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Research paper

Early Cenozoic rapid flight enigma of the Indian subcontinent resolved: Roles of topographic top loading and subcrustal erosion

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ABSTRACT

Intrinsic magmatic processes are considered as critical operators of plate movements. Here we demonstrate the role of extrinsic processes consequent to intrinsic processes as a catalyst for anomalous rapid plate movement. The rapid and accelerated flight of the Indian subcontinent since Deccan volcanism until its collision with Eurasia remains as one of the geological conundrums. Data on seismic tomography, peninsular geomorphology and inferences on continuum of subcrustal structures are utilized to address this enigma. We propose geomorphic isostasy as the mechanism that has driven this fastest drift ever recorded in geological history. It was initiated by sudden instability after the Deccan volcanism and resultant extensive accumulation of lava pile over continental lithosphere of northern India, northern-eastern tilt due to crustal thickness heterogeneity and subcrustal thermal stratification. The drift was sustained by Carlsberg and Central Indian ridge-push until collision and sediment top loading at northeast thenceforth. These inferences and geomorphic isostasy as a catalytic mechanism necessitate variability of drift rates as integral inputs for any continental scale modeling.

1. Introduction

Driven by deep convection currents, continental plates drift over the plastic asthenosphere at rates of few centimeters per year (Jagoutz et al., 2015). Large scale plate reorganization plays first order controls on orogeny, changes in ocean-basin volume, basin evolution, climate and sea level and enforce topographic feedback as a continuum (Campanile et al., 2008). Plate reconstruction theories and models of rifts/drifts often take into account intrinsic magmatic processes as the critical operator of continental drifts (Cande and Stegman, 2011; Müller, 2011; van Hinsbergen et al., 2011; Koptev et al., 2015). And more frequently overlook the inherent nature of these events that always work on differential rates and at highly discontinuous periodicity (Müller, 2011). The resultant surficial disequilibrium operates under the influences of a variety of factors and responds in distinct spatio-temporal scales. Little is known how rapid plate reorganization events that continue for long geological timescales can be highly varied, persistent and produce topographic feedbacks.

The tectono-geomorphic evolution of the Indian subcontinent commenced at ~167 Ma following the breakup of Gondwana supercontinent. The subsequent drift represents exceptional journeys (~9000 km) of all the continents involving plate tectonic and landform diversification events (Chatterjee et al., 2013). Soon after the basaltic eruption at the end of Cretaceous, India drifted northward at about 20 cm/yr; a rate exceptionally high (Chatterjee et al., 2013) as compared to present-day rate of ~5 cm/yr. The driver of this early-Cenozoic acceleration still remains enigmatic. Here we demonstrate the interplay between intrinsic and extrinsic sources as catalysts of anomalous rapid plate reorganization. Based on isostatic compensation, denudation and recurrent reactivation

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of Proterozoic–Cretaceous tectonic structures, and subcrustal dynamism, we establish geomorphic isostasy as the mechanism that initiated the faster drift of the Indian subcontinent in the aftermath of Deccan volcanism.

2. Geological setting

The Indian subcontinent is an assemblage of microcontinents that experienced extensive volcanism, plutonism, metamorphism, and sedimentation preserving structures (Fig. 1) inherited since early Proterozoic (Chatterjee et al., 2013; Collins et al., 2014). A continuum of structural and resultant geological-geomorphic evolution of the Indian subcontinent is evident from the occurrences and/or alignments of Paleozoic, Mesozoic and Cenozoic sedimentary basins (Banerji, 1984) and escarpments, and plateaus (Fig. 1) essentially along older faults/suture zones (Jayalakshmi et al., 2004; Biswas, 2005; Mishra and Kumar, 2005; Ramkumar et al., 2016). Occurrences of Permo-Triassic and early Cretaceous deposits only in the downwarped grabens of Gondwana basins, extensive Cenozoic deposits offshore (Bastia and Radhakrishna, 2012; Chatterjee et al., 2013) and Neogene–Holocene deltaic deposits all along the east coast (Ramkumar, 2003; Campanile et al., 2008), the absence of comparable deltaic sequences in the west coast (Kale, 2014; Kale and Vaidyanadhan, 2014), the historic and ongoing seismicity either at or in the vicinity of paleo-sutures and structures (Radhakrishna,

