# ENVIRONMENTAL AND ANALYTICAL CHEMISTRY

## Annual Activity Report 2013

#### **UNIT: Chemical and Radiopharmaceutical Sciences**

#### TEAM

Name	Category	<b>R&amp;D</b> (%)
M. Fátima Araújo	Principal Researcher	100
A.M. Monge Soares	Principal Researcher	100
Paula M. M. Carreira Paquete	Auxiliary Researcher	100
Pedro M.F. Valério	Graduate Technician (PhD)	100
Dina Nunes	Graduate Technician	100
António Amaro	Laboratory Technician	100
M. Manuela Correia	Laboratory Technician	100
Elin Figueiredo	Post-doc, FCT Grant	50
M. João Furtado <sup>1</sup>	PhD student, FCT grant	50
José Manuel M. Martins <sup>1</sup>	PhD student, FCT grant	100
Filipa Pereira	PhD student, FCT grant	50
Filipa Lopes	PhD student, FCT grant	50
Susana Sousa Gomes	PhD student, FCT grant	100
Rui Câmara Borges	PhD student, FCT grant	50
Paulo Portela <sup>1</sup>	Project grant	100
Ana Medeiros <sup>1</sup>	Project grant	100
Vera Lopes <sup>1</sup>	Project grant	

<sup>1</sup>-Contract finished during 2013.

#### **OBJECTIVES**

Main objectives of the EAC Group are focused on the development and application of Elemental, Isotopic Analysis and Dating in the following areas:

#### Environmental Geochemistry

Evaluation of the variability on elemental (major, minor and trace elements), isotopic ( $\delta^{13}$ C,  $\delta^{15}$ N) contents along the dated sedimentary record of estuarine environments along the Portuguese coast (Minho, Tagus, Sado, Mira, Neiva, Alcabrichel and Bensafrim) to identify changes in the dominant sedimentary sources, the evolution of fluvial and marine influences, the responses to climatic events and the impact of land use changes in the estuarine environmental conditions over the last millennia.

#### Isotope Hydrology

Determination of isotopic composition: <sup>2</sup>H/<sup>1</sup>H, <sup>13</sup>C/<sup>12</sup>C, <sup>15</sup>N/<sup>14</sup>N and <sup>18</sup>O/<sup>16</sup>O, tritium and radiocarbon dating in water and carbonate samples (from water systems and carbonates), aiming to construct/identify groundwater circulation models (including origin of salinization in coastal aquifers or local infiltration of rainwater in mineral waters) and residence time for protection, sustainability and proper management of groundwater and surface water resources.

#### Archaeometry – Provenance, metal composition and manufacturing techniques

Investigation of archaeological metallic artefacts by a multidisciplinary approach to understand the technological and social conditions that control raw materials origin, trade routes and metallurgical manufacturing processes from Chalcolithic till Roman Period on Portuguese territory.

Study of the Indo-Portuguese Silver jewellery Museum artefacts collections and coeval silver artefacts to establish composition patterns, raw materials provenances and production centres.

Besides research carried out in the framework of financed research projects services to public and private Institutions are carried out mainly concerning radiocarbon dating and isotope ratio determinations in different types of samples.

#### MAIN ACHIEVEMENTS

#### Environmental Geochemistry

Geochemical approaches including elemental (major, minor and trace constituents) and isotopic ( $\delta^{13}$ C,  $\delta^{15}$ N) determinations were applied in the study of sedimentary coastal systems evolution. Sedimentary records of saltmarshes from protected settings of several estuaries of the W coast (Minho, Tagus, Sado, Mira, Neiva, Alcabrichel and Bensafrim) were studied to evaluate recent environmental changes. These estuaries present diverse characteristics; some are strongly impacted by recent human activities, nevertheless preserving the record of climatic change and sea level rise. The



chronological framework was established by using a combination of techniques (<sup>210</sup>Pb, <sup>137</sup>Cs and <sup>14</sup>C). Some enrichments in anthropogenic trace elements (e.g. Cu, Zn, As and Pb), occurred in specific periods could be related to the effects of Human occupation and industrialization. Besides, over the last 5000 years different trends of sea level, climatic fluctuations, Bond events or humid episodes have been recorded in the Iberian Peninsula, as well as human intervention in the landscape, particularly sensitive since the Middle Bronze Age, were imprinted in the filling up of alluvial plain estuaries. Temporal variations on the elemental contents and isotopic composition ( $\delta^{13}$ C,  $\delta^{15}$ N) of sedimentary sequences could be related with different contribution of the terrestrial sources or associated with a dominant marine contribution, allowing to identify the evolution of fluvial and marine influences, the responses to climatic events and the impact of land use changes in the estuarine environmental conditions.

#### Isotope Hydrology

Water rock interaction studies have contributed to the conceptual hydrogeological circulation model of the Cabeço de Vide mineral waters. Research showed local shallow HCO<sub>3</sub>-Mg groundwaters, discharging from the serpentinized dunites exhibit similar  $\delta^2$ H and  $\delta^{18}$ O mean values than those measured for Cabeço de Vide mineral waters (~ -27%o and -4.5%o, respectively), indicating that mineral waters could have evolved ascribed to the deep infiltration of the shallow HCO<sub>3</sub>-Mg groundwaters. Also, previous work carried out in the N of Portugal (Minho and Trás-os-Montes) has shown that mineral groundwater resources can be associated with major structural



accidents, where mineralized hot springs and a large number of cold  $\mathrm{CO}_2$  rich mineral waters are found.

Isotope techniques were also used in the identifying of salinity source and renewability of groundwater on coastal aquifers of Algarve, Sado (Portugal), Cap Bon (Tunisia) and Cape Verde. Results indicate that the increase in mineralization of groundwater resources is often due to inflow of saline (dense) water, during heavy withdrawals of fresh water, and/or mobilization of saline formation waters by overexploitation of inland aquifer systems.

#### Archaeometry – Provenance, metal composition and manufacturing techniques

Studies on the elemental and microstructural characterization of archaeological metallic artefacts and production remains (crucibles, slags, prills and metallurgical debris) from various archaeological sites of the Portuguese territory have been carried out to investigate the metallurgical evolution from Chalcolithic till Iron Age. Large artefact collections from all over the territory, namely the Northeastern area (mostly Early/Middle Bronze Age); Estremadura (Chalcolithic); and Southern zone, including grave goods and artefacts from Montinhos 6 and Torre Velha 12 (Middle Bronze Age) and



some Late Bronze and Iron Age bronze collections.

Artefacts have diverse typologies, variable compositions and different thermomechanical treatment/cycles, in some cases dependent on the use of artefacts. Chemical composition varied from copper or arsenical copper (copper alloyed with arsenic -As>2%), low tin bronzes with some arsenic contents, binary bronze alloys (~9-12% Sn) and leaded bronzes. Analysis of crucibles with adherent slag provided some hints about production the metal methods: smelting/melting operations.

Also, radiocarbon dating of some contexts have allowed to set up a chronological

framework where the metallurgical evolution, namely changes in the 'chaîne opératoire' and in the content of the alloys used for the manufacture of the artefacts, could be anchored. In this way, the introduction of the bronze alloys in the Southwestern Iberia was dated to the second quarter of the II Millennium BC, perhaps as imports, but earlier than it was thought, while the production of bronze alloys started in this region during the third quarter of the II Millennium BC.

