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Neutron-irradiated concrete: Structural characterisation and gamma dosimetry.

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Increased reactivity of radiation-damaged quartz in the alkaline pore water of concrete and its role in radionuclide transport is a subject that is becoming increasingly important as nuclear power plants (NPPs) around the world reach end-of-life. Quartz contributes more than half the weight of most concretes and up to 40 % of the total radioactive waste volume associated with the dismantling of an NPP.

The gamma-emitting radionuclides are the major contributors to the radiation dose rate in the concrete biological shield in the intermediate term after NPP shut-down. The appreciable activity and associated half-lives of these radionuclides pose a problem not only during the safe dismantling of NPPs, but also in terms of processing the concrete to reduce the active waste volume for final disposal in a repository.

While thermal neutrons are captured by atomic nuclei according to their thermal neutron cross-sections, fast neutrons undergo collision cascades, which cause defects in the structure of materials. The concentration of defects accumulates as a function of neutron energy and fluence. The high covalency and the density of Si-O bonds in tectosilicates, primarily quartz, followed by feldspars, makes these minerals very susceptible to radiation damage.

In this study, two inactive concrete powder samples were placed inside an instrumentation channel passing through the first biological shielding of an operating German NPP, respectively for a half- and a full fuel cycle. Using a plant-specific 3D-reactor model in conjunction with Monte Carlo neutron transport calculations, neutron fluences at the sample positions and the resulting gamma activities are calculated. We compare the measured and calculated activities of the gamma-emitting radionuclides

Synchrotron X-ray powder diffractometry was used to examine structural changes on sub-nanoscale. The local structure of the silicate aggregate minerals was investigated by solid-state magic angle spinning nuclear magnetic resonance (NMR) spectroscopy using 27Al and 29Si as probes.

With this work we wish to gain insights into the potential for alkali-silica reaction (ASR) in radiation-damaged concrete and the role this plays in the transport or sorption of radionuclides either present in situ via neutron activation or ex situ due to transport of leaked reactor cooling water.

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