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Sr, Nd and Pb isotopic and chemical compositions of central Deccan Traps lavas and relation to southwestern Deccan stratigraphy

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ABSTRACT

Sr, Nd and Pb isotopic compositions, and major and trace element abundances of lavas in five central Deccan Traps sections are generally very similar to those of lavas in the southwestern Deccan (Western Ghats escarpment). The combination of strong isotopic and chemical similarities between lavas of the two regions indicates that they shared a closely similar petrogenesis. Our results indicate that, unlike many lavas in the northeastern Deccan, most of the lavas studied in the central Deccan sections can be grouped into different stratigraphic members and chemical types (CTs) belonging to four formations (Thakurvadi, Bhimashankar, Khandala, and Poladpur) present in the type sections of the Western Ghats. Bhimashankar- and Thakurvadi-type lavas are found in a section near Outram, whereas only Khandala-type lavas make up the Mhaishmal, Ellora and Ajanta sections to the east, and only Poladpur-type lavas are present in the easternmost section at Lonar. This west-east sequence is the same as that seen going upward in the Western Ghats stratigraphy, except that Bushe-type lavas, which are located stratigraphically between the Khandala and Poladpur formations in the Western Ghats, have not been found in this study. Overall, our results indicate that the Khandala and Poladpur formations extend over west-east distances of more than 300 km, and some individual members (e.g., the Dhak Dongar) may extend over as much as 500 km. The regional dip from Igatpuri in the southwest to Lonar in the east-central Deccan is less than 0.5° to the east, which is similar to the southward regional dip in the southwestern Deccan. Near-horizontal flows in the central and southwestern Deccan areas suggest that post-Deccan tectonic activity has had limited effects on the studied area. Large volumes of basaltic lavas derived from eruptive centers in the western Deccan may have covered both the central and southwestern Deccan areas.

1. Introduction

The Deccan Traps of India (Fig. 1a) consist of thick successions of subaerially erupted flood basalt lavas which are nearly flat-lying over most of the province. The lavas are believed to have been emplaced during rapid eruptive pulses (e.g., Chenet et al., 2008, 2009). Some authors have proposed that Deccan magmas were generated by a mantle melting anomaly as the Indian plate moved northward over the Réunion hotspot 66 m.y. ago (e.g., Duncan, 1991). Previous work to determine the volcanic stratigraphy of the province has concentrated on the southwestern region of the Western Ghats escarpment (Fig. 1), where it is thickest (~3500 m) (e.g., Bodas et al., 1984; Cox and Hawkesworth, 1985; Beane et al., 1986; Lightfoot et al., 1990; Peng et al., 1994; Subbarao et al., 1994). In the Western Ghats, eleven stratigraphic formations have been identified (Fig. 1b) based on field relationships, magnetic polarities, and geochemical composition of the lavas. Beane et al. (1986) used multi-element statistical discrimination methods to assign newly studied flows (and dikes) to the geochemically defined stratigraphic formations of the western Deccan, as part of an effort to map these formations beyond their original type locations. Results indicate that there is a very slight (<0.5°) southward regional dip of the chemostratigraphic boundaries: the oldest exposed formation, the Jawhar, crops out in the northern part of the area studied, near Igatpuri, and the youngest, Panhala, is found near Amboli in the southern Deccan (e.g., Devey and Lightfoot, 1986; Watts and Cox, 1989; Mitchell and Widdowson, 1991; Jerram and Widdowson, 2005).