Study on the Portuguese silverware alloys from the XV - XVII centuries, was pursued to establish their composition patterns, technological production and provenance. Analyses of about 100 coins of that period belonging to the *Imprensa Nacional Casa da Moeda* have identified particular compositional patterns ascribed to reigns and production centres (Lisbon, Porto).

#### Other

The EAC group was highly engaged in education and training of MSc and PhD students in collaboration with different Universities. Technical services, including elemental and isotopic analysis and radiocarbon dating were carried out for Public and Private Institutions.

## **RELEVANT PUBLICATIONS**

- P.M. Carreira, J.M. Marques, D. Nunes, F. A. Monteiro Santos, R. Gonçalves, A. Pina, A. Mota Gomes, Isotopic and geochemical tracers in the evaluation of groundwater residence time and salinization problems at Santiago Island, Cape Verde, *Procedia Earth and Planetary Science*, 7, 113-117 (2013), doi:10.1016/j.proeps.2013.03.063.
- E. Figueiredo, R.J.C. Silva, M.F. Araújo, F.M. Braz Fernandes. Multifocus optical microscopy applied to the study of archaeological metals, *Microscopy and Microanalysis* 19/5, 1248–1254 (2013). (doi:10.1017/S1431927613001608)
- J.M. Marques, H. Graça, H.G.M. Eggenkamp, O. Neves, P.M. Carreira, M.J. Matias, B. Mayer, D. Nunes, V.N. Trancoso, Isotopic and hydrochemical data as indicators of recharge areas, flow paths and Water rock interaction in the Caldas da Rainha Quinta das Janelas thermomineral carbonate rock aquifer (Central Portugal), *Journal of Hydrology*, 476, 302-313 (2013), doi: 10.1016/j.hydrol.2012.10.047.
- J.M.M. Martins, A.M.M. Soares (2013). Marine Radiocarbon Reservoir Effect in Southern Atlantic Iberian Coast. *Radiocarbon*. 55(2-3), 1123-1134.
- P. Valério, A. M. M. Soares, R.J.C. Silva, M. F. Araújo, P. Rebelo, N. Neto, R. Santos, T. Fontes. Bronze production in Southwestern Iberian Peninsula: the Late Bronze Age metallurgical

workshop from Entre Águas 5 (Portugal). Journal of Archaeological Science, 40/1, 439-451 (2013).

## FUNDS

Project/Service	Reference	Start/End	2013
Early Metallurgy in the Portuguese	PTDC/HIS-	01 April 2010 –	
Territory (EARLYMETAL). Leading	ARQ/110442/2008	30 September	50,907.66
Institution IST/ITN, Coordinator: M.F.		2013	
Araújo			
Recent evolution of Portuguese W	PTDC/CTE-	01 January 2010	5,333.41
coast estuaries: high resolution studies	GIX/105370/2008	– 30 June 2013	
from marshes geological record			
(WesTLog). Leading Institution			
FCUL; IST/ITN Coordinator: M.F.			
Araújo			
Fluvio-marine interactions over the	PTDC/CTE-	01 February	26,144.94
last 5000 yrs (FMI 5000). Leading	GIX/104035/2008	2010; 31 July	
Institution IGOT-UL; IST/ITN		2013	
Coordinator: A.M.M. Soares			
Radiocarbon dating	Portucel - Emp. Prod. de		4,120.50
	Pasta de Papel, SA		
	Ozecarus, Serviços		
	Arqueológicos, Lda,		
	Município de Torres		
	Vedras		
Advanced training	IAEA		4,480.80
Isotope Hydrology (Services)	Univ. Madeira		300.00
The Cabeço de Vide mineral waters	PTDC/AAG-	2013 - 2015	8,070.00*
(Central Portugal): a natural analogue	MAA/2891/2012		
to increase understanding of the origin			
of life on Earth and possibly elsewhere			
(ORVITER). Leading Institution IST,			
IST/ITN Coordinator: P.M Carreira			
\			99,357.31

\*Project is being administrated by IST-ID, since the coordinator is an IST (CEPGIST/CERENA) member. The amount attributed to the IST/ITN ( $C^2TN$ ) team has never been transferred (including overheads) and all the acquisitions (including those of IST/ITN) are being performed through the project coordinator.

## TEAM RESEARCHERS

**NAME: Maria de Fátima Duarte de Araújo** CATEGORY: Principal Researcher IST-ID: 5372

#### ACTIVITIES

Nº	Activity Description	R&D (%)
1	Ancient Metallurgy of the Portuguese Territory - Provenance, metal	30
	composition and manufacturing techniques	
2	Characterization and provenance of metallic artefacts museological	10
	collections.	
3	Sedimentary geochemistry of the Portuguese coastal area	20
4	Coordination of the Environmental and Analytical Chemistry Group	15

5	Student supervision	25
6	PRESTAÇÃO SERVIÇOS/Other	
Total		100

## WORK SUMMARY

N°	Work Summary and Main Achievements
1	Studies on the elemental and microstructural characterization of archaeological metallic artefacts and production remains (crucibles, slags, prills and metallurgical debris) from various archaeological sites of the Portuguese territory have been carried out to investigate the metallurgical evolution from Chalcolithic, Early/Middle Bronze Age period till Iron Age. Artefact collections (more than one hundred) came from all over the territory, namely the North-eastern area (mostly Early/Middle Bronze Age); Estremadura including Vila Nova de S. Pedro, Moita da Ladra e Outeiro Redondo settlements (Chalcolithic); and Southern zone, including grave goods and artefacts from pits at Montinhos 6 and Torre Velha 12 (Middle Bronze Age); and bronze collections (Moita da Ladra, Évoramonte, Mangancha, Outeiro do Circo and Almeirim (Late Bronze Age) and Cabeço Redondo (Iron Age).
	Artefacts present different typologies, variable compositions and different thermo- mechanical treatment/cycles, in some cases dependent on the use of artefacts. Chemical composition varied from copper or arsenical copper (copper alloyed with arsenic - As>2%), low tin bronzes with some arsenic contents, binary bronze alloys (~9-12% Sn) and leaded bronzes. Analysis of crucibles with adherent slag provided some hints about the metal production methods: smelting/melting operation.
2	Study on the Portuguese silverware alloys from the XV till XVII centuries, mostly from the large collection of National Museum of Ancient Art in Lisbon (MNAA), was pursued aiming at the establishment of composition patterns, technological production and provenance of these museological silver artefacts. Coins (~100) from same period belonging to the <i>Imprensa Nacional Casa da Moeda, SA</i> collections were analysed using non invasive techniques to ascertain about compositional differences attributable to reigns/production centres (Lisbon, Porto).
3	Elemental and isotopic geochemical approaches were applied in the study of sedimentary coastal systems evolution. Sedimentary records of salt-marshes from protected settings of several estuaries of the W coast (Minho, Tagus Sado and Mira rivers) were studied to evaluate recent environmental changes. The chronological framework was established by using a combination of techniques (210Pb, 137Cs and 14C). Some enhanced values anthropogenic trace elements (e.g. Cu, Zn, As and Pb), determined in specific periods could be related to the effects of Human occupation and industrialization. Temporal variations on the elemental contents and isotopic composition of sedimentary sequences could be related with different contribution of the terrestrial sources or associated with a dominant marine contribution.
4	Specific duties involve the coordination of the EAC group, including the management and maintenance of some laboratories and infrastructures, coordination of technical staff, research planning and discussions with the other research team members, organization of team reports, processes of acquisition, and elaboration of project proposals.
5	Several PhD thesis are running, under my supervision or co-supervision, in collaboration with <i>Faculdade de Ciências e Tecnologia</i> , <i>Universidade Nova de Lisboa</i> . The PhD dissertation of Maria João Furtado (under my supervision) "Chinese coins in copper based alloys: elemental and microstructural characterization" was defended. This year, MSc. Filipa Lopes and Susana Sousa Gomes have started their PhD programs "The copper metallurgy at the <i>Lusitania</i> in Roman period: Archaeometallurgical study of <i>Situlae</i> of Conimbriga" and "Lead in the Roman architecture of <i>Lusitania</i> : provenance and metallurgical techniques used in the hydraulic system of Conimbriga", also under my supervision. Other PhD works (co-supervision) are currently being developed: Filipa Pereira (The first metallurgical steps in the prehistory of the Portuguese Estremadura) and Rui Borges (Portuguese silverware alloys

