

(2) prompt gamma rays produced in the analyzer construction materials; (3) natural gamma rays from K-40 and the uranium and thorium decay chains; and (4) prompt and decay gamma rays produced in the NaI detector by neutron activation. A number of unforeseen problems have arisen in pursuing this approach including: (1) the neutron activation of the most common detector (NaI) used in bulk analysis PGNAA systems, (2) the nonlinearity of this detector, and (3) difficulties in obtaining detector response functions for this (and other) detectors. These problems have been addressed by CEAR recently and have either been solved or are almost solved at the present time. At first some of the libraries were determined experimentally including: (1) the three libraries necessary for the neutron activation of the NaI detector which includes the decay of I-128, the decay of Na-24, and the prompt gamma rays from both Na and I and (2) the three natural gamma rays from K-40 and the uranium and thorium decay chains. While accurate, the experimental approach was undesirable in that any change in the analyzer system required that these experiments be repeated. We have now finished the development of Monte Carlo simulation for all of these libraries except the prompt gamma-ray library from the activation of the NaI detector. We must first determine the coincidence scheme for Na and I to complete the Monte Carlo simulation of this last library.

251 A NEW NAI DETECTOR ARRANGEMENT FOR EFFICIENT DETECTION OF HIGH ENERGY GAMMA RAYS. R.P. Gardner¹ and W.A. Metwally¹, ¹ Center for Engineering Applications of Radioisotopes (CEAR), North Carolina State University, Raleigh, NC 27695-7909 USA

Prompt Gamma Neutron Activation Analysis (PGNAA) and Neutron Inelastic Scattering (NIS) techniques have been widely used for measuring elemental composition in bulk samples. They have the advantage of producing high energy (highly penetrating) gamma rays which allow us to analyze large sample volumes. In the oil well logging industry, there are limitations on the size and type of detectors used. These limitations can lead to a low detection probability of high energy gamma rays. A new NaI detector arrangement has been designed to deal with this problem. The arrangement consists of two NaI detectors, one of which is a well type. The first detector is 1x5 inches and the second is a well type 5 inches long with a wall thickness of 0.35 inches, which gives a hole diameter of one inch. They are assembled together, as shown in Figure 1. The concept behind this arrangement is that the gamma ray that undergoes pair production in the inside detector will result in 0.511 MeV gamma rays emitted towards the well detector. Measuring the coincidence spectrum in both allows us to identify the original gamma ray and thus its source. Feasibility studies were performed with this setup using a Na-24 radioactive source, as shown in Figure 2. In the figure, three spectra are shown for the inside detector. They are: the single detector spectrum, the total coincidence spectrum (no energy gating), and the coincidence spectrum with a 0.511 MeV energy window in the well detector. Observing the third spectrum, we notice that the escape peaks show up very clearly and there is a great enhancement in the Signal to Noise Ratio. We are investigating the design and use of this detector system for oil well logging applications.

252 NATURAL RADIOACTIVITY IN PHOSPHATE ROCK, PHOSPHOGYPSUM AND PHOSPHATE FERTILIZERS IN BRAZIL. C.H. Saueia¹, B.P. Mazzilli*¹, D.I.T. Fávoro². ¹Laboratório de Radiometria Ambiental, ²Laboratório de Análise por Ativação Neutrônica, Instituto de Pesquisas Energéticas e Nucleares, Caixa postal 11049, São Paulo, BRAZIL

Phosphate deposits are generally characterised by enhanced radionuclide concentrations compared to natural levels. The mining and processing of this phosphate ore redistribute radionuclides throughout the environment and introduce them into final products and by-products. The Brazilian phosphate fertilizer is obtained by wet reaction of igneous phosphate rock with concentrated sulphuric acid, giving as final product phosphoric acid and dihydrate calcium sulphate or phosphogypsum as by-product. Phosphoric acid is the starting material for triple superphosphate (TSP), single superphosphate (SSP), monoammonium phosphate (MAP), diammonium phosphate (DAP), NPK fertilizers and di-calcium phosphate (DCP). Contents of natural radionuclides from thorium and uranium series, Ra-226, Pb-210 and Ra-228, were measured in Brazilian igneous phosphate rock, phosphoric acid, phosphogypsum and phosphate fertilizer samples, using

high-resolution gamma spectrometry. Radionuclides concentration in the phosphate rock and phosphogypsum presented the same pattern for Ra-226, Pb-210 and Ra-228, ranging from 53 to 723 Bq/kg. Fertilizer samples, which are derived directly from phosphoric acid, MAP and DAP, presented in its composition activities concentrations below the detection limits of the counting system. SSP, TSP and NPK, which are obtained by mixing phosphoric acid with different amounts of phosphate rock and NH₃, presented higher concentrations of radionuclides, up to 871 Bq/kg for Ra-226 and 278 Bq/kg for Ra-228.

