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REE mobilisation from carbonatite to weathered materials at Miaoya, China and Ambadongar, India

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Rare earth elements (REE) are essential for renewable energy and are typically associated with carbonatites and alkaline igneous complexes. Although major REE deposits occur in these rocks, exceptional light (L)REE grades can occur in laterites above the carbonatite parent rocks (e.g., Mt Weld, Australia, and Araxá, Brazil). These elements are either adsorbed onto the surfaces of clay minerals or are hosted in various supergene REE minerals [1]. However, the mechanisms regulating REE enrichment and mobilisation in the weathered regolith are poorly understood.

This study presents the mineralogical and geochemical characteristics of weathered profiles from two distinct carbonatite localities: the Miaoya carbonatite and syenite complex (MCSC), China, and the Ambadongar carbonatite complex (ADCC), India. The MCSC was emplaced during the Silurian period followed by Triassic metasomatism resulted in niobium and REE mineralisation [2]. The Late Cretaceous ADCC is part of the Deccan-related alkaline–carbonatite magmatism and is an important source of REE and fluorite [3]. The MCSC is primarily syenite with fine-to-medium-grained carbonatite as stocks and dykes, while the ADCC carbonatites are younger composed of sövite and ankerite. These sites provide natural comparison of REE weathering in different geological environments.

Weathering produces goethite, montmorillonite, kaolinite and vermiculite. Major REE minerals in the MCSC weathering profile include secondary bastnäsite and monazite, with accessory Nb-rutile and hematite. In contrast, parisite and monazite are the dominant REE minerals in ADCC weathered materials along with altered pyrochlore. Chondrite normalised REE patterns reveal strong LREE enrichment at both sites, with varying REE concentrations down profile and exhibiting variable Ce anomalies. Sequential leaching experiments demonstrate that LREE are more mobile in the upper regolith, while the resistate REE phases increases with depth.

Overall, this study highlights the contrasting pathways of mineralogical variation and weathering processes that influence REE redistribution in carbonatite derived regolith. These results have implications for evaluating the potential of weathered carbonatite systems as alternative LREE resources.

References:

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