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Trace of multiple sources in the Girnar Complex, Deccan Traps: A geochemical perspective

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An enormous volume of mafic magma derived from multiple mantle sources passes through thick continental crust and builds up the Continental Flood Basalts (CFBs). The ca. 66 Ma Girnar Complex in the Saurashtra region of the Deccan Traps contains a diverse range of basic to intermediate plutonic rocks and silicic volcanic rocks. These rocks act as a potential site to trace multiple sources along with deep magma chamber processes of a CFB system. In this Girnar Complex, alkaline rocks (e.g., diorite/monzodiorite, mafic dyke) in the central portion are surrounded by tholeiitic rocks (e.g., gabbro and basalt), and silicic rocks (SiO_2 >65 wt%) occupy at the outer margin of the complex. The alkaline rocks display enriched light rare earth element (REE) patterns (La/Sm_N ~5.0 to 7.8) and trace elements reveals an origin from a spinel lherzolite lithospheric mantle source via partial melting (∼9%), followed by subsequent fractional crystallization (58 to 80%). Tholeiitic basalt, on the other hand shows flat light REE patterns (La/Sm_N ~0.8 to 1.8), could be generated from a more incompatible element depleted mantle (asthenosphere) source via 3-5% melting. About 20-30% olivine, orthopyroxene, clinopyroxene, and plagioclase crystals accumulation from the tholeiitic melt generated the tholeiitic gabbro. Both alkaline and tholeiitic rocks range from $^{87}Sr/^{86}Sr_i$ =0.7046-0.7062, $e_{Nd(i)}$ = -0.2 to +2.1, $e_{Hf(i)}$ = +5.1 to +6.8, $^{206}Pb/^{204}Pb_i$ =17.99-18.46, $^{207}Pb/^{204}Pb_i$ =15.59-15.70, $^{208}Pb/^{204}Pb_i$ =38.15-39.25, which indicates small-scale isotopic heterogeneity in the source or limited crustal contribution (<2%). The isotopic composition of silicic rocks of the Girnar Complex ($^{87}Sr/^{86}Sr_i$ = 0.7204-0.7275, $e_{Nd(i)}$ = -6.8 to -7.3, $^{206}Pb/^{204}Pb_i$ = 18.74-19.02, $^{207}Pb/^{204}Pb_i$ = 15.76-15.79, $^{208}Pb/^{204}Pb_i$ = 39.63-40.03, $e_{Hf(i)}$ = -6.0 to -7.3) reveals that they have evolved via AFC processes with 80-95% fractional crystallization of mantle-derived magma and assimilation of ~7 to 9% continental crust. This study suggests that melts from various sources evolved within the crust in an intricate plumbing system and emplaced in a close spatial association of a CFB settings.