the new laboratory. For some sites, a collaboration with the chronometric dating unit (ESR, TMS-U-series) at McMaster University, Hamilton (Canada) was established [1-10].

Almonda region (Portugal):

- *Gruta do Oliveira*, Middle Palaeolithic, collaboration Prof. Zilhão (IPA, Lisbon) and Prof Schwarcz (McMaster University)

- *Grutas Pesadas* and *Breccia das Lascas*, Lower and Middle Palaeolithic, collaboration Prof. Marks (SMU,

Dallas, USA) and Prof.s Schwarcz and Rink, (McMaster University)

El Kowm (Syria):

- *Ain Hummal* and *Nadaouiyeh Ain Askar*, collaboration Prof. LeTensorer (University Bales, Switzerland), funded by a travel grant from the Leakey Foundation (USA) to DR.

Several contacts to the establishment of further contracts were done.

Further Work

In the TL-OSL laboratory the equipment will have to be installed, which includes the calibration of radioactive sources and other equipment. A dosimetric system adapted to the needs in luminescence dating has to be designed, tested and set up. Blind tests with various materials will be performed in order to check for the quality of sample preparation procedures and dating results. The following methods and materials will be introduced and checked one by one: TL on sediment and heated SiO₂-bearing materials, G-OSL and B-OSL on quartz from sediment, IRSL on feldspar from sediment.

Contract work was acquired to provide extra funding of the laboratory:

Alqueva Dam (Portugal):

- *Sapateiros 2*, *Barca do Xerez* and *Porto Meirinho I*, Lower Palaeolithic to Mesolithic, collaboration Prof. Ribeiro (Lisbon University) (for EDIA, S.A.)

City of Porto (Portugal):

- *Late Palaeolithic site* in Porto (for O'Porto 2001, funding pending)

Alentejo (Portugal):

- *Vale de Rodrigo 3*, Neolithic megalith, collaboration Dr. Kalb (RGK, Germany), (DAAD grant pending)

The focus is currently on the archaeological application, but includes the dating of geological deposits as well, which help to establish chronologies. The potential of the methods especially in Quaternary Geology will be disseminated, in order to provide a wide basis for partial funding of the laboratory.

Published (or in press) work

- [1] Richter, D., Thermoluminescence dating of heated flint. Method and Application, *Proceedings of the VIII International Flint Symposium* (2000), in press.
- [2] Richter, D, Wagner, G.A., Rink, W.J., Freund, G., Weismüller, W., Reisch, L., Böhner, U., Luminescence ages for the Middle Palaeolithic sequences of the ‘Sesselfelsgrötte’ and the ‘Abri I Schulerloch’, Bavaria, Southern Germany, in: *Wissenschaftliche Veröffentlichungen des Neanderthalmuseums* (2000), in press.
- [3] Richter, D., Waiblinger, J., Rink, W.J. & Wagner, G.A. Thermoluminescence, Electron Spin Resonance and ¹⁴C-Dating of the Late Middle and Early Upper Palaeolithic Site Geißenklösterle Cave in Southern Germany, *Journal of Archaeological Science* **27** (2000) 71-89.
- [4] Kieselbach, P., Kind, C.-J., Miller, A.M., Richter, D., Siebenlinden 2. Ein mesolithischer Lagerplatz bei Rottenburg am Neckar, Kreis Tübingen. *Materialhefte zur Archäologie* in Baden-Württemberg 51, Konrad Theiss Verlag, Stuttgart (2000) 235 pp..
- [5] Zink, A.J.C., Luminescence dating - A new research tool in ITN, Internal report ITN/SQ-N-2000/1, Sacavém (2000).
- [6] Zink, A.J.C., TL/OSL I-méthodologie, *Workshop Ciências Aplicadas à Arqueologia*, April 2000, Sacavém, Portugal (oral).
- [7] Zink, A.J.C., Richter, D., Prudêncio, M.I. Setting-up of a new luminescence dating lab (ITN, Sacavem, Portugal) *Annual UK Luminescence Workshop*, 10-12 July 2000, Oxford (UK) (poster).
- [8] Visocekas, R., Zink, A.J.C., Comparing fading in feldspars by the Bir spectral analysis, *Annual UK Luminescence Workshop*, 10-12 July 2000, Oxford, UK (oral).
- [9] Richter, D., Zink, A.J.C., Prudêncio, M.I., Luminescence dating in archaeology and the new laboratory at ITN, *6th Annual meeting European Archaeologists Association*, 10-17 September 2000, Lisbon, Portugal (poster).
- [10] Zink, A.J.C., Multiplicité des méthodes de datation par luminescence: inconvénient ou avantage? *XXI Rencontre Intenationales d'Archéologie et d'Histoire d'Antibes - Datation*, 19-21 October 2000, Antibes, France (poster).

3. Immovable Cultural Assets

Historical Buildings and Monuments

M. I. Prudêncio, M. Nasraoui, M.A. Gouveia, J. C. Waerenborgh

Objectives

This research domain aims to contribute for the detailed characterisation of the prevailing degradation state of the igneous rocks in historical buildings and monuments, as well as the responsible mechanisms, with the identification of the main decay agents. A better definition of preservation actions will be a major objective of the research results and interpretations.

Results

Among the rocks studied a special attention was paid to trachytes behaviour in Azores monuments. Three important monuments were studied in detail - Angra do Heroísmo Cathedral and the S. Sebastião Church (Fig. 1) in Terceira Island and the Misericórdia Church of Ribeira Grande in the S. Miguel Island. Despite the possibility of the application of further conservation methods, one advice derived from the results is the substitution of this type of stone for others such as the vacuolar andesite, particularly in the case of the main façade of the Ribeira Grande Church [1-3].