253 DETERMINATION OF U AND Th DECAY SERIES AND RARE EARTH ELEMENTS IN SEDIMENTS IN AN AREA AFFECTED BY PHOSPHATE FERTILIZER PLANTS. P.S.C. Silva¹; B.P. Mazzilli^{1*} and D.I.T. Favaro². ¹Laboratório de Radiometria Ambiental. ²Laboratório de Análise por Ativação Neutrônica. Instituto de Pesquisas Energéticas e Nucleares, Caixa Postal 11049, São Paulo, BRAZIL

In the last decades considerable attention has been given to technologically enhanced natural occurring radioactive material (TENORM). Within this frame, of particular concern is the phosphate fertilizer industry. Santos Basin, located in Southwest Brazil, São Paulo State, comprising the counties of Santos, São Vicente and Cubatão, is considered the most important industrial region of the country. Among the industrial activities present, phosphate fertilizer plants are responsible for the production of 69 millions tons of phosphogypsum waste, which is stockpiled in the surrounding environment. This waste concentrates radionuclides of the natural series as well as rare earth elements originally present in the phosphate rock used as raw material. This study aims to evaluate the environmental impact of such activities in the sediments of the estuarine system. U, Th and rare earth elements La, Ce, Nd, Sm, Eu, Tb, Yb and Lu were determined by neutron activation analysis. Radionuclides ²²⁶Ra, ²²⁸Ra, ²²⁸Th and ²¹⁰Pb were determined by gamma spectrometry. The results were analysed using normalization with PAAS and the baseline concentrations obtained from the sediments collected in depth. Cluster analysis and principal component analysis were also used for data interpretation. In the vicinity of fertilizer plants, a strong correlation was observed between sediments concentration and antropic activities.

254 SELECTED TRACE AND MINOR ELEMENTS IN SOFT ROCKS FROM ASUNCION AREA - J.F.Facetti-Masulli¹, P.Kump², J.J.Bosio³. -¹Hydroconsult SRL-De Gaulle 980-Asunción-Paraguay -²J. Stefan Institute -1000 Ljubljana, Jamova 39, Slovenia -³. Facultad de Ingeniería -Universidad Católica -Asunción -PARAGUAY.

Soft-rocks from Asuncion area were investigated with XRF techniques. Such rocks occur widespread, are the main bedrock of the area, and are of unknown age. On the other hand magmatic rocks, represented by nephelinite/ankaratrite, occur in several plugs, flows, etc, bearing mantle xenoliths of spinel periodotite; they were subjected recently to excellent geochemical studies and useful data are available. These outcrops belong to Tertiary alkaline magmatism of the so called Central Alkaline Province of Paraguay; their ages are around 41 to 48 Ma. Selected trace elements analyzed in soft-rocks were Zr- Nb-Ba-La-Ce-Nd using an Am-241 source whereas Ti, Mn, Fe, which are very often correlated with the above elements, using a Mo tube. The analysis of complex spectra was performed by the AXIL software, and the quantitative analysis, by the QAES software. REE are considered as useful indicators of geochemical processes, and in this case, of provenance. Usually they maintain their primary relation and are transferred almost directly into sediments. Their values here found, absolute and normalized, are well correlated to those of the magmatic rocks, ie, the former are derived from the latter. Thus, the higher limit of their age can be estimated.

255 INAA FOR THE CHEMICAL CHARACTERIZATION OF FULL SUN- AND SHADED-ORGANIC COFFEE SYSTEMS. C. F. Moreira*, E. A. De Nadai Fernandes. University of Sao Paulo, Nuclear Energy Center for Agriculture (CENA), Piracicaba, SP, BRAZIL

The consumption of special coffee, mainly organic coffee, is increasing worldwide. Brazil is the largest world coffee producer, with 2,700,000 tons of green coffee in the 2002 harvest. However, only 4,200 tons are