Executive Summary

Hydrometallurgical testing was conducted on a master composite of whole ore and/or products of the master composite. The master composite contained 4.2% rare earth elements (REE) with 96% distributed in the light REE (La, Ce, Pr, Nd, and Sm). The main gangue elements were iron (18.4% Fe), aluminum (12% Al), and silicon (11.4% Si).

The conceptual hydrometallurgical flowsheet developed consists of a two stage sulphuric acid bake followed by water leaching. The purpose of the first stage of baking was to convert REE minerals to soluble REE sulphates, while the second stage of baking converts gangue sulphates to insoluble oxides prior to water leaching to extract REE. The water leach pregnant leach solution (PLS) was then treated with calcium carbonate followed by magnesium carbonate to remove the majority of key impurities from solution (such as aluminum, iron, and thorium) prior to precipitation of an intermediate rare earth carbonate by addition of sodium carbonate (Na_2CO_3). The conceptual hydrometallurgical flowsheet is included as Figure i.

Two stage acid baking/water leaching of ground whole ore (100% passing 75 µm) achieved 82% total REE (TREE) extraction (88% neodymium) along with limited impurity co-extractions (27% Al and 8% Fe) using an acid dosage of 1500 kg/t (approximately 70% of the acid was volatilized during the bake) and bake temperatures of 250°C and 810°C. High levels of impurity elements (92% Th, 88% Al, and 98% Fe) were removed from the PLS with less than 1% REE co-precipitation by the addition of $CaCO_3$ to pH 3.2 followed with the addition of $MgCO_3$ to pH 3.6. An intermediate rare earth carbonate product was precipitated at pH 6.7 by the addition of Na_2CO_3 with an REE yield of 99.9% of the REE in the solution after impurity removal.

Initial scoping testing improved the grade of the intermediate REE product from 49% to 80.9% TREE (elemental) by hydrochloric acid re-leaching at pH 1.9 and a secondary impurity removal with $MgCO_3$ at pH 4.4, followed by oxalic acid precipitation and calcination of the REE. The calculated final REE oxide grade was 97.0% with 0.64% gangue compounds detected (elemental assays expressed as simple oxides). The primary impurity elements were potassium and calcium.

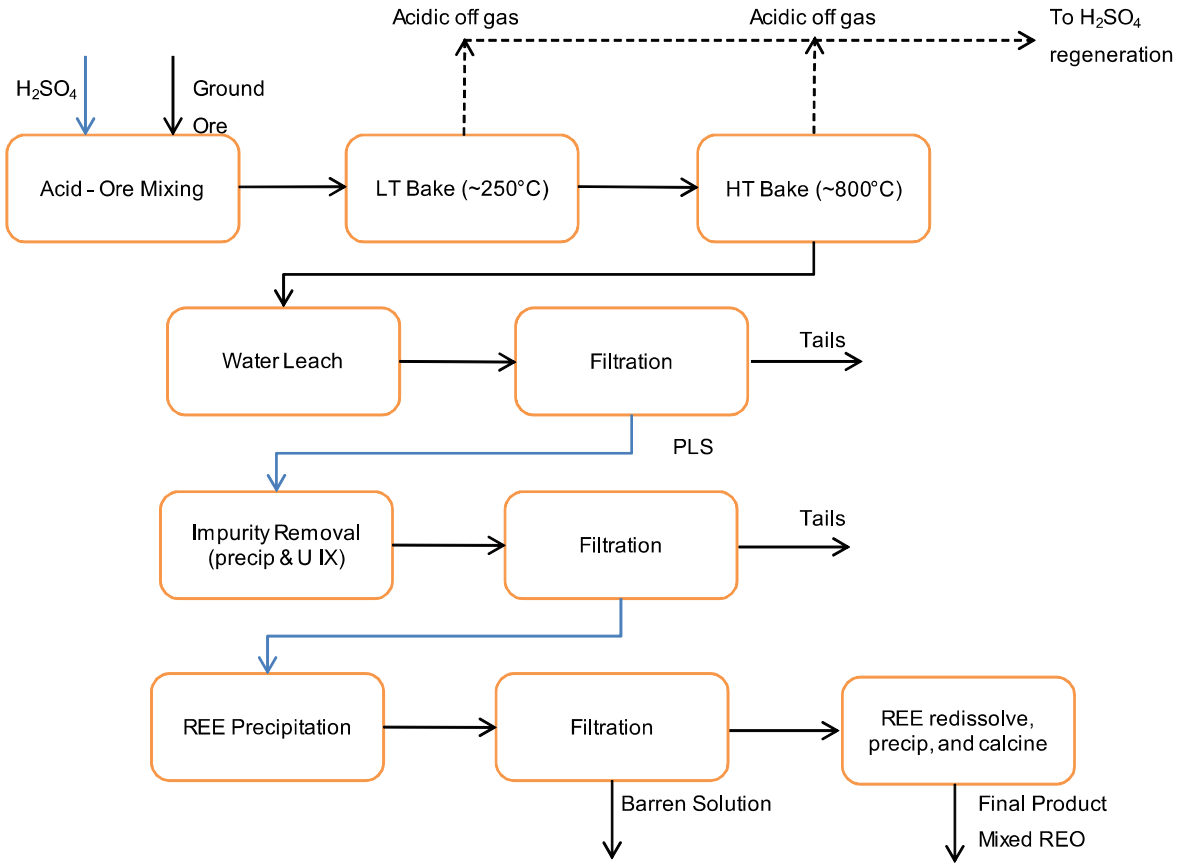

Figure i: Conceptual Hydrometallurgical Flowsheet

A tailings grade of 6147 g/t thorium and 60 g/t uranium (6570 g/t and 73 g/t in the ore, respectively) was calculated for the conceptual flowsheet. It assumed that the water leach residue, primary impurity removal precipitate, and secondary impurity removal precipitate (from REE redissolve liquor) would be blended.

Atmospheric hydrochloric acid leaching, roast-leach, and caustic crack-acid leach REE extraction methods were also tested. Strong hydrochloric acid leach tests achieved acceptable REE extractions, but at high acid consumptions as did caustic crack-leach tests. The roast-leach test performed achieved poor REE extractions.