### **Radioprotection and Radioactive Waste**

Romão Trindade

The Radioprotection and Radioactive Waste Group (GRRR) is involved in many diversified activities ranging from R&D to services to the community and international representations by legal demand. In terms of R&D, GRRR has pursued its activities in the following funded organizations: FCT: KADRWASTE Project -ITN/UPSR/Lisbon, Porto and Évora Universities; FP7/Euratom-Fission: Integrated Project ACSPET- ITN-UCQR-UPSR; and Coordination Action PETRUS II- ITN-UPSR/IAEA/NEA/EC.

Still in terms of R&D, the Group has participated in the elaboration of new candidatures to research projects that were presented to FCT in 2009.

Concerning Education & Training, two Master Degrees were completed during 2009, one in Microbiology of Soils with the collaboration of U. Aveiro (Dept. of Biology) and GDR/UPSR and the other in Applied Geology to Clays, with the collaboration of Sciences Faculty of Porto (Dpt. Geology) and the GRA/UPSR. A PhD degree in the field of radioactive waste management in collaboration with Sciences Faculty of Lisbon (Dpt. Geology) is ongoing.

Members of the GRRR have participated as lecturers and invited professors in high-level education activities: Advanced Post-Graduation Studies (DFA) on "Safety and Radiological Protection" at IST, Lisbon (Dpt. Physics). They have also participated in several professional training courses, in-house through the Training Centre and upon external request.

Members of the Group were also involved in several national and international committees, working groups and task forces related to radwaste management, transport of radioactive materials, radiological protection and monitoring, decommissioning of radioactive and nuclear facilities, surveillance of contaminated scrap metal and radiological emergencies.

During 2009, ITN/UPSR/GRRR started radwaste data submission to the IAEA' NEWMDB Database. Also GRRR' members have participated in several informal meetings with CIPRSN, to analyse and discuss specific Portuguese legislation aspects in the broad area of radiological protection

Considering the activities related to legal obligations such as licensing of sealed sources for medical, industrial, teaching and research applications the Group has issued 304 licensing requested for analysis and authorization during 2009. Also during last year and still considering legal obligations, 158 requests for collecting and storing radioactive waste were received and processed. Related to this subject, GRRR has sent to ITN/CD information about the situation in the storage site at ITN (PAIRR), resulting from lack of space and personnel. Despite the comprehension shown by the Authority, the reply received has not been sound enough to allow ITN/CD to take measures in order to solve what can become a serious problem in a very short time. However, both ITN/CD and GRRR have been pursuing activities (R&D) similar to what other Countries have been doing to foreseen a possible future solution.

Detection of radioactive substances in scrap metal is still in the increase as happening in other EU MS and only this year, 10 events were reported to ITN and monitoring by GRRR. Radiological protection and safety verifications of facilities were carried out by GRRR at 4 medical establishments and 4 industrial facilities. Radiological surveillance was carried out by GRRR during the stay of 3 military nuclear vessels at the Lisbon Harbour. The Monitoring Programme of the radioactive liquid discharges from public and private nuclear medicine facilities into the public sewage of Lisbon as well as the monitoring of the four ETAR'S (waste water treatment facilities) was continued in 2009, in collaboration with Lisbon Council Borough.

ITN's radioactive wastes discharges compliance with Art<sup>o</sup> 35<sup>o</sup> of Euratom Treaty recommendations was pursued in 2009 with the renewal and improvement of the new ITN's Treatment Station, the ECoDELiR. This has been another step into the direction of assuring a more efficiently controlled released into the outside sewer. The *Campus* environmental gamma radiation dose has continued to be assessed through the gamma monitoring network, GAMMANET and the data reported in the framework of the Euratom Treaty.

Setup of the Radiological Protection Program (PPR) for UPSR (approved by Directive Board of ITN) was another action that deeply involved GRRR in 2009.

Also in 2009, GRRR was involved in the specifications file elaboration to acquire an ICP-MS equipment and in the jury of the proposals appreciation.

