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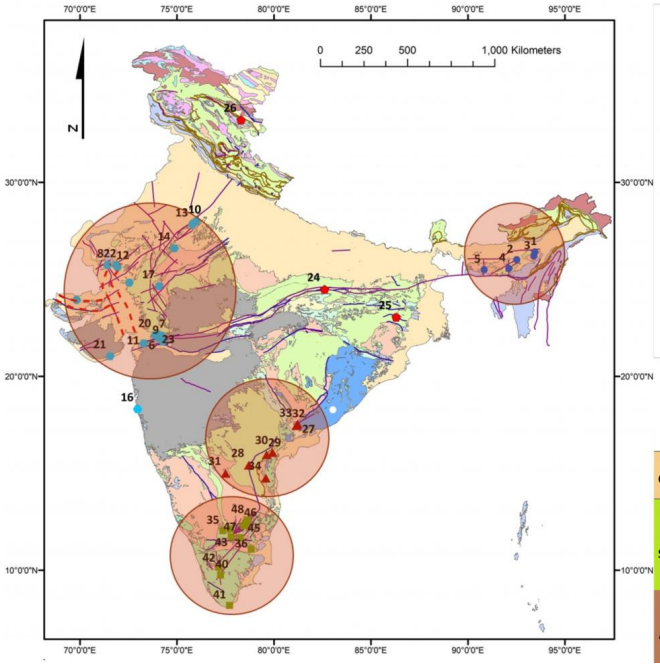
Carbonatites in India through Time and Space: A Review and Implications for REE Exploration

Malcolm Aranha[1], Alok Porwal[1, 3], Ignacio González-Álvarez[2, 3]
1. Indian Institute of Technology Bombay, Mumbai, MH, India, 2. Commonwealth Scientific and Industrial Research Organisation (CSIRO), Kensington, WA, Australia, 3. Centre for Exploration Targeting, University of Western Australia, Crawley, WA, Australia

Chronotectonic settings and petrogeochemistry of carbonatite occurrences of India are compiled and reviewed in relationship to global tectonic events associated with the amalgamation and breakup of supercontinents. Four chronotectonic domains, namely, southern domain, southeastern domain, northeastern domain and northwestern domain, are delineated based on the geographical distribution, tectonic settings, and temporal relationships among the carbonatite complexes. The southern domain comprises two subdomains—Paleoproterozoic and Neoproterozoic. The Paleoproterozoic subdomain is related to extension due to relaxation after the Southern Granulite Terrain-Dharwar accretion, while the Neoproterozoic subdomain is related to rifting related to the fragmentation of Rodinia. The southeastern domain is associated with the Mesoproterozoic fragmentation of Columbia. The northeastern domain is related to the Mid-Cretaceous breakup of Greater India from Australia-Antarctica driven by the Kerguelen mantle plume that also produced the Rajmahal-Sylhet Large Igneous Province (LIP). Finally, the northwestern domain is related to the Late Cretaceous Indo-Seychelles-Madagascar split and the passage of Greater India over the reunion hotspot, which also produced the Deccan LIP.

Petrogenetically, the Cretaceous carbonatites of the northeastern and northwestern domains are results of low-degree partial melting of a subcontinental lithospheric mantle (SCLM) that was metasomatised by a mantle plume. The older carbonatites of the southern and southeastern provinces show no geologic evidence of mantle-plume associations and are most likely results of low-degree partial melting of an SCLM, which was metasomatised by decompressional anatexis in an extensional regime. In each province, the carbonatites occur along major crust penetrating faults and are often polychronous. Geochemically, the Precambrian carbonatites display EMI or HIMU + EMI source features, whereas the post-Cambrian carbonatites are interpreted to be produced in a HIMU + EMII magmatic source—a trend that is observed in prominent carbonatites globally. In terms of the depth of the carbonatitic magma source, the southern domain likely had a shallow source, while the northeastern domain had a much deeper source.

In terms of REE exploration, presence of (1) metasomatised SCLM pockets, which form fertile source regions for REE-bearing fluids, (2) extensional geodynamic settings, mainly intracontinental rifts, with a possible association with mantle plumes, and (3) lithospheric-scale network of fluid plumbing architecture, which includes reactivated zones of structural weakness in the lithosphere and trans-lithospheric faults for tapping REE-rich fluids from SCLM and near-surface upper-crustal faults and joints for focusing the fluids to near-surface levels, are identified as prerequisites for the emplacement of REE-rich alkaline-carbonatite complexes. Further enrichments by metasomatic processes can be traced by geochemical sampling, radiometric surveys, and emplacement depth determination for direct detection of REE deposits.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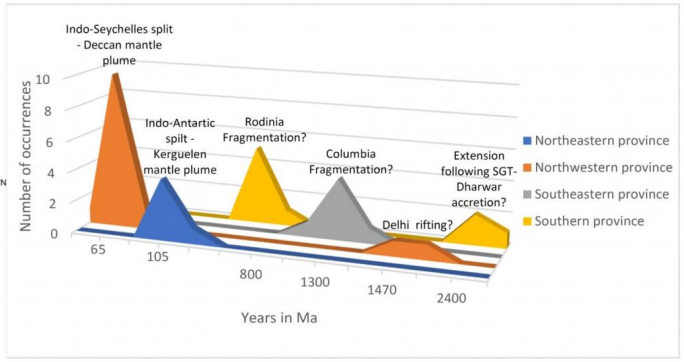
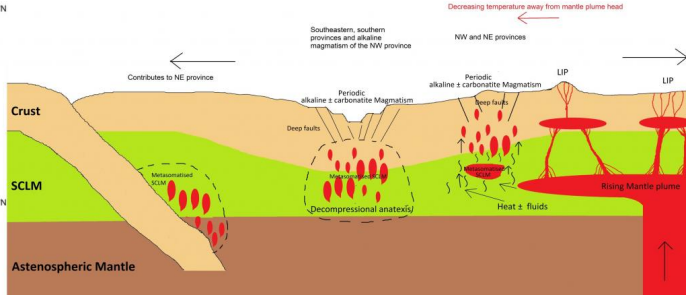

Indo-Seychelles split - Deccan mantle plume
Indo-Antartic spilt - Kerguelen mantle plume
Rodinia Fragmentation?
Columbia Fragmentation?
Extension following SGT-Dharwar accretion?
Delhi rifting?
Number of occurrences
Years in Ma
65
105
800
1300
1470
2400
Northeastern province
Northwestern province
Southeastern province
Southern province


Decreasing temperature away from mantle plume head
Southeastern, southern provinces and alkaline magmatism of the NW province
NW and NE provinces
Contributes to NE province
Periodic alkaline ± carbonatite Magmatism
LIP
Deep faults
Crust
SCLM
Metasomatised SCLM
Decompressional anatexis
Heat ± fluids
Rising Mantle plume
Astenospheric Mantle