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Chemical and mineralogical re-evaluation of the Mary Kathleen uranium tailings, Australia: New opportunities for rare earth element extraction

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The Mary Kathleen uranium deposit, located in Queensland Australia, was operated in two phases between 1958-1963 and 1976-1982 and generated up to 7.5 million tonnes of tailings. Despite high rare earth element (REE) grades in the primary ore, REE extraction was actively suppressed during the first phase of mining due to high rates of sulphuric acid consumption by REE-bearing minerals. During the second mining phase, use of higher sulphuric acid concentrations facilitated recovery of only a small proportion of the total REE endowment. Consequently, whilst the historical tailings were known to contain elevated REE contents, the grade distribution and mineralogical hosting of these REEs is complex. In this study, tailings materials were obtained from a previous drilling program which sampled the historical Mary Kathleen tailings to a depth of 30 metres and indicated that total rare earth element content varied between 0.5 and 4.7 % based on bulk chemical assays. This study adopted a geometallurgical approach to provide detailed geochemical and mineralogical constraints on the deportment of REEs within the tailings to guide opportunities for reprocessing.

Tailings samples were wet screened and each size fraction subjected to multielement assay and mineralogical analysis (automated mineralogy and XRD) including mineral chemistry (LA-ICPMS analysis) of major mineral phases. Overall, the Mary Kathleen tailings are highly enriched in light REEs (~3 to 4 wt. %) with only minor total heavy REEs (~140 ppm). Mineralogically, the tailings comprise andradite garnet, allanite, diopside and apatite as well as trace quantities (<0.5 wt. %) of ‘exotic’ REE-minerals including stillwellite, bastnasite and florencite. Mineral chemistry indicates that allanite contains up to 16 wt. % TREE content and whilst this proportionately represents the dominant REE host mineral, other phases including garnet also contain significant REE deportment, specifically with higher HREE contents. Mass balance approaches indicate more ‘exotic’ REE minerals only represent 1 % of the total REE content of the tailings and as such, reprocessing opportunities are suggested based on modified hydrometallurgical approaches (sulphuric acid leaching) to target allanite and garnet as the new ‘primary’ REE ore minerals which are known to be highly refractory in nature.