from the fifteenth to seventeenth centuries – Characterization and provenance of silver alloys). Two research students (Ana Medeiros and Vera Lopes) have developed research work on geochemistry of coastal sediments (WesTLog project, PTDC/CTE-GIX/105370/2008).

#### PUBLICATIONS

- Susana Sousa Gomes, Elin Figueiredo, Maria Fátima Araújo, Filipa Lopes, João Carlos Senna-Martinez (2013). Isotopic lead characterization of archaeological bronzes from Fraga dos Corvos (N Portugal). *International Journal of Conservation Science*, 4, SI, 661-672 (2013).
- Pedro Valério, António M. Monge Soares, Maria Fátima Araújo, Rui J.C. Silva, Filipe J. C. Santos. The distinctive grave goods from Palhais (Beja, Portugal). New insights into the metallurgical evolution under Orientalizing influence in the southwestern end of Iberia. *Trabajos de Prehistoria*, 70, N.º 2, 361-371 (2013). (doi: 10.3989/tp.2013.12119)
- E. Figueiredo, R.J.C. Silva, M.F. Araújo, F.M. Braz Fernandes. Multifocus optical microscopy applied to the study of archaeological metals, *Microscopy and Microanalysis* 19/5, 1248–1254 (2013). (doi:10.1017/S1431927613001608).
- M.A. Barreiros, T. Pinheiro, P.M. Felix, C. Franco, M. Santos, F. Araújo, M.C. Freitas, S.M. Almeida SM. Exhaled Breath Condensate as a biomonitor for metal exposure: A new analytical challenge. *J. Radional Nucl Chemistry* 297/3, 377-382 (2013). (doi:10.1007/s10967-012-2366-x).
- Elin Figueiredo, M. Fátima Araújo, Rui J.C. Silva, Raquel Vilaça. Characterisation of a Protohistoric bronze collection by micro-EDXRF. *Nuclear Instruments and Methods in Physics Research B* 296, 26–31 (2013).
- F. Pereira, R.J.C. Silva, A. M. M. Soares, M. F. Araújo. The role of arsenic in Chalcolithic copper artefacts insights from Vila Nova de São Pedro (Portugal). *Journal of Archaeological Science*, 40/4, 2045-2056 (2013).
- P. Valério, A. M. M. Soares, R.J.C. Silva, M. F. Araújo, P. Rebelo, N. Neto, R. Santos, T. Fontes. Bronze production in Southwestern Iberian Peninsula: the Late Bronze Age metallurgical workshop from Entre Águas 5 (Portugal). *Journal of Archaeological Science*, 40/1, 439-451 (2013).
- P. Duarte, L. Silva, A. Mateus, M. F. Araújo, M. Reis, R. Trindade, Isabel Paiva. Radiological and geochemical characteristics of an ultramafic massif (NE Portugal) regarding the site aptness to host a near surface repository for low and intermediate level radwaste. *Environmental Earth Sciences*, 68 (2), 547-557 (2013).
- M.F. Araújo, R.J.C. Silva, J.C. Senna-Martinez, P. Valério, E. Figueiredo, A. Monge Soares. Investigação em Arqueometalurgia em Portugal: resultados recentes e perspectivas futuras de uma equipa multidisciplinar, *Al Madan* 17 (2), 69-78 (2013).
- J.C. Senna-Martinez, E. Luís, J. Pimenta, E. Figueiredo, F. Lopes, M.F. Araújo, R.J.C. Silva. Nota sobre um machado plano em bronze de "Tipo Bujões" de Vila Franca de Xira, *Cira Arqueologia* 2, 96-103 (2013).
- E. Porfírio, M. Serra, P. Valério, A.M. Monge Soares, M. Fátima Araújo, R.J.C. Silva, Os metais da Idade do Bronze de Torre Velha 3 (Serpa) e os seus contextos arqueológicos, in *Arqueologia em Portugal. 150 Anos* (eds. J.M. Arnaud, A. Martins, C. Neves), Associação dos Arqueólogos Portugueses, Lisboa, 563-571 (2013), ISBN: 978-972-9451-52-2.
- S.S. Gomes, P. Valério, M. Fátima Araújo, A.M. Monge Soares, A. Guerra. Caracterização isotópica do Pb em glandes plumbeae do Alto dos Cacos (Almeirim), in *Arqueologia em Portugal*. *150 Anos* (eds. J.M. Arnaud, A. Martins, C. Neves), Associação dos Arqueólogos Portugueses, Lisboa, 835-839 (2013), ISBN: 978-972-9451-52-2.
- P. Valério, A.M. Monge Soares, M. Fátima Araújo, R.J.C. Silva, E. Porfírio, M. Serra, Estudo de metais e vestígios de produção do povoado fortificado do Bronze Final do Outeiro do Circo

(Beja), in Arqueologia em Portugal. 150 Anos (eds. J.M. Arnaud, A. Martins, C. Neves), Associação dos Arqueólogos Portugueses, Lisboa, 609-615 (2013), ISBN: 978-972-9451-52-2.

- J.C. Senna-Martinez, J. Reprezas, E. Figueiredo, F. Lopes, S.S. Gomes, M.F. Araújo, R.J.C. Silva, Metal Artefacts of Mediterranean Affiliation from Fraga dos Corvos Habitat Site (Eastern Trás-os-Montes, Portugal): A First Appraisal, *O Arqueólogo Português*, Série V, 2, 239-261 (2013).
- Pedro Valério, Mário Monteiro, António M. Monge Soares, Maria de Fátima Araújo, The bracelet from São Pedro (Moura) ancient or modern? *Estudos de Arqueologia e Património Cultural*, 1, 1-3 (2013).

