Presence of two plume-related volcanic events along the Indian northern passive margin evidenced by the geochemistry of the Carboniferous Baralacha La dykes, the Permian Panjal traps and the Drakkar Po phonolites

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The built-up of the Himalayan Ranges is related to the collision of the Indian and Asian plates which occurred 52 Ma ago. Subduction-related magmatism developed, south of the Tibet block while the Indian northern margin remained passive. During the collision, the Indian northern margin was dismembered in several tectonic units, caught between the High Himalayan Cristalline domain and the Indus-Zangbo suture. These tectonic units are largely exposed in the Zanskar, Spiti and Upper Lahul areas in north-western Himalayas.

The pre-rift units consist of platform-type detritic sediments ranging in age from the Late Precambrian up to the mid to late Permian; they are characterized by four magmatic events, i.e., the Cambrian to Ordovician granites, the Baralacha La Carboniferous basaltic dykes, the Yunam Early Permian intrusives and the Middle Permian Panjal traps. The latter are related to the Neotethys opening. In the Indus-Zangbo suture, blocks of Late Permian phonolites associated with reefal limestones represent the remnants of the oceanic basin neighbouring the northern Indian passive margin.

The Lower Carboniferous Baralacha La basaltic dykes emplaced along transtensional faults that never affected the "pre-rift units" younger than Early Carboniferous. The basalts exhibit tholeiitic and alkaline affinities. The tholeiites are TiO_2-poor, moderately enriched in light rare earth elements (LREE) ($La/Yb)_N$<2.9), and display Nb(La/Nb=1.5) and Ta negative and Th positive anomalies. The alkali basalts, compared to the tholeiites, have higher TiO_2, rare earth and incompatible trace element contents and LREE enrichments (3.5<$(La/Yb)_N$<5.2). The Nb and Ta negative anomaly is not systematically present in the alkali basalts. The Nd (+2.3<eNd<-1.3) and Pb isotope compositions of the Baralacha La basalts suggest that they were derived from the partial melting of an enriched OIB mantle source, characterized by an HIMU component, and contaminated by the lower continental crust. The Baralacha La dyke swarms represent the remnants of an early rifting event of the northern Indian passive margin.

Major and trace element analyses show that the Permian Panjal traps exhibit features of continental tholeiites: low TiO_2 contents (<1.6%), LREE enrichments and Nb and Ta negative anomalies (1.25<La/Nb<1.8). The initial Nd and Pb ratios show that the Panjal traps derived from an enriched OIB-type mantle source (-1.5<$e(Nd)_i$<+0.8), contaminated by the upper continental crust (high Pb/Pb ratios, low $e(Nd)_i$ values). The Drakkar Po phonolites derived from melting of an enriched OIB mantle source (+4<$e(Nd)_i$<+6) but are devoid of crustal contamination.

Remnants of volcanic suites related to the Neotethys opening are found also in the Hawasina nappes and Saih Hatat tectonic window, exposed in the Oman Ranges. The basalts of the Hawasina basin exhibit tholeiitic and alkaline affinities and derived from the mixing of depleted and enriched mantle sources without crustal contamination. In contrast, the low $e(Nd)_i$ values and the initial Pb isotopic ratios indicate that the enriched mantle source of the mafic lavas erupted on the Arabian platform (Saih Hatat) have features consistent with contamination by the lower crust. Thus, the Permian mafic lavas related to the Neotethys opening exhibit features typical of within-plate volcanism. Continental crust is involved solely in the genesis of the volcanics erupted on the Indian and Arabian margins. According to the palinspatic maps for Permian times, the Indian plate was close to the Arabian plate. This geographic layout and the similarities of the mantle sources of the Permian volcanics emplaced on the northern Gondwana margin and in the Neotethyan basin suggest the presence of a wide igneous province (2000 to 3000 km long). The latter could be linked to the melting of a large plume (Tethyan plume) or to activity of some smaller hot spots.