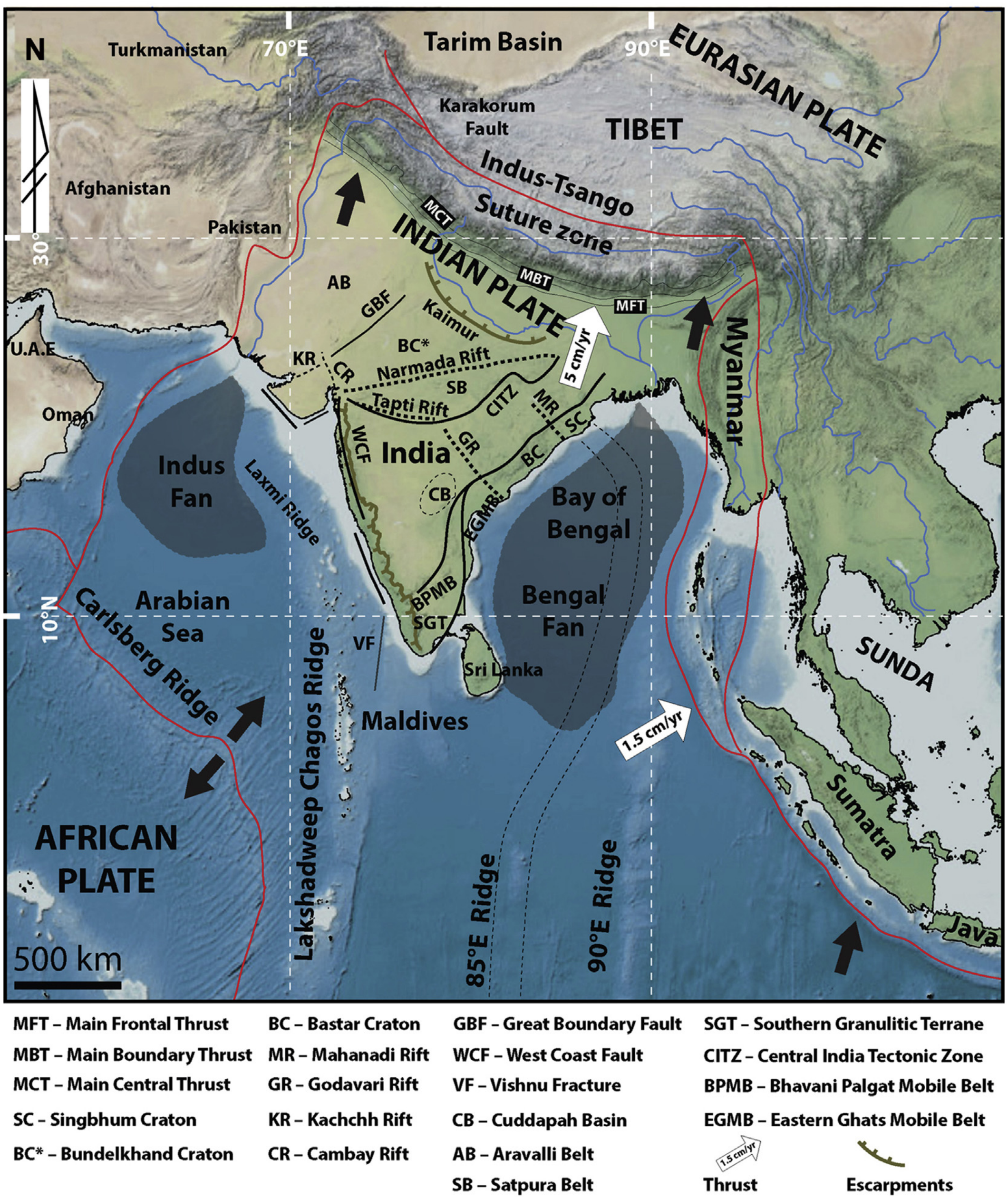

Figure 1. Regional structural trends of the Peninsular India. This figure depicts the inheritance of structural trends from Proterozoic paleo-suture zones. These underwent reactivation during Permo-Triassic, late Jurassic–early Cretaceous, upper Cretaceous, end Cretaceous–early Cenozoic. Occurrences of ongoing seismicity, at or along boundary faults of sedimentary basins, deltaic systems, plateaus, escarpments, strandlines, waterfalls, knick points, terraces, etc., evidence tectonic continuum until recent (Ramkumar et al., 2016). Owing to the connectivity between subcrustal causative mechanism and progressively weakened nature, these suture zones were the zones of reactivation repeatedly, during geologic-historic-recent times. It also evidences to the subcrustal origin for them and single mechanism–subcrustal erosion and periods of intensive mantle plume activity.