## COMMUNICATIONS

- Malhada do Vale da Água novos dados sobre a metalurgia do Bronze Pleno no Sudoeste, P. Valério, L. Baptista, S. Gomes, R. Pinheiro, S. Fernandes, A.M. Monge Soares, M. Fátima Araújo. VII Encontro de Arqueologia do Sudoeste Peninsular, Aroche Serpa, Spain Portugal, Nov 29 Dec 1 (2013), poster.
- Os Machados Bujões/Barcelos e as Origens da Metalurgia do Bronze na Fachada Atlântica Peninsular, J.C. Senna-Martinez, E. Luís, J. Reprezas, F. Lopes, E. Figueiredo, M.F. Araújo, R. J.C. Silva, I Congresso da Associação dos Arqueólogos Portugueses (AAP), Lisbon, Portugal, Nov 21-24 (2013).
- Ancient copper and bronze axes from the Portuguese territory: an elemental and microstructural study by micro-EDXRF, Optical Microscopy and SEM-EDS, F. Lopes, E. Figueiredo, M.F. Araújo, R.J.C. Silva, J.C. Senna-Martinez and E. Luís, 1st International Conference on Innovation in Art Research and Technology, Évora, Portugal, July 10-13 (2013), oral.
- Estudo de metais e vestígios de produção do povoado fortificado do Bronze Final do Outeiro do Circo (Beja), P. Valério, A.M. Monge Soares, M. Fátima Araújo, R.J.C. Silva, E. Porfírio, M. Serra, I Congresso da Associação dos Arqueólogos Portugueses (AAP), Lisbon, Portugal, Nov 21-24 (2013), poster.
- Os metais da Idade do Bronze de Torre Velha 3 (Serpa) e os seus contextos arqueológico, E. Porfírio, M. Serra, P. Valério, A.M. Monge Soares, M. Fátima Araújo, R.J.C. Silva, I Congresso da Associação dos Arqueólogos Portugueses (AAP), Lisbon, Portugal, Nov 21-24 (2013), oral.
- Caracterização isotópica do Pb em glandes plumbeae do Alto dos Cacos (Almeirim), Susana Sousa Gomes, Pedro Valério, Maria Fátima Araújo, António Monge Soares, Amilcar Guerra, I Congresso da Associação dos Arqueólogos Portugueses (AAP), Lisbon, Portugal, Nov 21-24 (2013), poster.
- Estudo das Evidências de Produção Metalúrgica no Outeiro Redondo (Sesimbra), F.Pereira, M.J. Furtado, A.M.Monge Soares, M.F.Araújo, R.J.C.Silva, J.L.Cardoso, Congresso em Arqueologia da Associação dos Arqueólogos Portugueses (AAP), Lisbon, Portugal, Nov 21-24 (2013), poster.
- *Metallurgical Production Evidences in Outeiro Redondo, Sesimbra (Portugal),* M.J. Furtado, F. Pereira, A.M. Monge Soares, M.F. Araújo, R.J.C. Silva, J.L. Cardoso, 1<sup>st</sup> International Conference on Innovation in Art Research and Technology, Évora, Portugal, July 10-13 (2013), poster.
- *Metallurgical Production Evidences in Outeiro Redondo, Sesimbra (Portugal).* M.J. Furtado, F. Pereira, A.M. Monge Soares, M.F. Araújo, R.J.C. Silva, J.L. Cardoso, 3<sup>as</sup> Jornadas do CENIMAT, CENIMAT-13N, Monte de Caparica, Portuga), June 2013.
- Isotopic lead characterization of archaeological bronzes from Fraga dos Corvos (N Portugal), S.S. Gomes, E. Figueiredo, M.F. Araújo, F. Lopes, J.C. Senna-Martinez, 1<sup>st</sup> International Conference on Innovation in Art Research and Technology, Évora, Portugal, July 10-13 (2013), poster.
- Neutron Imaging Techniques in the study of Archaeological Metals: preliminary results from the Portuguese Research Nuclear Reactor, E. Figueiredo, M.A. Stanojev Pereira, J.G. Marques, J.P. Santos, M.F. Araújo, 1<sup>st</sup> International Conference on Innovation in Art Research and Technology, Évora, Portugal, July 10-13 (2013), poster.

- Copper plus Tin plus People Co-smelting experimentation in northwestern Iberia, A.Lackinger, B. Comendador, E. Figueiredo, M.F. Araújo, R.J.C. Silva, S. Rovira, 7<sup>th</sup> Experimental Archaeology Conference, Cardiff, Wale, Jan 11-12 (2013), poster.
- Geoquímica do Registo Sedimentar Holocénico: Impactes antrópicos e evolução paleoambiental na plataforma portuguesa, Maria Fátima Araújo, António Monge Soares, João Alveirinho Dias, III Meeting BRASPOR - Scientific network on Interactions Man-Environment on Coastal Areas, Ponte de Lima, Portugal, 22-24 July (2013), invited talk.
- Datação pelo radiocarbono de formações eolianíticas da costa sul portuguesa, J.M.M. Martins, O. Ferreira, J.M.A. Dias, A.M.M. Soares, A.M.M., M.F. Araújo (2013), III Meeting BRASPOR Scientific network on Interactions Man-Environment on Coastal Areas, Ponte de Lima, Portugal, 22-24 July (2013), poster.
- Arqueometalurgia em Portugal: metodologias analíticas e resultados recentes, M. Fátima Araújo, Workshop Arqueologia e outras ciências: que presente e que futuro?, Secção de Arqueologia da Sociedade de Geografia de Lisboa, Portugal, April 17(2013), invited talk.

## EDUCATION

- Supervisor, PhD. Thesis, *Chinese coins in copper based alloys: elemental and microstructural characterization*, by Maria João Narciso Furtado de Melo Pereira, Departamento de Conservação e Restauro, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, March 2013.
- Member of the jury, PhD. Thesis, *Chinese coins in copper based alloys: elemental and microstructural characterization*, by Maria João Narciso Furtado de Melo Pereira, Departamento de Conservação e Restauro, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, March 2013.
- Member of the jury, MSc. Thesis, *Análise Elementar e Isotópica de Sedimentos Estuarinos do Rio Alcabrichel (Torres Vedras) e da Ribeira de Bensafrim (Lagos)*, by Paulo Jorge Cesário Portela, Departamento de Geologia, Faculdade de Ciências, Universidade de Lisboa, June 3.
- Invited Lecturer, in "Energy Dispersive X-ray Fluorescence Spectrometry" in the framework of one semester course on "Examination and Analysis Methods I" for the Master degrees in "Conservation and Restoration" and "Conservation Sciences", FCT/UNL.
- Member of the core team of the *PhD. Course in the Conservation and Restoration of Cultural Heritage*, approved in 2013 (financed by the FCT).

## PROJECTS

- *Early Metallurgy in the Portuguese Territory* (EarlyMetal) PTDC/HIS-ARQ/110442/2008. Leading Institution IST/ITN. Coordinator: M. Fátima Araújo (30%).
- Evolução recente dos estuários da costa oeste portuguesa: estudo do registo geológico dos sapais em alta resolução (WesTLog) - PTDC/CTE/105370/2008. Leading Institution FCUL. IST/ITN Coordinator: M. Fátima Araújo (10%).

## **CONFERENCE ORGANIZATION / SCIENTIFIC COMITTEES**

• Scientific Commission of the *III Meeting BRASPOR* - *Scientific network on Interactions Man-Environment on Coastal Areas*, Ponte de Lima, Portugal, 22-24 July (2013).

## COLLABORATIONS

• Jose Maria de La Rosa, Instituto de Recursos Naturales y Agrobiología, IRNAS-CSIC, Seville, Spain, May and December, Collaboration research work on environmental geochemistry of fluvial and coastal environments.