Fig. 1. S. Sebastião Church (Terceira Island).

Field and laboratory work have proceeded in the Alentejo region particularly in granite rocks of Évora, applied to the Évora Cathedral study. The results

obtained so far showed that at least two main types of granite were used for the construction and restoration of the monument.

Proceedings

- [1] Romão, P., Prudêncio, M.I., Figueiredo, M.O., Trindade, M.J., Nasraoui, M., Gouveia, M.A., Silva, T., The São Sebastião Church of Terceira Island (Azores, Portugal) – characterisation of the stones and their biological colonisation. *Proceedings of the IX International Congress on Stone*, Venice, Elsevier Eds., Vol 1 (2000) 493-497.
- [2] Prudêncio, M.I., Nasraoui, M., Trindade, M. J., Sequeira Braga, M.A., Figueiredo, M.O., Secondary Phosphate Phases in Altered Trachyte from S. Miguel Island (Azores, Portugal) – a Possible Contribution to the Stone Degradation. *Proceedings of the IX International Congress on Stone*, Venice, Elsevier eds., Vol 1 (2000) 165-170.
- [3] Sequeira Braga, M.A., Delgado Rodrigues, J., Alves, C.A., Costa, D., Silva, T., Trindade, M.J., Waerenborgh, J.C., Nasraoui, M., Gouveia, M.A., Trachyte stones in monuments of the São Miguel and Terceira Islands, Azores (Portugal). *Proceedings of the IX International Congress on Stone*, Venice, Elsevier eds., Vol 1 (2000) 235-245.

Further work

The detailed study of the degradation state of granite stones from the Évora cathedral will proceed. A detailed study of the interaction rock/percolation solutions will be done.

A new project concerning the characterisation of pollution sources and the migration paths of the pollutants from the pollution sources to the monument stones will start in 2001. This project will include monuments built with different granite types in continental Portugal and with different volcanic rocks in Azores Islands.

4. Instrumental Neutron Activation Analysis - development and applications

M. Ângela Gouveia

Objectives

The analytical capabilities of this research group are rather unique. Besides dating methods, instrumental neutron activation analysis is a method developed by members of this group since the seventies. It is based on the use of the nuclear research reactor (unique in the Iberian Peninsula). This analytical method (complemented with other methods) supports all the research activities of the CHS group and is also used by other ITN researchers. Public and private institutions requested often CHS group for services, considering the high performance of the chemical analysis that it allows. Another main objective of this research activity of the group is to develop and increase the application of INAA to other scientific areas, making our *know how* more profitable to the community.

Results

This analytical method is fundamental for the research activities of the group, allowing determine trace elements, especially Rare Earth Elements, which are excellent geochemical fingerprints to be used in the archaeometric work developed by the CHS group, especially in provenance studies of ceramics, and in their production technology characterisation.

Services were done to other cultural public institutions rather than IPA, particularly IPPAR, concerning the study of islamic ceramics of Lisbon. Services have been done also to industry, namely in the chemical characterisation of environmental samples in the vicinity of an urban solid residues power plant (CTRSU, S. João da Talha) for Valorsul and fuel samples for Petrogal [1, 2].

The quality of the analytical procedures is periodically controlled through the analyses of international standards and inter-calibrations with other laboratories, in order to maintain and increment the

good performance of the laboratories, aiming excellent quality in the results obtained [3].

A large number of chemical analyses occurred in 2000, with a total of 1270 samples irradiated.

Published (or in press) work

- [1] Prudêncio, M.I., M.A. Gouveia, M.A., Freitas, M.C., Chaves, L., Marques, M.A., Soil versus lichen analysis on elemental dispersion studies (north of Portugal), IAEA- TECDOC-1152, Proceedings of the *International Workshop "Biomonitoring of Atmospheric Pollution (with emphasis on trace elements)- BIOMAP* (2000) pp. 91-99.
- [2] Prudêncio, M.I., Sequeira Braga, M.A., Paquet, H., Waerenborgh, J.C., PEREIRA, L.C.J., Gouveia, M.A., Clay mineral assemblages in weathering basalt profiles from central and southern Portugal: climatic significance. *Weathering 2000*, Belfast, U.K, June 2000.
- [3] Gouveia, M.A., Prudêncio; M.I., New data on sixteen reference materials obtained by INAA. *J. Radioanal. Nucl. Chem.* **245** (1) (2000) 105-108.

Further work

- Progression of the analytical work involved in the contract "Monitoring program of trace elements in the vicinity of CTRSU, S. João da Talha" (Valorsul), and of the chemical analysis of fuel samples of Petrogal.
- Application of INAA to other scientific research areas, setting out of a new collaboration with the Pharmaceutical University of Lisbon to study the distribution of specific chemical elements in biological samples, only possible with INAA method.

Services

Chemical analyses by INAA

Services have been done to public institutions and industry:

- Chemical analysis of ancient ceramics and geological materials (IPPAR)
- Chemical characterisation of environmental samples in the vicinity of an urban solid residues power plant (CTRSU, S. João da Talha) for VALORSUL
- Chemical analysis of fuel samples for PETROGAL.

Radiocarbon Dating

1. Radiocarbon dating of geological materials:
 - Univ. Azores
 - Univ. Aveiro
 - IST
 - Soc. "Águas do Luso"
2. Radiocarbon dating of archaeological materials:
 - Câm. Mun. Pinhel
 - IICT