#### **Research Team**

**Researchers** R. TRINDADE, Aux., Group Leader M. I. PAIVA, Aux. **Technical Personnel** L.M. PORTUGAL, graduated technician J. VENÂNCIO **Collaborators** P. DUARTE A. BAPTISTA

## KADRWASTE – Study of the Adsorption Mechanisms and Kinetics in Geomaterials and Their Structural Characterisation: Implications for Processes of Natural Attenuation of Heavy Metal Contamination and Radioactive Wastes Confinement

M. Abel<sup>1</sup>, A. Mateus<sup>1</sup>, I. Bobos<sup>2</sup>, I. Paiva, R. Trindade, P. Duarte, M. Reis, M. J Madruga, M. F. Araújo, J. Mirão<sup>3</sup> et al

This project (PTDC/CTE-GEX/82678/2006) has pursed its objectives in 2009 with the radiometric, chemical and mineralogical characterization of the two previous defined scenarios. The radiometric surveys consisted in several linear profiles (transects) with distinct lengths and waypoints spacing about 50m, completed with scatter waypoints to account for non-accessible areas Radiometric data were obtained from in-situ gamma spectrometry with NaI(Tl) 3"x 3" e 5"x 5" probes (Target systemelectronic gmbh), a multichannel (MCA) and palmtop for data registration. In each point, detectors were calibrated with a certified <sup>137</sup>Cs sealed source and placed 1 meter above the soil with a special apparatus. After stabilisation, and at each waypoint ten values in "count rate" mode (cps) were registered. The geographic coordinates (WGS84 system) of the waypoints, with ca. 4m uncertainty, were obtained with a portable handled GPS.

Statistical treatment of the data defined the sampling points for soils (vertical profiles in three different levels) rocks and surface vegetation. Samples were identified and taken out to the lab for pH and total organic carbon, determination, radiometric and chemical characterization of the total fraction and fraction sizes < 63 and < 36micra. Radiological characterization of soils samples' different fractions were performed with HpGe planar detectors (LEM/LM/UPRS) and with NaI(Tl) planar detectors (GRRR/UPSR). Soil samples (<63 and <36 micra) were also analysed by ED-XRD, FTIR (FCUL and FCUP) and FRX (UCQR/ITN). Samples of surface and underground waters were also collected in different seasons for chemical and radiological characterization. The GIS software (ESRI® ArcMap<sup>TM</sup> 9.2) was used to construct the predictive maps characterising the spatial variability of the gamma radiation data, once the statistic parameter coefficient of variability, CV, can be used to the homogeneity and confidence of the verify measurements at each point). The spatial analysis of the raw data was carried out by applying the ordinary kriging as geostatistical method. To study the role of the different geologic formations on gamma radiation data, the Kolmogorov-Sminrnov test, with  $\alpha = 0.05$  was used to test fitness of data from the two scenarios studied to normality. Also last year, specific rock fragments of selected soils were used to make fine slices for microprobe analysis to access the presence of clay minerals, in special serpentine and inter-stratified minerals and

resulting data was analysed by FCUL. Eight Teflon continuous flux reactors for batch mode experiments were constructed at ITN workshop according to a FCUL model to be used at ITN, FCUL and FCUP for adsorption/desorption studies of radioactive and nonradioactive elements in solutions containing clay minerals.

Included in the KADRWaste was also made a visit to El Cabril by Project participants from ITN, FCUL and FCUP.

Two Master Thesis within the framework of KADRWASTE were submitted and finished in 2009:

E.Andrade, "Characterization of Geomaterials from raña Deposits for Radiocesium Retention" (GRA/UPSR/ITN, GRRR/UPSR/ITN and FCUP).

S. Fernandes, "*Bacterial communities in soils with ability to retain radionuclides*", I. Paiva (GRRR/UPSR/ITN) and A. Cunha (U.Aveiro, Dpt. Biology).



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#### ACSEPT-Actinide reCycling by SEParation and Transmutation (7th Programme EURATOM- FP7-Fission 2007)