#### **NAME: António Manuel Monge Soares** CATEGORY: Principal Researcher IST-ID: 25351

## ACTIVITIES

N°	Activity Descrition	<b>R&amp;D</b> (%)
1	Project PTDC/HIS-ARQ/110442/2008, Early Metallurgy in the Portuguese	20
	Territory (EARLYMETAL)	
2	Project PTDC/CTE-GIX/105370/2008, Recent evolution of Portuguese W	5
	coast estuaries: high resolution studies from marshes geological record	
	(WesTLog)	
3	Project PTDC/CTE-GIX/104035/2008, Fluvio-marine interactions over the last	5
	5000 yrs (FMI 5000)	
4	Supervision of the Radiocarbon and IRMS Laboratories	40
5	Supervision of PhD and M. Sc. Thesis	25
6	Services	5
Total		100

## WORK ACTIVITIES

Nº	Work Activity and Main Achievements
1	Metallurgical activities include a series of processes which begin with the concentration and
	subsequent reduction of ores and continue with the treatment of the metal, including the
	shaping of the object. In this project, that has is terminus during 2013, the chemical and
	structural characterization of final archaeological metallic artefacts, tools and materials
	employed in the metallurgical process (ores, moulds, crucibles and tuyeres) as well as by-
	products that were originated during metallurgical operations (slags and metal droplets)
	were made. Several archaeological and metallurgical contexts were analyzed. On the other
	hand, radiocarbon dating of the most part of these contexts have allowed to set up a
	chronological framework where the metallurgical evolution, namely changes in the "chaine
	operatorie and in the content of the alloys used for the manufacture of the arteracts, could
	be anchored. In this way, the introduction of the bronze alloys in the Southwestern identation was dated to the second quarter of the II Millennium PC, parkens as imports, but earlier then
	it was thought, while the production of bronze allows started in this ragion during the last
	auarter of the II Millennium BC
2	Estuaries are highly productive environments that have been strongly impacted by human
2	activities during the last 200 years but where some natural profound changes may also
	happen. Data from Portuguese marshes are essential to support reliable interpretation of the
	geological record in a regional as well as in a global context. The IST/ITN team of this
	project was in charge of geochemical analysis of sediment cores, namely those concerning
	the determination of elemental (C,N) and isotopic ( $\delta^{13}$ C, $\delta^{15}$ N) composition of the sediment
	samples.
3	The estuarine environment is one of the most sensitive areas to climatic change and sea level
	rise as it constitutes an interface between fluvial and marine influence and supports not only
	important wetland biodiversity but also strategic economic activities. Over the last 5000
	years different trends of sea level, climatic fluctuations, Bond events or humid episodes
	have been recorded in the Iberian Peninsula, as well as the increase of human intervention in
	the landscape, particularly sensitive since the Middle Bronze Age, all imprinting in the
	filling up of alluvial plain estuaries. In this Project estuarine sedimentary organic matter was
	characterized using geochemical analysis, including elemental (C, N) and stable isotope
	(0.°C, 0.°N) analysis. Radiocarbon dating was used in order to set up the chronological
	iramework where to put the geochemical changes identified the cores study. Data
	concerning the variability of those proxies along the sedimentary record allow to identify

	changes in the predominant sedimentary sources, the evolution of fluvial and marine
	influences, the responses to climatic events and the impact of land use changes in the
	estuarine environmental conditions over the last 5000 years.
4	The radiocarbon dating and the IRMS laboratories are unique in Portugal. If the radiocarbon
	lab started to work in the eighties, the IRMS only started two years ago. Although the first
	one works in a routine base each sample is unique and, consequently, the decontamination
	procedure, the time for the benzene synthesis and the set up of the batch for counting is of
	my responsibility. Also the interpretation of results concerning their reliability. As
	mentioned before the mass spectrometry of light elements (C; O; N) using very small
	samples is new in Portugal and a great care is needed in order to settle the ideal conditions
	for measurements. All these procedures are highly time consuming.
5	Several PhD and M. Sc. Thesis have been supervised by me in the field of radiocarbon and
	environmental isotope applications and also in the field of Archaeometallurgy. Radiocarbon
	and environmental stable isotopes (namely C, O and N) are of paramount importance in the
	study of palaeoenvironments and in Palaeoclimatology (two of the Research Projects
	mentioned above were concerned with these fields). Two of the Thesis are in these fields,
	while the other two are concerned with the study of Pre-historic and Roman metallurgies,
	fields still poorly developed in Portugal.
6	As mentioned above the laboratories that I am in charge are unique in our country and for
	that reason since the start of the laboratories our team are concerned in order to offer good
	services to people interested in using these capabilities (archaeologists, geologists,
	oceanographers). Nevertheless, due to the lack of upgrade of the radiocarbon laboratory with
	the new technique (AMS), archaeologists and geologists are using foreign laboratories
	instead of the Portuguese one.

## PUBLICATIONS

- MARTINS, V.A.; SANTOS, J.F.; MACKENSEN, A.; DIAS, J.A.; RIBEIRO, S.; MORENO, J.C.; SOARES, A.M.; FRONTALINI, F.; REY, D.; ROCHA, F. (2013). The sources of the glacial IRD in the NW Iberian Continental Margin over the last 40 ka. *Quaternary International*. 318, 128-138.
- MARTINS, V.A.; DIAS, J.A.; BERNARDES, C.; RUBIO, B.; BERNABEU, A.; REY, D.; SOARES, A.M.; SOBRINHO, F.; LAUT, L.M.; FRONTALINI, F.; TERROSO, D.; MIRANDA, P.; FERNÁNDEZ-FERNÁNDEZ, S.; RODRIGUES, M.A.; FIGUEIRA, R.; SOUSA, S.; AMARAL, P.; MAHIQUES, M.; ROCHA, F. (2013). The ITRAX core scanner, a useful tool to distinguish anthropic vs. Climatic influences in lagoon of Aveiro (Portugal). Journal of Coastal Research. Special Issue 65, 70-75.
- MARTINS, J.M.M.; SOARES, A.M.M. (2013). Marine Radiocarbon Reservoir Effect in Southern Atlantic Iberian Coast. *Radiocarbon*. 55(2-3), 1123-1134.
- VALÉRIO, P.; SOARES, A.M.M.; SILVA, R.J.C.; ARAÚJO, M.F.; REBELO, P.; NETO, N.; SANTOS, R.; FONTES, T. (2013). Bronze production in Southwestern Iberian Peninsula: the Late Bronze Age metallurgical workshop from Entre Águas 5 (Portugal). Journal of Archaeological Science. 40(1), 439-451.
- VALÉRIO, P.; SOARES, A.M.M.; ARAÚJO, M.F.; SILVA, R.J.C.; F.J.C. Santos (2013). The distinctive grave goods from Palhais (Beja, Portugal). New insights into the metallurgical evolution under Orientalizing influence in the south-western end of Iberia. *Trabajos de Prehistoria*. 70(2), 361-371.

## Other Publications

• CARVALHO, F.P.; OLIVEIRA, J.M.; SOARES, A.M. (2013). <sup>210</sup>Pb-Excess and Sediment Accumulation Rates at the Iberian Continental Margin. In *Isotopes in Hydrology, Marine Ecosystems and Climate Change Studies (proceedings of the International Symposium held in Monaco, 27 March-1April, 2011)*. Vol 1, 451-462.

