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Plume-ridge interaction beneath the central Gulf of Aden: Sr, Nd, Pb and Hf isotopic evidence from dredged basalts

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Gulf of Aden is one of the ideal places to investigate processes of continental break-up and the interaction of plume with oceanic spreading ridge system. The Afar plume has strongly been affecting the formation and evolution of the Gulf of Aden and the Red Sea. Indeed, plume material flow could have played a role in the opening of the Gulf of Aden. Therefore, to evaluate the involvement of plume material in the source of basalts we measured Sr-Nd-Pb and Hf isotopic compositions of tholeiitic basalts dredged along the central Gulf of Aden ridge (45.5E-49E). Based on their contrasting spatial geochemical signatures, two groups (Group 1 and 2) of tholeiitic basalts are identified. Group 1 basalts, dredged from east of 46.20E, have relatively wide variations of $^{87}\text{Sr}/^{86}\text{Sr}$ (0.70278-0.70304) and $^{206}\text{Pb}/^{204}\text{Pb}$ (18.21-19.03) and limited range of $^{143}\text{Nd}/^{144}\text{Nd}$ (0.51301-0.51309) and $^{176}\text{Hf}/^{177}\text{Hf}$ (0.283224-0.283276; $\epsilon_{\text{Hf}}=15.98-17.83$); analogous to the geochemical signature of enriched (E) to depleted normal-type mid-oceanic ridge basalts (N-MORB). In contrast, Group 2 basalts, dredged between 45.6E and 46.2E, have limited ranges of $^{87}\text{Sr}/^{86}\text{Sr}$ (0.70323-0.70341), $^{206}\text{Pb}/^{204}\text{Pb}$ (19.33-19.49), and $^{143}\text{Nd}/^{144}\text{Nd}$ (0.51285-0.51292) and wide range of $^{176}\text{Hf}/^{177}\text{Hf}$ (0.283020-0.283155; $\epsilon_{\text{Hf}}=8.77-13.54$). The geochemical variations reflect the involvement of at least three components in their mantle source; these are (1) depleted MORB-type mantle, (2) plume matrix of the Afar plume, and (3) blobs in the plume matrix. Mixing between the first and second components would have produced Group 1 basalts, while mixing between the second and third components produced Group 2 basalts. The spatial variations in isotopic composition of the basalts suggest that the Afar plume head extends upto 48E along the Aden Ridge.

Keywords: Gulf of Aden, Afar plume, ridge-plume interaction, Sr-Nd-Pb-Hf isotopes