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Portland cement paste behaviour under gamma radiation field in geological repository

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ABSTRACT

The Radioactive Waste Management Laboratory at the Nuclear and Energy Research Institute in São Paulo, Brazil (IPEN-CNEN-SP), is developing the concept of a repository for disposition of disused sealed radioactive sources in a deep borehole in which cement paste is intended to be used as a backfill between the steel casing and the geological formation around the borehole. The cement paste is intended to function as structural material, a blockage against the transport of water between the different strata of the geological setting, and as an additional barrier against the migration of radionuclides. The assessment of the cement paste behaviour in long term is necessary to increase the confidence that the material will perform as required during the service life of the facility.

Under radiation, pore water present in cement paste suffers radiolysis and some products can be highly reactive, as electrons and hydroxyl radicals and hydrogen peroxide. These radiolysis products will interact with cement paste and its hydration products, forming a wide range of compounds.

Previous work focused on assessing the synergic effects of radiation and environmental conditions, like higher temperature and aggressive groundwater chemicals, on cement paste. Examination of samples detected small differences in mineralogy and microstructure. However, the radiation dose to which samples were exposed (400kGy) was only a fraction of the expected accumulated dose in cement paste until complete decay of some sealed sources in the repository. Therefore, several thousand kilograys must be tested the possibility of radiation to alter cement mineralogy and, as a consequence, its durability

The objective of this research is to evaluate the changes in mineralogy and microstructure of irradiated cement paste specimens, in an attempt to establish a relationship between irradiation and durability. Cubic Portland cement specimens were casted and exposed to the gamma radiation of a ^{60}Co multipurpose irradiator, at IPEN-CNEN/SP. The effects of doses between 1000 kGy and 4000 kGy are evaluated by X-Ray Diffraction, Scanning Electron Microscopy, X-ray micro tomography, neutrongraphy and neutron scattering. This report presents the changes in cement paste mineralogy when samples are examined by XRD. Results indicate that durability can be affected because of the observed changes.

Results are expected to indicate the induced changes in cement paste under high radiation doses and to provide hints on its behaviour in the long-term and service-life. The results can be used in safety analysis for deep geological repositories that use cement based materials as engineered barriers.