- DELGADO DOMÍNGUEZ, A.; SOARES, A.M.M.; QUEIROZ, P.F. (2013). A Datação pelo Radiocarbono de Elementos de Rodas Romanas de Madeira para Elevação de Água nas Minas de Rio Tinto. *Revista Onoba.* 1, 275-284.
- De MAN, A.; SOARES, A.M.M. (2013). Elementos para uma definição dos horizontes tardios. In J.L. Quiroga (ed.), *Conimbriga tardo-antigua y medieval. Excavaciones arqueológicas en la domus tancinus (2004-2008) (Condeixa-a-Velha, Portugal)*. BAR International Series 2466. 209-220.
- PIMENTA, J.; SOARES, A.M.M.; MENDES, H. (2013). Cronologia Absoluta para o Povoado Pré-Romano de Santa Sofia (Vila Franca de Xira). *Cira-Arqueologia*. 2, 181-194.
- ARAÚJO, M.F.; SILVA, R.J.; SENNA-MARTINEZ, J.C.; VALÉRIO, P.; FIGUEIREDO, E.; SOARES, A.M. (2013). Investigação em Arqueometalurgia em Portugal. Resultados recentes e perspectivas futuras de uma equipa multidisciplinar. *Al-Madan (on line)*. 17(2), 69-78.
- PORFÍRIO, E.; SERRA, M.; VALÉRIO, P.; SOARES, A.M.M.; ARAÚJO, M.F.; SILVA, R.J.C. (2013). Os metais da Idade do Bronze de Torre Velha 3 (Serpa) e os seus contextos arqueológicos. In J.M.Arnaud, A. Martins, C. Néves (eds.), Arqueologia em Portugal 150 anos. Lisboa: Associação dos Arqueólogos Portugueses. 563-571.
- PEREIRA, F; FURTADO, M.J.; SOARES, A.M.M.; ARAÚJO, M.F.; SILVA, R.; CARDOSO, J.L. (2013). Estudo das evidências de produção metalúrgica no Outeiro Redondo (Sesimbra). In J.M. Arnaud, A. Martins, C. Néves (eds.), Arqueologia em Portugal 150 anos. Lisboa: Associação dos Arqueólogos Portugueses. 463-469.
- VALÉRIO, P.; SOARES, A.M.M.; ARAÚJO, M.F.; SILVA, R.; PORFÍRIO, E.; SERRA, M. (2013). Estudo de metais e vestígios de produção do povoado fortificado do Bronze Final do Outeiro do Circo (Beja). In J.M.Arnaud, A. Martins, C. Néves (eds.), Arqueologia em Portugal 150 anos. Lisboa: Associação dos Arqueólogos Portugueses. 609-615.
- GOMES, S.S.; VALÉRIO, P.; ARAÚJO, M.F.; SOARES, A.M.M.; GUERRA, A. (2013). Caracterização isotópica do Pb em glandes plumbeae do Alto dos Cacos (Almeirim). In J.M.Arnaud, A. Martins, C. Néves (eds.), Arqueologia em Portugal 150 anos. Lisboa: Associação dos Arqueólogos Portugueses. 835-839.
- PEREIRA, C.; SOARES, A.M.M.; SOARES, R.M. (2013). Os mausoléus da villa romana de Pisões: a morte no mundo rural romano. *Revista Portuguesa de Arqueologia*. 16, 303-321.
- ARRUDA, C.; SOARES, A.M.M.; FREITAS, V.T.; OLIVEIRA, C.F.; MARTINS, J.M.M.; PORTELA, P.J.C. (2013). A cronologia relativa e absoluta da ocupação sidérica do Castelo de Castro Marim. *Saguntum.* 45, 101-114.

## COMMUNICATIONS

Oral

- PORFÍRIO, E.; SERRA, M.; VALÉRIO, P.; SOARES, A.M.M.; ARAÚJO, M.F.; SILVA, R.J.C. (2013). Os metais da Idade do Bronze de Torre Velha 3 (Serpa) e os seus contextos arqueológicos. I Congresso da Associação dos Arqueólogos Portugueses (Lisboa, 21-24 November 2013).
- VALÉRIO, P.; SOARES, A.M.M.; ARAÚJO, M.F.; SILVA, R.; PORFÍRIO, E.; SERRA, M. (2013). Estudo de metais e vestígios de produção do povoado fortificado do Bronze Final do Outeiro do Circo (Beja). I Congresso da Associação dos Arqueólogos Portugueses (Lisboa, 21-24 November 2013).
- BARGÃO, P.; SOARES, A.M.M. (2013). **Pisões 5: um sítio de fossas nos Barros de Beja**. *VII Encuentro de Arqueologia del Suroeste Peninsular* (Aroche/Serpa, 29 November-1 December 2013).
- ARAÚJO, M.; SOARES, A.M.M.; CUNHA, P.P.; GOMES, A.; VIEIRA, M. (2013). Anthropic interference versus littoral dynamics: Aguda (Northern Portugal) breakwater, Holocene evolution and recent coastal erosion. 8<sup>th</sup> International Conference (AIG) on Geomorphology. (Paris, 27-31 August 2013).
- PORTELA, P.; MARTINS, J.; SOARES, A.M.M.; PEREIRA, A.R. (2013). Age modelling of Mid-Holocene sedimentar sequences using a Bayesian approach. 8<sup>th</sup> International Conference (AIG) on Geomorphology. (Paris, 27-31 August 2013).

• PEREIRA, A.R.; RAMOS, C.; TRINDADE, J.; DANIELSEN, R.; SOARES, A.M.M.; PORTELA, P.J.C.; MARTINS, J.M.M. (2013). Infilling constraints of the Estuary of River Alcabrichel since Middle Holocene. 8<sup>th</sup> International Conference (AIG) on Geomorphology. (Paris, 27-31 August 2013).

## Poster

- MARTINS, J.M.M.; FERREIRA, O.; DIAS, J.M.A.; SOARES, A.M.M.; ARAÚJO, M.F. (2013).
   Datação pelo radiocarbono de formações eolianíticas da costa sul portuguesa. III Encontro da Rede BRASPOR "Ambientes Costeiros e Bacias Hidrográficas" (Ponte de Lima, 22-24 July 2013).
- PEREIRA, F; FURTADO, M.J.; SOARES, A.M.M.; ARAÚJO, M.F.; SILVA, R.; CARDOSO, J.L. (2013). Estudo das evidências de produção metalúrgica no Outeiro Redondo (Sesimbra). I Congresso da Associação dos Arqueólogos Portugueses (Lisboa, 21-24 November 2013).
- GOMES, S.S.; VALÉRIO, P.; ARAÚJO, M.F.; SOARES, A.M.M.; GUERRA, A. (2013). Caracterização isotópica do Pb em glandes plumbeae do Alto dos Cacos (Almeirim). I Congresso da Associação dos Arqueólogos Portugueses (Lisboa, 21-24 November 2013).
- DEUS, M.; FERNANDES, R.; BARBOSA, S.; TÁTÁ, F.; RODRIGUES, P.; SOARES, A.M.M. (2013). Algar do Guano – Cova da Adiça (Sobral da Adiça, Moura). VII Encuentro de Arqueologia del Suroeste Peninsular (Aroche/Serpa, 29 November-1 December 2013).

## Other

- *O radiocarbono quatro revoluções*, Sociedade de Geografia de Lisboa, 17 April 2013. Invited talk.
- *O Bronze do Sudoeste uma visão a partir da margem esquerda do Guadiana*, Sociedade de Geografia de Lisboa, 7 November 2013. Invited talk.
- Lectures in "Isotope Analysis", "Radiocarbon dating" and "Luminescence Dating" in the framework of one semester course on "Examination and Analysis Methods II" for the Master degrees in "Conservation and Restoration" and "Conservation Sciences", FCT/UNL. Invited Lecturer.

