ABSTRACT

Rare earth elements (REE) are a group of the lanthanides and are significant in the world's economic growth and modern technology market. This REE technological resource is globally distributed and highly monopolised in China. The global demand in REE led to China – "the leading economic producer of REE", limiting its export quotas of the commodity, thus reducing the supply of REE. The decline in REE supply opened up opportunities for other countries to explore alternative and additional sources of REE.

This research aims to investigate alternative sources of REE and to explore an efficient means of processing REE minerals from an existing beach placer deposit operation, currently being mined for titanium. Mineralogical characterisation and hydrometallurgical testwork were chosen for this study.

The sample represented a tailings fraction from heavy mineral concentration. The sample was screened into four size classes namely; +212µm, –212+150µm, –150+106µm and –106µm. Each size class was mineralogically characterised. Mineralogy is an important factor in plant optimisation and process route predictions. In order to process REE efficiently, an upfront mineralogy is a necessity to reduce the rising hefty ore-processing costs.

An integration of X-ray diffraction, optical microscopy, scanning electron microscopy (SEM), electron microprobe analysis (EMPA), automated SEM and bulk chemical analysis was employed in defining the mineralogical characteristics of the tailing sample.

The mineralogical analysis of the tailing sample showed monazite as the prominent REE-bearing mineral, followed by zircon. Other minerals such as epidote, amphibole, rutile, quartz, leucoxene, titanite and almandine were identified in the sample. The results also revealed that the mineralogy of the sample varies per size fraction. The concentrations of REE in other minerals were confirmed in zircon, leucoxene, titanite and almandine by means of EMPA.

The mineralogy findings showed that zircon and monazite are well liberated, with the majority of these minerals distributed in the–150+106µm and –106µm finer fractions. Approximately 50 mass% of the sample, constituting the finer fraction, has concentrated monazite and zircon. The naturally concentrated monazite and zircon in the finer size fractions showed that the fraction does not require ore upgrading and it is amenable to direct leaching.

Subsequent to the mineralogical findings, the leaching testwork was carried out on the combined –150+106µm and –106µm finer fractions in three stages: caustic cracking, water leaching and HCl leaching. The leached products and residues were investigated for their REE extraction success. The extraction findings showed a 55% extraction efficiency of rare earth elements extracted from monazite only. The mineral zircon was identified as an alternative source of REE, apart from monazite, although processing of zircon proved to be inefficient.