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Kimberlite Activation, Radiological Assessment, and Diamond Damage for the MinPET Technology

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The ionizing radiation produced during the activation stage of the MinPET technology can pose a radiological concern to the environment and be harmful to biological life if not carefully managed. Moreover, it can lead to the alteration of diamonds (production of defects), making the technology unsuitable for diamond discovery. This study investigates the long-term activation of kimberlite and the issue of alteration of the diamonds. The composition of different kimberlite rocks was obtained from XRF analysis to provide information about the parent isotopes that led to the activated isotopes. The MinPET technique activation stage and the subsequent evolving time differential remnant activation, including all decay pathways, were simulated. The activation experiment used the 100 MeV Aarhus microtron electron beam injector and degraded the beam energy and converted electrons to photons using a combination of stainless steel and copper plates. The samples were placed a distance away from the beam exit, and irradiated and cooled down for 10 minutes respectively.
This is to allow the shorter-lived activated isotopes time to decay. The study analysed the gamma spectrum of the activated radioisotopes and compared the specific activity results for the long-term activation with NORM. Numerical simulations were performed with both Geant4 and FISPACT benchmarked together to experiments, and the results were extrapolated to demonstrate further that the MinPET technique has no long-term radiological concerns, as the specific activity results of different radionuclides are reduce to below the recommended value by the IAEA of 1 Bq/g per isotope. Another part of the study examines the damage due to both the mixed radiation field and the secondary carbon ion cascade. The primary damage created is the single neutral vacancy (GR1 defect) and self interstitials. These interstitials can be the single dumbbell interstitial on the cubic face center (R2 defect) or the self-trapped pair of these (R1 defect).
As most of these defects are optically active, measurements were performed using UV-VIS absorption spectroscopy, IR absorption spectroscopy, and very sensitive photoluminescence (PL) spectroscopy at 77K. The result shows that these special techniques possibly found some evidence of MinPET related treatment at the extreme limit of their sensitivity (resonant PL at low temperature with intense pumping). Such a low defect level (below ppb) was not deemed to lead to any effective "alteration"of the diamond, as it could not change the physical, chemical, or optical properties in a reliably detectable manner even at high sensitivities. The results therefore indicate that the radiological safety of the MinPET technology can be engineered by the appropriate. They further show the effect on diamond (defect production) is below a threshold.

Abstract Category

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