## EDUCATION

- Supervisor, PhD Thesis, *Plataforma Continental Algarvia como Arquivo de Paleo-ambientes e Paleoclimas Holocénicos no Algarve Costeiro e Marinho. O papel do radiocarbono no seu estudo*, by José Manuel de Matos Martins, Universidade do Algarve.
- Supervisor PhD Thesis, *The first metallurgical steps in the prehistory of the Portuguese Estremadura*, by Filipa Isabel Peralta da Silva Pereira, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa.
- Supervisor PhD Thesis, *O chumbo na arquitectura Romana da Lusitânea: proveniência e técnicas metalúrgicas no sistema hidráulico de Conimbriga*, by Susana Alves de Sousa e Silva Gomes, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa.
- Supervisor, M. Sc. Thesis, Análise Elementar e Isotópica de Sedimentos Estuarinos do Rio Alcabrichel (Torres Vedras) e da Ribeira de Bensafrim (Lagos), by Paulo Jorge Cesário Portela, Faculdade de Ciências, Universidade de Lisboa.
- Jury membership of the PhD Thesis "*Chinese Coins in Copper Based Alloys: Elemental and Microstructural Characterization*" by Maria João Narciso Furtado de Melo Pereira, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa.

## PROJECTS

- PTDC/HIS-ARQ/110442/2008, Early Metallurgy in the Portuguese Territory (EARLYMETAL). IST/ITN Coordinator: M.F. Araújo
- PTDC/CTE-GIX/105370/2008, Recent evolution of Portuguese W coast estuaries: high resolution studies from marshes geological record (WesTLog). IST/ITN Coordinator: M.F. Araújo

- PTDC/CTE-GIX/104035/2008, Fluvio-marine interactions over the last 5000 yrs (FMI 5000). IST/ITN Coordinator: A.M.M. Soares
- EXPL/EPH-ARQ/2443/2013, Seasonality of prehistoric marine mollusk collection isotopic measurements of micro samples (CONCHAS). IST/ITN Coordinator: A.M.M. Soares (submitted).

## SCIENTIFIC COMMITTEES

- Member of Scientific Committee of the Congress "Arqueologia em Portugal 150 Anos" (Portuguese Archaeologists Association).
- Member of the Scientific Board of the Journal "Quaternary Studies" (Journal of the Portuguese Association for Quaternary Research).

## ACTIVITIES

Nº	Activity Description	<b>R&amp;D</b> (%)
1	Isotope geochemistry studies in cold and hot mineral groundwaters - Portugal	25
2	Assessment of groundwater salinity in coastline aquifers: natural vs. human	20
	interference	
3	Thesis supervision and laboratory formation	25
4	Laboratory Management and Setup of GNIP Stations (IAEA / WMO)	20
5	Services to the scientific community:	10
6		
Total		100

# WORK SUMMARY

N°	Work Summary and Main Achievements
1	Isotope geochemistry studies in cold and hot mineral groundwaters - Portugal
	Under the project PTDC/AAG-MAA/2891/2012, I&D work has been developed in Cabeço
	de Vide mineral waters. Isotopic measurements carried out: the local shallow HCO <sub>3</sub> -Mg
	groundwaters, discharging from the serpentinized dunites, and the Cabeço de Vide mineral
	waters have similar $\delta^2$ H and $\delta^{18}$ O mean values (around -27% and -4.5%, respectively),
	indicating that the mineral waters could have evolved ascribed to the deep infiltration of the
	shallow HCO <sub>3</sub> -Mg groundwaters. Besides the isotopic results obtained in the CH <sub>4</sub> are
	different from that of typical microbial or thermogenic gas, falling in the range of typical
	abiotic gas found in other serpentinizing sites. The origin of ethane is unknown at this stage;
	isotopic analyses are foreseen.
	Also, on the following up of previous I&D projects, works have been carried out in the N of
	Portugal (Minho and Trás-os-Montes region) mainland. The mineral groundwater resources
	are associated with major structural accidents. Throughout these structural accidents
	mineralized hot springs and a large number of cold CO <sub>2</sub> rich mineral waters are found.
	The research work carried out in mineral systems (Melgaço-Messagães and in the ultramafic
	rocks Bragança –Vila Real) aimed to establish relationship between mineral water and local
	infiltration of rainwater and to evaluate their isotopic composition, with main goals
	protection and management of natural resources. These investigations are essential to the
	exploitation and future development of regional water resources and to the delimitation of
	protection areas.
	As part of these studies, articles to international journals and international symposiums were
	submitted (2 published, 2 accepted for publication, 2 under revision).
2	Assessment of groundwater salinity in coastline aquifers: natural vs. human interference
	The increase in mineralization of groundwater resources is often due to inflow of saline
	(dense) water, during heavy withdrawals of fresh water from coastal aquifers, and/or
	mobilization of saline formation waters by overexploitation of inland aquifer systems. Not
	only sea-water mixing is responsible for water resource degradation. Among the different
	approaches, isotope techniques are particularly effective for identifying the source of salinity
	and renewability of groundwater. The variability in chemical and isotopic composition of
	deep and shallow groundwater indicates that differences exist in the salts origin in
	groundwater systems.
	As part of these studies papers have been submitted to international journals and
	international symposiums (3 published, 1 accepted for publication, 1 under revision).
3	Thesis supervision and laboratory formation
	Co-supervisor, PhD Thesis "Contribuição para o conhecimento da hidrogeologia da região
	do parque natural da Serra da Estrela (sector de Seia – Torre – Covilhã)", by Alexandra
	Maria Magalhaes Carvalho. Faculdade de Ciencias, Universidade do Porto.
	Supervisor, MsC Thesis "Assessment of marine intrusion using geochemical and isotope

	( <sup>18</sup> O, <sup>2</sup> H,and <sup>3</sup> H) data: Cap Bon, N- Tunisia", by António Osório Silva, Instituto Superior Técnico, Universidade Técnica de Lisboa.
	<ul> <li>Scientific Visitors:</li> <li>Visitor: Mona Abbas Ahmed (1 month)</li> <li>Affiliation: Egypt Nuclear Radiological Regulatory Authority (ENRRA)</li> <li>Objective: Isotope Hydrology. Training in routine operation of LGR for analysis of stable isotopes in water samples; 3H dating (tritium laboratory). Measurements and application of environmental isotopes as tools in water management problems (mixing; groundwater salinization; groundwater dating).</li> </ul>
	<ul> <li>Visitor: <i>Rasha Abd Allah Hussien Abd El-Fattah</i> (1 month)</li> <li>Affiliation: Egypt Nuclear Radiological Regulatory Authority (ENRRA)</li> <li>Objective: Isotope Hydrology. Training in routine operation of LGR for analysis of stable isotopes in water samples; <sup>3</sup>H dating (tritium laboratory). Measurements and application of environmental isotopes as tools in water management problems (mixing; groundwater salinization; groundwater dating).</li> </ul>
4	<ul> <li>Laboratory Management and Setup of GNIP Stations (IAEA / WMO)</li> <li>Responsible for the management and setup of the Mass Spectrometry Light Isotope Laboratory and Tritium Dating Laboratory in which two guidelines have been established:</li> <li>i) development of research projects or participation in research projects in collaboration with other national and international institutions, and</li> <li>ii) Services by performing isotopic analyses and / or as a consultant in Isotope Hydrology area.</li> </ul>
	with this goal the reinitiation of the National Network Isotopes in Precipitation was started with the help of the Isotope Hydrology Section – IAEA and WMO (World Meteorologicl Organization) with the supplying of 5 specifically suited rain collectors for the following stations: Porto (with the collaboration of Universidade do Porto); Serra da Estrela (with the collaboration of Parque Nacional da Serra da Estrela); Lisbon – IST/CTN; Évora (with the collaboration of Universidadde de Évora) and at Faro through the collaboration of Universidade do Algarve.
5	<i>Services to the scientific community</i> The provision of services to the scientific community has been achieved in the form of research projects, consultancy or in the form of provision of services. The entities through their investigators have used this service (determination of the isotopic composition of light isotopes: <sup>2</sup> H, <sup>3</sup> H, <sup>13</sup> C, and <sup>18</sup> O) during 2013 were: - Faculdade de Ciências da Universidade de Lisboa
	<ul> <li>- LNEG – Laboratório Nacional de Energia e Geologia</li> <li>- Universidade de Coimbra</li> <li>- Municipalities</li> </ul>

