From Deccan to Réunion: No trace of a mantle plume

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ABSTRACT

The widely accepted mantle plume model postulates that (1) the currently volcanically active Réunion Island in the Indian Ocean is fed by the narrow "tail" of a mantle plume that rises from the core-mantle boundary, (2) the Deccan continental flood basalt province of India originated from the "head" of the same plume during its early eruptive phase near the end of the Cretaceous, and (3) the Lakshadweep-Chagos Ridge, an important linear volcanic ridge in the Indian Ocean, is a product of the plume. It is not generally appreciated, however, that this "classic" case of a plume contradicts the plume model in many ways. For example, there is little petrological evidence as yet that the Deccan source was "abnormally hot," and the short (~1.0–0.5 m.y.) duration claimed by some for the eruption of the Deccan is in conflict with recent Ar-Ar age data that suggest that the total duration was at least ~8 m.y. The Deccan continental flood basalts (CFB) were associated with the break-off of the Seychelles microcontinent from India. Geological and geophysical data from the Deccan provide no support for the plume model and arguably undermine it altogether. The interplay of several intersecting continental rift zones in India is apparently responsible for the roughly circular outcrop of the Deccan. The Lakshadweep-Chagos Ridge and the islands of Mauritius and Réunion are located along fracture zones, and the apparent systematic age progression along the ridge may be a result of southward crack propagation through the oceanic lithosphere. This idea avoids the problem of a 10° paleolatitude discrepancy which the plume model can solve only with the ad hoc inclusion of mantle roll. Published Ar-Ar age data for the Lakshadweep-Chagos Ridge basalts have been seriously questioned, and geochemical data suggest that they likely represent postshield volcanism and so are unsuitable for hotspot-based plate reconstructions. "Enriched" isotopic ratios, such as values of $^{87}Sr/^{86}Sr$ higher than those for normal mid-ocean ridge basalts, which have been observed in basalts of the ridge and the Mascarene Islands, may mark the involvement of delaminated enriched continental mantle instead of a plume. High values of $^{3}He/^{4}He$ also do not represent a deep mantle component or plume. The three Mascarene islands (Mauritius, Réunion, and Rodrigues) are not related to the Deccan but reflect the recent (post-10 Ma) tectonic-magmatic development of the Africa Plate. I relate CFB volcanism to continental rifting, which often (but not always) evolves into full-fledged seafloor spreading. I ascribe the rifting itself not to mantle plume heads but to large-scale plate dynamics themselves, possibly aided by long-term thermal insulation beneath a supercontinent that may have surface effects similar to those predicted for "plume incubation" models. Nonplume plate tectonic models are capable of explaining the Deccan in all its greatness, and there is no trace of a mantle plume in this vast region.