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Prospectivity Modeling of NE India for REE Deposits Associated with Carbonatites and Alkaline Complexes

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The rare earth elements (REEs) are a group of 17 metallic elements that are projected to be critical for future industrial development. Currently, China dominates the world production of REEs, contributing >55% of the global output. The entire production of REEs in India comes from the monazite-bearing beach sands along the eastern and western coasts. No primary economic-grade deposit of REEs has been discovered so far in India, despite the presence of a variety of enriched source rocks such as carbonatites, pegmatites, and alkaline complexes. In this contribution, we develop a GIS-based prospectivity model for exploration targeting of REEs associated with carbonatites and alkaline complexes in the Assam-Meghalaya plateau, NE India.

Drawing from McCuaig and Hronsky (2014) and Groves et al. (2020), a generalised mineral systems model for alkaline-carbonite-complexes-related REEs was developed to identify regional-scale targeting criteria for REEs in the study area. The main components of the mineral systems are (1) pockets of metasomatised SCLM, which form fertile source regions for REE-bearing fluids, (2) extensional geodynamic settings, mainly intracontinental rifts and large igneous provinces associated with mantle plumes, and (3) lithospheric-scale network of fluid plumbing architecture, which includes reactivated zones of structural weakness in the lithosphere and translithospheric faults for tapping REE-rich fluids from SCLM and near-surface upper-crustal faults and joints for focusing the fluids to near-surface levels. Finally, a postemplacement tectonic regime preserves the deposits. A series of predictor maps were generated from public domain geologic, geophysical, geochemical, and satellite data to represent the above components. A fuzzy inference system (FIS) was designed to model the interactions of the above REE mineral systems components. The outputs of the FIS were mapped to generate n REE prospectivity map of the study area. Furthermore, systemic and stochastic uncertainties in the model are estimated using the methods and procedure described by Lisitsin et al. (2014), Chudasama et al. (2017), and Porwal et al. (2003).

The following are the main findings of this exercise. Project-scale detailed ground exploration is recommended for the Sung Valley and Jasra Complexes, which show high prospectivity at all confidence levels. More data collection is recommended for the Mikir Hills in the areas surrounding Samchampi and Barpung Complexes. Similarly, more data should be collected around the swarms of dikes in the Garo Hills in the western part of the study area, where plugs or even a major intrusion of alkaline-carbonatite rocks may be present. The area northeast of Tura is geophysically similar to the Sung Valley and Jasra Complexes and is therefore a possible exploration target. Finally, to better understand the prospectivity of the Mawpyut ultramafic complex, detailed geochemical sampling and surface or airborne radiometric surveys should be carried out. This study is one of the first comprehensive GIS-based prospectivity models for exploring REEs associated with carbonatites and alkaline complexes that we are aware of in literature.