# PUBLICATIONS

- P.M. Carreira, J.M. Marques, D. Nunes, F. A. Monteiro Santos, R. Gonçalves, A. Pina, A. Mota Gomes, Isotopic and geochemical tracers in the evaluation of groundwater residence time and salinization problems at Santiago Island, Cape Verde, *Procedia Earth and Planetary Science*, 7, 113-117 (2013), doi:10.1016/j.proeps.2013.03.063.
- M.F. Ben Hamouda, P.M. Carreira, J.M. Marques, H. Eggenkamp, Geochemical and isotopic investigations to study the origin of mineralization of the coastal aquifer of Sousse, Tunisia, *Procedia Earth and Planetary Science*, 7, 61-64 (2013), doi:10.1016/j.proeps.2013.03.106.
- J. Espinha Marques, J.M. Marques, H.I. Chaminé, P.M. Carreira, P.E. Fonseca, f:A. Monteiro Santos, R. Moura, J. Samper, B. Pisani, J. Teixeira, J. Martins de Carvalho, F. Rocha, F.S. Borges,

Conceptualizing a mountain hydrogeologic system by using an integrated groundwater assessment (Serra da Estrela, Central Portugal): a review, *Geosciencies Journal*, 17 (3), 371-386 (2013), doi: 10.1007/s12303-013-0019-x.

- M. Bahir, R. el Moukhayar, N. Chkir, H. Chamchati, P. Galego Fernandes, P.M. Carreira, Groundwater Chemical Evolution in the Essaouira aquifer basin NW Morocco, *Open Journal of Modern Hydrology*, 3, 130-137 (2013), doi: 10.4236/ojmh.2013.33017.
- J.M. Marques, H. Graça, H.G.M. Eggenkamp, O. Neves, P.M. Carreira, M.J. Matias, B. Mayer, D. Nunes, V.N. Trancoso, Isotopic and hydrochemical data as indicators of recharge areas, flow paths and Water rock interaction in the Caldas da Rainha Quinta das Janelas thermomineral carbonate rock aquifer (Central Portugal), *Journal of Hydrology*, 476, 302-313 (2013), doi: 10.1016/j.hydrol.2012.10.047.
- P.M. Carreira, J.M. Marques, M.R. Carvalho, D. Nunes, M. Antunes da Silva, Isotopic and geochemical signatures of Melgaço CO<sub>2</sub> rich cold mineral waters, NW Portugal. International Atomic Energy Agency, *Proceedings Series Isotopes in Hydrology, Marine Ecosystems and Climate Change Studies*, Vol. 2, 63-71 (2013), ISSN 0074-1884; ISBN 978-92-0-135610-9.
- P.M. Carreira, J.M. Marques, C. Matos, O. Neves, D. Nunes, H. Graça, An isotopic ( $\delta^{18}$ O) approach in the assessment of shallow/thermomineral Water interactions in a karst region (Portugal), Book of Abstracts, 10<sup>th</sup> Applied Isotope Geochemistry Conference, *Central European Geology, Acta Geologica Hungarica*, 56 (2-3), 42-44 (2013), ISSN 1788-2281, doi: 10.1556/CEuGeol.56.2013.2-3.1.
- J.M. Marques, S. Vance, L. Christensen, G. Etiope, P. M. Carreira, S. Suzuki, Methane and ethane in hypheralkaline mineral waters in the Alter-do-Chão ultramafic intrusive massif (Cabeço de Vide Portugal), Book of Abstracts, 10<sup>th</sup> Applied Isotope Geochemistry Conference, *Central European Geology, Acta Geologica Hungarica*, 56 (2-3), 44-51 (2013), ISSN 1788-2281, doi: 10.1556/CEuGeol.56.2013.2-3.1.
- C. Matos, J.M. Marques, P.M. Carreira, Environmental aspects associated with the use of geothermal Resources: high vs. low enthalpies, *Técnica Revista de Engenharia*, 01, 44-50 (2013), ISSN 0040-1714.

## COMMUNICATIONS

• Mineral and geothermal groundwater dating (Datação de águas minerais e geotérmicas), <u>P.M.</u> <u>Carreira</u>, Mestrado IST- LEGM, Disciplina Recursos Hidrominerais e Geotérmicos (12 de Abril 2013) MSc Lecture.

## **EDUCATION**

- Co-supervisor, PhD. Thesis, *Hidrogeologia ambiental da região do Parque Natural da Serra da Estrela (sector de Seia-Torre-Covilhã): uma abordagem multidisciplinar*, by Alexandra Maria Magalhães Carvalho, Faculdade de Ciências da Universidade do Porto e Departamento de Geociências, Universidade de Aveiro, 21 de October 2013.
- Supervisor, MSc Thesis, Avaliação da intrusão marinha em recurso à geoquímica e composição isotópica (<sup>18</sup>O, <sup>2</sup>H e <sup>3</sup>H) de águas subterrâneas (Cap Bon, N-Tunísia), by António José Osório Dias da Silva, Instituto Superior Técnico, Universidade de Lisboa, 25 November 2013.

## PROJECTS

• The Cabeço de Vide mineral waters (Central Portugal): a natural analogue to increase understanding of the origin of life on Earth and possibly elsewhere. PTDC/AAG-MAA/2891/2012 – IST/CTN Coordenador: P. Carreira Paquete (20 %) Financiamento aprovado pela FCT

## SCIENTIFIC COMMITTEES

Member of the Local Organizing Committee of the International Symposium Water Rock Interaction -15 (WRI 15), Évora, Portugal, 2016.

#### **COLLABORATIONS**

- Mona Abbas Ahmed, Egypt Nuclear Radiological Regulatory Authority (ENRRA), Egypt, 21 January 20 February 2013. Training under the scope of IAEA scientific visit, on Isotope Hydrology Training in Routine Operation of LGR for Analysis of Stable Isotopes in Water Samples.
- Rasha Abd Allah Hussien Abd El-Fattah, Egypt Nuclear Radiological Regulatory Authority (ENRRA), Egypt, 21 January 20 February 2013. Training under the scope of IAEA scientific visit, on Isotope Hydrology Training in Routine Operation of LGR for Analysis of Stable Isotopes in Water Samples.