THE DECCAN BEYOND THE PLUME HYPOTHESIS

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Since the rapid rise to dominance of the plume head-tail model for flood basalts (*Richards et al.*, 1989; *Campbell and Griffiths*, 1990), literally hundreds of papers have invoked, or supported, a plume head origin for the Deccan Traps of India. These papers are unanimous on two counts: (i) the Deccan originated from the Réunion hotspot which upwelled beneath India in the late Cretaceous, and (ii) the hotspot, now located on the African plate, represents a deep mantle plume. However, I consider the mantle plume model invalid for the Deccan.

I relate continental flood basalt (CFB) volcanism to continental rifting, which often (but not always) evolves into full-fledged sea-floor spreading (*Sheth*, 1999a). I relate the rifting itself to plate stresses and possible heat buildup under an insulating supercontinent, not to deep mantle plume heads. Long-term mantle insulation under a supercontinent, an entire shallow-level mechanism, may have surface effects similar to those predicted for "plume incubation" models. The three major, relatively young CFBs India hosts (Rajmahal, ~116 Ma; Indo-Madagascar, ~88-85 Ma; Deccan; 65-60 Ma) all formed during continental rifting followed by full breakup (between India-Australia, India-Madagascar, and India-Seychelles, respectively). Shallow-mantle geodynamic mechanisms, such as EDGE effects, continental mantle delamination, crack propagation through oceanic lithosphere, and crack-controlled melting and magma focusing, can well explain observations generally ascribed to plumes, such as "enriched" magma chemistry and systematic age progressions (*Sheth*, 1999b).

There is no petrological evidence that the sources of any Deccan lavas were "abnormally hot". The short (1.0-0.5 MY) duration claimed by some for this grand episode is in conflict with recent data that suggest the total duration to have been of the order of 8-9 MY (*Sheth et al.*, 2001a,b). The eruption rates are not known to have been particularly high, and the large volumes erupted could be due to the great lengths of the eruptive fissures. No systematic age progression exists within the Deccan, and reliable ^{40}Ar-^{39}Ar ages of 60-61 Ma for lava flows from Bombay (*Sheth et al.*, 2001a,b) are impossible to reconcile with a plume-model-based expected age of 60 Ma for the Laccadives Ridge, 1000 km south of Bombay. Also, if the ~69 Ma mafic dykes reported from Kerala, southernmost India (*Radhakrishna et al.*, 1994) do represent early Deccan-related magmatism, an entirely different, non-plume, passive, EDGE-model (*Anderson*, 1998a) for Deccan volcanism seems even more attractive. "Enriched" isotopic ratios such as higher-than-N-MORB values of ^{87}Sr/^{86}Sr, encountered along the island/seamount chain southward from the Deccan and up to Réunion Island, are usually taken to be plume signatures, but such compositions may instead mark an involvement of shallow-level enriched continental mantle (*Smith*, 1993). High values of ^{3}He/^{4}He ratios also do not represent a deep mantle or plume component (e.g., *Anderson*, 1998b). The ~68.5 Ma alkaline complexes (Mundwara, Barmer) in the northern Deccan, previously ascribed to a plume (*Basu et al.*, 1993) on this basis, could derive from the continental mantle. The same may be true of 72-73 MY old mafic ophiolitic rocks outcropping in Pakistan, with Réunion-like chemical and isotopic compositions (*Mahoney et al.*, 2002). The systematic age progression along the Chagos-Laccadive Ridge and up to Réunion Island, is due to southward crack propagation through the oceanic lithosphere, not to Indian plate motion over a plume (*Sheth*, 1999b). The narrow "hotspot track" may represent localized melting and magma focussing from a wider area (the "transform-fault effect", *Langmuir and Bender*, 1984).

One interesting possibiity needing exploration is whether eclogite could have been a source in part for the Deccan lavas. The rifted western continental margin of India follows the NNW-SSE Dharwar structural trend of the Precambrian southern Indian shield (e.g., *Biswas*, 1987), and the lines of breakup of India from Seychelles, and also Greater India (India + Seychelles) from Madagascar, may have been ancient sutures with large amounts of trapped eclogite and enriched mantle in them. If such eclogite constituted a major source for the Deccan, mantle fertility and not high mantle temperatures were important (see *Yaxley*, 2000). The ENE-WSW Narmada zone running along central India has been argued previously to represent an ancient suture between two protocontinents.

The interplay of the rift zones underlying the Deccan, which come together in west-central India, is apparently responsible for the roughly circular outcrop of the Deccan, resembling what is expected from a spherical plume head. Along the rift zones (the Cambay, Kachchh, Narmada-Tapi and Godavari rifts), EDGE effects (*Anderson*, 1998a), and crustal extension (*Sheth*, 2000) were important. The "hotspot track" on the oceanic crust, as argued, is similarly related to melting and magma focussing along a southward-propagating fracture. To conclude, non-plume, plate tectonic models are fully capable of explaining the Deccan in all its greatness.

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