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Regional scale mineral prospectivity mapping of carbonatite-alkaline complex related REE deposits in northeast India.

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Rare Earth Elements (REE) are a group of 17 metals considered critical for future environmentally-friendly industries and are often concentrated in carbonatite-alkaline complexes. This study applies fuzzy inference systems (FIS), a symbolic knowledge-based artificial intelligence technique, to delineate regional-scale exploration targets for REEs associated with carbonatite-alkaline complexes in NE India. The two-stage FIS was structured based on a generalised conceptual REE mineral systems model, that was also used to identify the targeting criteria for REE deposits. Using geoprocessing and spatial analyses tools, predictor GIS layers that map these targeting criteria through their spatial proxies were obtained from primary geoscience datasets. These datasets include geology, topography, geophysics and geochemistry. Carbonatite-alkaline complexes, together with associated fenites, concentrate elements such as F, Cl, P, Nb, Ba, Sr, Zr, Mn, Ti, K and Na, besides REEs. Pathfinder maps targeting anomalous signatures of these elements, derived from stream and insitu geochemical data are crucial predictor maps.

Three individual FIS comprised the first of the two-stage FIS to represent

- Plume metasomatised subcontinental lithospheric mantle in an extensional setting that make up fertile source regions for REE-bearing fluids in favourable transient geodynamic settings,
- Trans-lithospheric structures that provide favourable lithospheric architecture for the transportation of REE-enriched magma from the source regions, and
- Shallow-crustal higher-order structures that provide favourable near-surface architecture that facilitates the emplacement of carbonatite-alkaline complexes.

In the second stage, the outputs of each of these three FIS representing the main components of the REE mineral system were integrated using the product operator to obtain the final REE prospectivity values. Uncertainties associated with the modelling process were quantified to aid decision-making.

High confidence targets are identified in areas surrounding the known occurrences of Sung valley and Jasra carbonatite-alkaline-complexes, where ground exploration is recommended. Low confidence targets were identified in the western part of the study area, around Swangkre and south of Nongstoin town, where detailed geological mapping is recommended. Data collection is recommended for the northeast part of the study area with the lowest confidence. The workflow presented in this study can delineate exploration targets in areas of similar geodynamic settings (mantle-plume-related intracontinental extensional settings) worldwide.