I. Paiva, J. Marçalo, R. Trindade, P. Vaz

Related to ACSEPT Project were organized in 2009 several Scientific & technical domain review meetings. The start of ACSEPT provided early interesting results, and first results indicate optimization of GANEX and 1c-SANEX as well as the need to accelerate production of TOGDA ligands. ITN has already presented 3 HYBAR's (Half Yearly Beneficiary Activity Report) in Domain 1, WP1.2, D1.2.1, Design, Synthesis and Assessment of New Ligands linked to the Selection of an Efficient Extraction System for An (III) Group Separation and a presentation on the "Applications of the FT-ICR/MS Technique to ACSEPT Ligands Characterization". ITN experimental achievements, a collaboration between UCQR and UPSR, were exclusively carried out at UCQR facilities, using a Finnigan FT/MS 2001-DT FT-ICR mass spectrometer. The main experimental achievements were: Setup of the experimental methodology to carry out studies on gas-phase reactions of Ln (III) and An(III) with ligands provided by ACSEPT partners (CEA and CIEMAT) and using a Finnigan FT/MS 2001-DT FT-ICR mass spectrometer. Tests started with the ligand Me-BTBP from CE. Gas-phase association of the ligand with Gd(III) and Cm(III) as  $MCl_2^+$  ions were performed. The formation of the  $MCl_2^+$  ions from the reactions of  $M^+$  or MO<sup>+</sup> with CH<sub>2</sub>Cl<sub>2</sub> was studied in detail. The kinetics of the M<sup>+</sup> and MO<sup>+</sup> reactions with CH<sub>2</sub>Cl<sub>2</sub> were studied and the reaction efficiencies determined. Preliminary studies with the Me-BTBP and TEMA ligands (CEA) in liquid phase, to study the competitive complexation with Pr, Nd and Sm were carried out using a Bruker HCT ESI-QIT mass spectrometer.

# GEOSAF- International Intercomparison and Harmonization Project On Demonstrating the Safety of Geological Disposal

#### I.Paiva, P.Vaz, R.Trindade et al.<sup>1</sup>

This intercomparison and harmonization project on the safety of radioactive waste management (GEOSAF) carried out in support of safety demonstration for radioactive waste management facilities and activities have pursued its objectives in 2009. It was agreed to structure the project into two working groups, WG1 dealing primarily with safety demonstration methodology and WG2, focusing on the regulatory process.. Based on the critical review of previous studies on the subject, detailed questionnaires for both WG's were developed during the meetings in Vienna, revised, sent to the MS and completed during 2009. The aim was to collect the relevant information from the GEOSAF participating MS to be used to start identifying possible issues for harmonization. Portugal, as a member of WG1, participated actively in the production of the respective questionnaire, by systematically reviewing the above mentioned documents, suggesting possible questions and subjects to be considered and by answering in relation with the National situation. Portugal also provided feed back to the Coordinator of WG1 on the answers provided by other MS as requested. Answers to both WG's questionnaires were synthesized by the SC and roadmap established has been revised in the last 2009 meeting in Vienna. For WG1 (Portugal), the focus of questionnaire should be kept on the technical issues that are expected to be reviewed by regulatory body at each phase of the safety case.

#### <sup>1</sup>IAEA MS, NEA/OCDE expert, EC expert

#### **PETRUS II—Towards an European training market and professional qualification in Geological Disposal** *I.Paiva, P.Vaz, R.Trindade et al.*<sup>1</sup>

PETRUS II, an EC Coordination and Support Action Project on E&T has already started in January 2009 but the final contract was only signed in the last few days of October due to changes imposed by Brussels. The aim of the PETRUS II project is to enable present and future professionals on radioactive waste management in Europe, whatever their initial disciplinary background, to follow a training program on geological disposal which would be widely recognized across Europe. PETRUS consortium composed of academia, training centres, nuclear waste management agencies and research centres will co-operate through a suitable organisational structure for co-ordinating its activities and deliveries since the conception of the training programmes by taking into account both training providers and end-users point of view to the development of a framework for the mutual recognition and accreditation of the training programmes and the settlement of a plan for assuring the update and long-term sustainability of the programmes. So, main achievements of PETRUS II in 2009 were: changes in the structural form to comply in terms of FP7 guidelines, the writing of the terms of reference for the End-Users Advisory Group, the setup of the link to ENEN, the inclusion of other partners, the production of specific questionnaires according to partners' different characteristics, the fulfillment and analysis of the partner's replies, the presentation of a poster and a paper to the ETRAP Conference in Lisbon, Portugal, entitled: "Education and Training in Radiological Protection and Safety in Portugal: Collaboration between a University (IST) and a Research Centre (ITN)" and, finally, the inclusion of the Project in the First Implementing Geological Disposal Technology Platform (IGD-TP), launched in November 2009.

