Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.25402

Processes of Magma Mixing and Trans-Lithospheric Magmatic Plumbing in End-Cretaceous (67 Ma) Lamprophyres from the Nirwandh Alkaline Complex, Kutch, Northwest India

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The end-Cretaceous (ca. 67 Ma) Nirwandh alkaline igneous complex in Kutch region of Northwest India represents one of the earliest instances of alkaline magmatism within the Deccan Large Igneous Province. This study focuses on the petrology and geochemistry of four alkaline lamprophyres from the complex. All the lamprophyres exhibit complexly zoned or unzoned clinopyroxenes and amphiboles. In-situ analysis of major and trace elements reveals four distinct clinopyroxene varieties (i) zoned Cr-Mg-rich diopside cores to titano-augite rims, (ii) unzoned Fe-diopside, (iii) Na-rich salite cores to diopside rims (GCPx), and (iv) salite cores to diopside rims (GYCPx). Similarly, the amphiboles exhibit three paragenetic groups: (i) zoned Ti-rich ferropargasite cores to sadanagite rims, (ii) unzoned sadanagite to Ti-rich magnesio-hastingsite, and (iii) Pb- and Ti-rich ferro pargasite cores to sadanagite rims. Trace element calculations of melts in equilibrium with clinopyroxene suggest the involvement of two distinct magma batches: (i) a camptonitic magma and (ii) a Na-Nb-Zr enriched evolved magma. A comparative analysis of these mineral variants and their corresponding magma compositions, in relation to both local and global igneous occurrences, suggests that the cores of GCPx and GYCPx crystallized from tephri-phonolitic magma within evolved shallow melt pockets. In contrast, the colorless rims of these minerals were formed through the interaction of tephri-phonolitic magma with Nir-Wandh camptonitic magma. This interaction resulted in zoned or unzoned characteristics observed within the Nir-Wandh camptonitic magma, with two distinct batches reflecting varying degrees of magma evolution. Despite the mixing of these two distinct magmas, they exhibit a narrow range of bulk-rock isotopic values for 87Sr/86Sri (0.70407 to 0.70441) and 143Nd/144Ndi (0.51279 to 0.51286), which overlap with other associated rocks in the complex, indicating a genetic relationship. Pressure-temperature (P-T) estimates indicate that the Nir-Wandh lamprophyres experienced processes such as fractional crystallization, magma recharge, mixing, and crystal recycling within multiple trans-lithospheric magmatic reservoirs.