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Long-term kimberlite activation for Radiological Assessment for the Min-PET technique.

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This study presents the activated and background sample activity results of different mined rocks from the Letseng diamond mine and the radiological impact due diligence simulated activation stage of the Mineral-Positron Emission Tomography (Min-PET) technique performed at Aarhus University. The activated and background-specific activities were validated by irradiating the kimberlite rocks with a 40 MeV photon beam and will not lead to any long-term radiological concerns. The Min-PET technique is the process by which a diamond is detected within the activated kimberlite rocks by the Min-PET detectors. The 100 MeV Aarhus microtron injector has been degraded to 40 MeV using a 2.3 mm stainless steel, 5 mm copper plate. The beam was a further incident on a 3 mm thick tungsten layer to produce bremsstrahlung photons for a long-term kimberlite activated to transmute the ^{12}C (γ, n)^{11}C to release back-to-back 511 keV gamma photons to be detected by two planar Min-PET detectors. The rocks were placed 800 mm away from the beam exit and were irradiated for 10 minutes and cooled for another 10 minutes. The longer cooling period leads to the activated isotopes such as oxygen that have a half-life of fewer than 10 minutes to decay off to the background level. After cooling time, the rocks were sent to High Purity Germanium detectors (HPGe) for data/spectra of the long half-life isotope acquisition. This step was also done for non-irradiated rock samples to identify the naturally occurring background isotopes. The energy spectra from the HPGe detectors data were used to identify the energy of each peak in the spectra and the online nuclear database was used to identify the isotope of each energy peak. The specific activities of the natural background and activated radionuclides were calculated by fitting a Gauss in each energy peak on the energy spectra. The natural background-specific activities resulting from an unirradiated sample were found to be 4.95 mBq/g for ^{40}K, and 2.85 mBq/g for 511 keV. The specific activity results for activated isotopes were studied in three stages of data acquisition, firstly a short-term activation (between 10 minutes and 15 hours after activation) where it was found to be 1004 mBq/g for 511 keV, 5.32 mBq/g for ^{40}K, and 400 mBq/g for ^{24}Na, secondly for medium-term activation (between 15 hours to 1 day after activation) were found to be 3.0 mBq/g for 511 keV, 4.2 mBq/g for ^{40}K, and 0 mBq/g for ^{24}Na respectively. The activated sample's specific activities decrease with time, but, still within the acceptable range recommended by IAEA for long-term activation. The natural background-specific activities and specific activities from activated rocks remain constant and are comparable in all different samples. These results proved and validated the Min-PET technique to be safer for any long-term radiological concerns.

Apply to be considered for a student ; award (Yes / No)?

yes

Level for award;(Hons, MSc, PhD, N/A)?

PhD

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