World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:16, No:06, 2022

Spectroscopic Autoradiography of Alpha Particles on Geologic Samples at the Thin Section Scale Using a Parallel Ionization Multiplier Gaseous Detector

Authors : Hugo Lefeuvre, Jerôme Donnard, Michael Descostes, Sophie Billon, Samuel Duval, Tugdual Oger, Herve Toubon, Paul Sardini

Abstract : Spectroscopic autoradiography is a method of interest for geological sample analysis. Indeed, researchers may face different issues such as radioelement identification and quantification in the field of environmental studies. Imaging gaseous ionization detectors find their place in geosciences for conducting specific measurements of radioactivity to improve the monitoring of natural processes using naturally-occurring radioactive tracers, but also for the nuclear industry linked to the mining sector. In geological samples, the location and identification of the radioactive-bearing minerals at the thin-section scale remains a major challenge as the detection limit of the usual elementary microprobe techniques is far higher than the concentration of most of the natural radioactive decay products. The spatial distribution of each decay product in the case of uranium in a geomaterial is interesting for relating radionuclides concentration to the mineralogy. The present study aims to provide spectroscopic autoradiography analysis method for measuring the initial energy of alpha particles with a parallel ionization multiplier gaseous detector. The analysis method has been developed thanks to Geant4 modelling of the detector. The track of alpha particles recorded in the gas detector allow the simultaneous measurement of the initial point of emission and the reconstruction of the initial particle energy by a selection based on the linear energy distribution. This spectroscopic autoradiography method was successfully used to reproduce the alpha spectra from a 238U decay chain on a geological sample at the thin-section scale. The characteristics of this measurement are an energy spectrum resolution of 17.2% (FWHM) at 4647 keV and a spatial resolution of at least 50 µm. Even if the efficiency of energy spectrum reconstruction is low (4.4%) compared to the efficiency of a simple autoradiograph (50%), this novel measurement approach offers the opportunity to select areas on an autoradiograph to perform an energy spectrum analysis within that area. This opens up possibilities for the detailed analysis of heterogeneous geological samples containing natural alpha emitters such as uranium-238 and radium-226. This measurement will allow the study of the spatial distribution of uranium and its descendants in geo-materials by coupling scanning electron microscope characterizations. The direct application of this dual modality (energy-position) of analysis will be the subject of future developments. The measurement of the radioactive equilibrium state of heterogeneous geological structures, and the quantitative mapping of 226Ra radioactivity are now being actively studied.

Keywords : alpha spectroscopy, digital autoradiography, mining activities, natural decay products
Conference Title : ICMLR 2022 : International Conference on Mining and Land Reclamation
Conference Location : Rome, Italy
Conference Dates : June 02-03, 2022