<sup>1</sup>Partners: INPL, CU, TUC, MA, POSIVA, ANDRA, ARAO, RWRA, ITC, REESN, GRS, NDA

# **Characterization of Suitable Areas for a Long-Term Radioactive Waste Repository Facility in Portugal** *P. Duarte, I. Paiva, A. Mateus*<sup>1</sup>, *R. Trindade*

The work in progress is part of a PhD thesis being carried out in collaboration with Department of Geology/FCUL. Statistical treatment of the data obtained from the radiometric profiles pointed out significant and representative sampling locals. In these locals, soils (through vertical profiles in three different depths), rocks, and vegetable covers were collected and were taken to the laboratory for ongoing analysis by gamma spectrometry, ED –XRD and FT-IR. Samples of soils, rocks, clays and waters are still being analyzed.

The table gives a possible justification for gamma radiation and the in the map are the measures sites and the places where soils and rocks sample were taken.



<sup>1</sup>Dep. Geologia, FCUL

### Services

#### 1. Radioactive waste management

During 2009 about 158 requests for radioactive waste collection were received and carried out. These radioactive wastes were collected, segregated, transported for interim storage at the "Pavilhão de Armazenamento Interino de Resíduos Radioactivos", (PAIRR) located at ITN *Campus*. In this year only one technician is working at PAIRR, which is not enough to carry out all present duties. It is very important and urgent to define and to establish a national plan related to radioactive wastes produced in Portugal, according international directives.

#### 2. Sealed sources licensing

According Decree-Law n° 38/2007 and Decree-Law n° 165/2002, 304 sealed sources licensing were issued: national territory introduction licences (110), transfer licences (28), transport licences (44) and ownership licences (122). Only one person is related with this activity.

#### 3. Gamma Monitoring Network (GAMMANET) of Instituto Tecnológico e Nuclear (ITN)

The environmental dose gamma radiation at ITN *Campus* is continuously being measured by the gamma network, GAMMANET. The data are collected, analysed and reported to the EU, according to articles 35° and 36° of the Euratom Treaty.

#### 4. Radioactive liquid discharges from Instituto Tecnológico e Nuclear (ITN)

Radioactive liquid wastes originated at ITN are analysed and measured at "Estação de Controlo das Descargas dos Efluentes Líquidos Radioactivos" (ECoDELiR) before being discharged into Estação de Águas Residuais (ETAR). The data are reported to the EU according Articles 35° and 36° of Euratom Treaty and to the Radioactive Substances Committee of OSPAR Convention. During 2009 the work to repair and to improve ECoDELiR was pursued.

#### 5. Radioactive liquid discharges from Instituto Portugês de Oncologia (IPO), Coimbra

In 2009 and as requested by IPO-CROC, EPE, Coimbra, the radiological survey of radioactive liquid effluents from the IPO's Medicine Nuclear Retention Tanks, was carried out by the Group before discharge into the public sewage.

#### 6. Radioactive Liquid Discharges from Hospitals in Public Sewage of Lisbon Borough Council (CML)

Radioactive liquid discharges from private and state owned nuclear medicines in Lisbon public sewage as well as residual effluents from Lisbon's four Water Treatment Plants (ETARs), have been monitored by UPSR/ITN in 2009. Sampling was carried out in order to identify the radionuclides present and their activities. About 100 samples of liquid effluents were collected and analysed by quantitative and qualitative gamma spectrometry. This monitoring programme, requested by CML, was divided in two different programmes. Programme I involved sequential collection of 4 discrete samples in 5 sampling points from nuclear medicine facilities. In Programme II, 4 discrete samples were taken at one single discharge point of each Lisbon's ETARs.

#### 7. Nuclear vessels radiological monitoring

In 2009, three nuclear vessels stayed at Portinho da Costa harbour and estuary of Rio Tejo. Environmental radioactivity survey programmes consisting on continuous monitoring of radioactive aerosols and airborne radioiodine, sampling of water, sediments and biological species for gamma spectrometry analysis were carried out. Sampling was done before, during and after the stay of the vessel. Reports were sent to Ministry of Defence.

#### 8. Radioactivity in scrap metal

In 2009, and as result of radiological surveys requested by the smelting industry, ten events related to the detection of radioactive materials in scrap metal at smelting factories have been reported. The material collected has been stored at Pavilhão de Armazenamento Interino de Resíduos Radioactivos, (PAIRR) as radioactive waste. Reports were sent to the smelting company.

#### 9. Radiological protection and safety verifications

During 2009, GRRR has carry out four verifications concerning radiological protection and safety at medical facilities in collaboration with GDR/UPSR and four at industrial facilities.