Natural Radioactivity in the Pilanesberg Alkaline Ring Complex

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The Pilanesberg Alkaline Complex in South Africa is one of the world's largest alkaline and partially peralkaline geological complexes, having distinctive lithological and mineralogical features which can be associated with natural radioactivity. The spatial distribution and geochemical behaviour of naturally occurring radionuclides (potassium-40, uranium-238, and thorium-232) within the complex are investigated by means of in situ gamma measurements. The investigation revealed that radionuclide concentrations vary significantly between rock types, owing to processes such as magmatic differentiation, hydrothermal alteration, and accessory mineral crystallization. The high quantities of uranium and thorium in red syenite in the complex are due to accessory minerals like zircon, titanite and apatite, which integrate these elements under reducing conditions during late-stage magmatic crystallization. In contrast, potassium enrichment is concentrated in foyaites, indicating advanced peralkaline magmatic evolution. Hydrothermal fluid interactions have also mobilized uranium, notably in the complex's faulted and fractured zones, resulting in varying uranium concentrations in volcanic and intrusive rocks. These findings underline the complex geochemical evolution of the Pilanesberg Alkaline Complex and its potential as a model for understanding radionuclide distribution in alkaline systems. The study adds to the overall understanding of uranium, thorium, and potassium geochemistry by providing insights on natural radioactivity in peralkaline environments.