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The Deccan tholeiite lavas and dykes of Ghatkopar–Powai area, Mumbai, Panvel flexure zone: Geochemistry, stratigraphic status, and tectonic significance

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ABSTRACT

Mumbai City, situated on the western Indian coast, is well known for exposures of late-stage Deccan pillow basalts and spilites, pyroclastic rocks, rhyolite lavas, and trachyte intrusions. These rock units, and a little-studied sequence of tholeiitic flows and dykes in the eastern part of Mumbai City, constitute the west-dipping limb of a regional tectonic structure called the Panvel flexure. Here we present field, petrographic, major and trace element and Sr–Nd isotopic data on these tholeiitic flows and dykes, best exposed in the Ghatkopar–Powai area. The flows closely resemble the Mahabaleshwar Formation of the thick Western Ghats sequence to the east, in Sr–Nd isotopic ratios and multielement patterns, but have other geochemical characteristics (e.g., incompatible trace element ratios) unlike the Mahabaleshwar or any other Formation. The flows may have originated from a nearby eruptive center, possibly offshore of Mumbai. Two dykes resemble the Ambenali Formation of the Western Ghats in all geochemical characteristics, though they may not represent feeders of the Ambenali Formation lavas. Most dykes are distinct from any of the Western Ghats stratigraphic units. Some show partial (e.g., Sr–Nd isotopic) similarities to the Mahabaleshwar Formation, and these include several dykes with unusual, concave-downward REE patterns suggesting residual amphibole and thus a lithospheric source. The flows and dykes are inferred to have undergone little or no contamination, by lower continental crust. Most dykes are almost vertical, suggesting emplacement after the formation of the Panvel flexure, and indicate considerable east–west lithospheric extension during this late but magmatically vigorous stage of Deccan volcanism.

1. Introduction

The Deccan Traps are a large continental flood basalt (CFB) province of Late Cretaceous to Palaeocene age, currently occupying ~500,000 km^2 in western and central India (Fig. 1a). They are best developed in the Western Ghats escarpment in the southwestern part of the province (Fig. 1a), where they have been divided into three subgroups and eleven formations with a total stratigraphic thickness of ~3.4 km over a ~500 km distance (e.g., Najafi et al., 1981; Beane et al., 1986; Lightfoot et al., 1990; Peng et al., 1994; Table 1). Several distant Deccan lava sections are broadly correlatable with the Western Ghats type section (e.g., Peng et al., 1998 and Peng et al., this volume; Mahoney et al., 2000), whereas others are stratigraphically and petrogenetically unrelated (e.g., Sheth and Melluso, 2008; Sheth et al., 2013), suggesting polycentric eruptions. Three major dyke swarms, including the ~ENE–WSW-trending Narmada–Tapi dyke swarm, the ~N–S-trending Coastal dyke swarm, and the more randomly oriented Nasik–Pune dyke swarm (Fig. 1a), have been extensively studied (e.g., Auden, 1949; Viswanathan and Chandrasekharam, 1976; Deshmukh and Sehgal, 1988; Melluso et al., 1999; Widdowson et al., 2000; Bondre et al., 2006; Ray et al., 2007; Sheth et al., 2009; Hooper et al., 2010; Vanderkluysen et al., 2011). These studies have indicated that the Narmada–Tapi dyke swarm fed some lower-and middle-level stratigraphic formations of the Western Ghats sequence, and the Coastal and Nasik–Pune swarms fed many lavas of the the middle and upper formations.

Alkalic and silicic rocks are concentrated in a few areas in the province, such as that of Mumbai City (Fig. 1a–c) on the western Indian rifted margin (e.g., Sukheswala and Poldervaart, 1958; Sukheswala, 1974; Sethna and Battiwala, 1977). Mumbai City is located in the ~150 km-long, structurally complex Panvel flexure zone, in which the volcanic pile shows significant tectonic dips

