The Deccan Traps (India) and the mantle plume model: Overview and 2018 update

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The mantle plume model (Morgan 1981; Campbell and Griffiths 1990) postulates that: (i) the Deccan Traps flood basalt province formed on the northward-drifting Indian subcontinent in the Late Cretaceous (66-65 Ma) from the "head" of a hot deep mantle plume; (ii) the plume "tail" subsequently produced the Lakshadweep-Chagos Ridge in the Indian Ocean; (iii) Réunion Island on the African plate is the current, volcanically active, expression of the same plume. This popular model faces several problems. The bulk (>95%) of the Deccan flood basalts are evolved (MgO 4-7 wt.%) tholeiites. Picrites, picritic basalts and ankaramites in the 2 km thick Western Ghats sequence are enriched in cumulus olivine and clinopyroxene, with maximum melt-MgO contents estimated at 10 wt.% (Beane and Hooper 1988; Chatterjee and Sheth 2015). There is thus no evidence for an abnormally hot mantle source for the bulk of the Deccan tholeiites; a peridotite source and large amounts (>30 wt.%) of olivine fractionation from their parental magmas are assumed rather than proven. Melt inclusion work is almost non-existent. Slightly alkaline primitive picritic liquids with an estimated 16 wt.% MgO are found only in one small area in the entire province (Krishnamurthy et al. 2000), where an intracontinental rift meets the western Indian rifted margin. Unlike the postulate in the thermal plume model, there was no province-wide, kilometer-scale prevolcanic uplift in the Deccan province (Sheth 2007). Slightly older (68.5 Ma) alkaline magmatism at the northwestern end of the province, considered to be an early expression of the Deccan-Réunion plume (Basu et al. 1993), is now recognized as just *one* episode of *recurrent* alkaline magmatism (at 110-102 Ma, 84 Ma, and 68.5-65 Ma), thus best ascribed to intraplate extension (Pande et al. 2017a; Sheth et al., 2017). On the other hand, a massive phase of tholeiite, rhyolite and trachyte magmatism occurred at Mumbai on the western Indian rifted margin at 62.5 Ma, during India-Seychelles rifting, with the Panvel monoclinal flexure forming contemporaneously and substantial offshore submarine volcanism in the Laxmi Basin (Pande et al. 2017b). This 62.5 Ma burst cannot be explained in the plume model which postulates only a short duration (1 m.y. at 66-65 Ma) duration of the "plume head" volcanism. Post-breakup intrusions of trachyte, syenite, *and basalt* were emplaced as late as 61 Ma in both Mumbai and the Seychelles, attesting to a total span of Deccan magmatism of ~9 m.y. (Owen-Smith et al. 2013; Pande et al. 2017b). The intense young (62.5-61 Ma) magmatism also cannot be ascribed to the "plume tail" phase, as the tail was suppposedly 1000 km south at the northern end of the Lakshadweep Ridge. In fact, accuracy of the geochronological data (Ar-Ar ages) on rocks of the Lakshadweep-Chagos Ridge used to construct the "hotspot track" has been seriously questioned (Baksi 1999). The Ridge may have been a leaky oceanic transform, without any systematic age progression, and there is evidence that it is at least partly continental (Bhattacharya and Yatheesh 2015). The Mascarene islands (Rodrigues-Mauritius-Réunion) have no relationship to the Deccan Traps and are among the youthful (<10 Ma) population of African plate hotspots (Burke 1996). Geochemical-isotopic similarities sometimes claimed between Réunion (and Mauritius) and Deccan lavas can arise from delamination of Indian continental mantle into the Indian Ocean asthenosphere during the India-Madagascar (~85 Ma) and India-Seychelles (62.5 Ma) continental breakup events. The roughly circular outcrop of the Deccan flood basalts does not indicate a spherical plume head below, but is due to several intersecting continental rift zones which show profuse dykes and intrusions (Sheth et al. 2018). The Deccan Traps are not a classical case supporting the deep mantle plume model, but appear ultimately related to continental extension and rifting.

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