Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.31061

Towards Sustainable Rare Earth Element Extraction: Mineralogical and Geochemical Characterization of Saudi Bauxite and Red Mud

ABDULAZIZ N ALMUTAIRI[1,2], KEVIN TAYLOR[1], VICTORIA COKER[1], SULTAN A ALKHAMMALI[2], JINXIN XIE[1] AND JONATHAN RICHARD LLOYD[1]

[1]University of Manchester
[2]King Abdulaziz City for Science and Technology (KACST), Riyadh, Saudi Arabia,

Rare earth elements (REE) are critical for advanced technological applications. With growing global demand and limited primary resources, bauxite residue (red mud) presents a strategic opportunity for sustainable REE recovery as a secondary source. This study investigates the mineralogical composition, REE concentrations, and leaching efficiencies of REE from Saudi bauxite ore and its residue (red mud) to trace REE behavior, and assess their potential as a secondary source.

XRD of bauxite shows the dominant minerals to be gibbsite, boehmite, hematite, anatase, rutile, and kaolinite, while red mud samples contains mainly hematite, gibbsite, boehmite, sodalite, cancrinite, and quartz. SEM and EPMA revealed that the REEs are associated with iron oxide minerals, particularly in red mud samples. ICP-AES analyses suggested that the bauxite contains high levels of Al_2O_3 (59.2 wt.%) with lower quantities of SiO_2 (10 wt.%), Fe_2O_3 (6.59 wt.%), and TiO_2 (3.41 wt.%). In comparison the red mud contains higher loadings of Fe_2O_3 (23.5 wt.%), SiO_2 (16.6 wt.%), and TiO_2 (6.25 wt.%). These data also shows that approximately 35 wt.% of the Al_2O_3 was removed during the process of forming red mud from bauxite, and 24.6 wt.% remaining in the red mud.

The total REE content in red mud (598 ppm) was higher than that in bauxite (322 ppm). Sequential extractions were conducted using a Tessier 5 step protocol. The results indicate varying REE leaching efficiencies at each extraction stage, with the highest recovery observed in the fourth step of Tessier's method (Fe–Mn oxide-bound fraction).

Ongoing work focuses on comparing chemical leaching to bioleaching for REE from Saudi red mud as potential secondary source, to underpin the development of sustainable mining practices. To help achieve this objective, microbial REE recovery systems are also being assessed.