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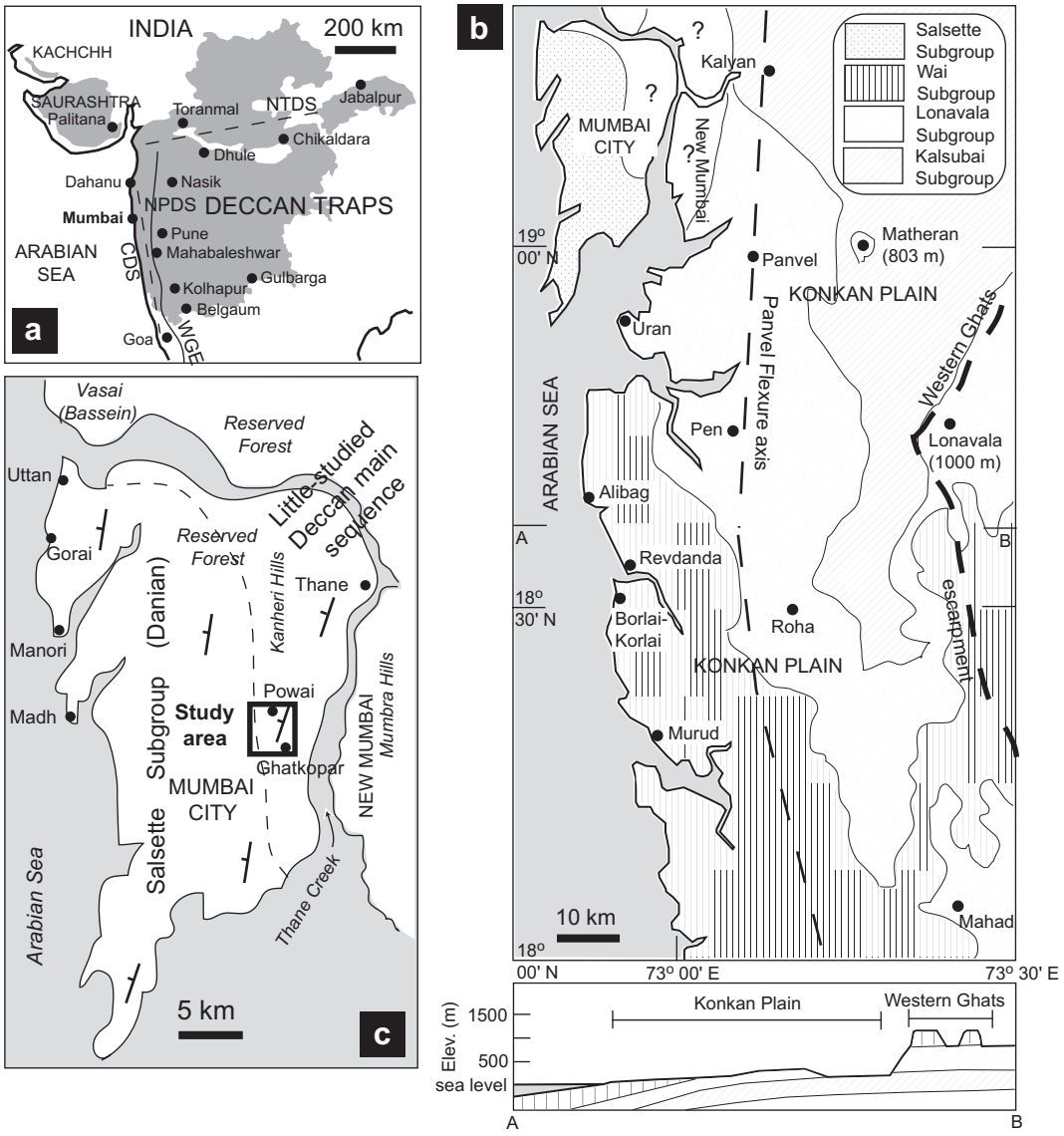

Fig. 1. Maps of the Deccan Traps (a), the western Deccan Traps (b) and Mumbai City (c), with important features and localities mentioned in the text marked. In (a), WGE is the Western Ghats escarpment, NTDS the Narmada–Tapi dyke swarm, CDS the Coastal dyke swarm, and NPDS the Nasik–Pune dyke swarm (Vanderkluysen et al., 2011 and references therein). (b) shows the map and west–east cross-section (drawn just south of Alibag) of the stratigraphic subgroups of the Western Ghats sequence (based on Hooper et al., 2010).

Table 1
Geochemical stratigraphy of the Western Ghats section, Deccan Traps.

Group	Sub-group	Formation	Magnetic polarity	$^{87}Sr/^{86}Sr_{(65Ma)}$
Deccan Basalt		Desur* (~100 m)	N	0.7072–0.7080
		Panhala (>175 m)	N	0.7046–0.7055
	Wai	Mahabaleshwar (280 m)	N	0.7040–0.7055
		Ambenali (500 m)	R	0.7038–0.7044
		Poladpur (375 m)	R	0.7053–0.7110
	Lonavala	Bushe (325 m)	R	0.7078–0.7200
		Khandala (140 m)	R	0.7071–0.7124
	Kalsubai	Bhimashankar (140 m)	R	0.7067–0.7077
		Thakurvadi** (650 m)	R	0.7067–0.7224
		Neral (100 m)	R	0.7062–0.7104
		Jawhar-Igatpuri (>700 m)	R	0.7085–0.7128

Notes: Table based on Subbarao and Hooper (1988) and references therein, Peng et al. (1994), and Vanderkluysen et al. (2011). N = normal magnetic polarity, R = reverse magnetic polarity.

* The Desur is considered by many as a "Unit" of the Panhala Formation itself.

** The Sr-isotopic range for most of the Thakurvadi Formation lavas is 0.7067–0.7112, but a single flow in the formation (Paten Basalt) has an anomalously high, broadly Bushe-like value (0.7224).