The lava flow successions studied in the southern and southeastern Deccan seem to correspond closely to the Western Ghats stratigraphy (e.g., Lightfoot and Hawkesworth, 1988; Mitchell and Widdowson, 1991; Jay and Widdowson, 2008; Self et al., 2008), but tholeiitic flows from the Mumbai region seem to be without geochemical equivalents in the Western Ghats (Sheth

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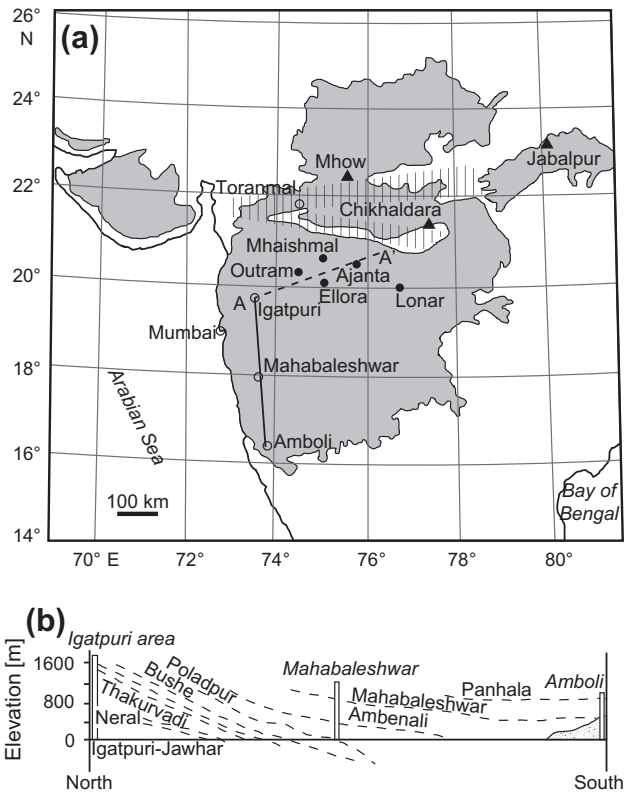

Fig. 1. (a) Map of the Deccan Traps (gray) and locations of Outram, Mhaishmal, Ellora, Ajanta and Lonar sections (black circles) of the central Deccan and Chikhaldara, Mhow and Jabalpur sections (triangles) of the northeastern Deccan (modified after Peng et al., 1994). Hashed area represents the Narmada-Tapi rift system. Solid line represents the Fig. 1b cross-section, and dashed line the cross-section in Fig. 9. (b) N-S stratigraphic cross-section of the southwestern Deccan from Igatpuri to Amboli. The approximate boundaries between formations are indicated by dashed lines. Dotted pattern at right represents Archean basement (from Mahoney, 1988, and references therein).

et al., 2014). On the other hand, significant isotopic differences have been found between most lavas of the northern and northeastern Deccan and those of the Western Ghats succession (Peng et al., 1998; Mahoney et al., 2000). Despite being isotopically different, most of the northeastern lavas have major and trace element characteristics broadly similar to those of Poladpur Formation (Fm.) or Khandala Fm. lavas of the Western Ghats, and also occur in the same general stratigraphic order. The chemical similarities between basalts of the two regions indicate that they may be petrogenetically related, but the northeastern lavas must have interacted less with low-$^{206}Pb/^{204}Pb$ continental material than their southwestern counterparts and thus probably erupted through different feeder dikes (possibly located along the Narmada-Tapi rift; e.g., Sheth et al., 2009; Vanderkluysen et al., 2011). A few northeastern flows, however, are closely similar in both isotopic and chemical compositions to the Dhak Dongar and Rajmachi members of the Khandala Fm., suggesting that these members may extend from the Western Ghats to the northeastern part of the province.

Stratigraphic studies in the central Deccan are very limited (Subbarao et al., 1994). We studied five sections in the central Deccan; although they are among the thickest in the region, all are thin (~100 m to ~300 m) compared to major sections in the Western Ghats escarpment. The isotopic and chemical characteristics of these central Deccan basalts reveal their stratigraphic similarity to the Western Ghats lavas, suggesting a shared or closely similar petrogenesis for many types of lava in both areas and that some central Deccan basalts are far-traveled counterparts of those in the southwest.

2. Methods

2.1. Samples and analytical methods

Samples in this study came from sections indicated by dots in Fig. 1a. In the Outram section, located about 120 km northeast of

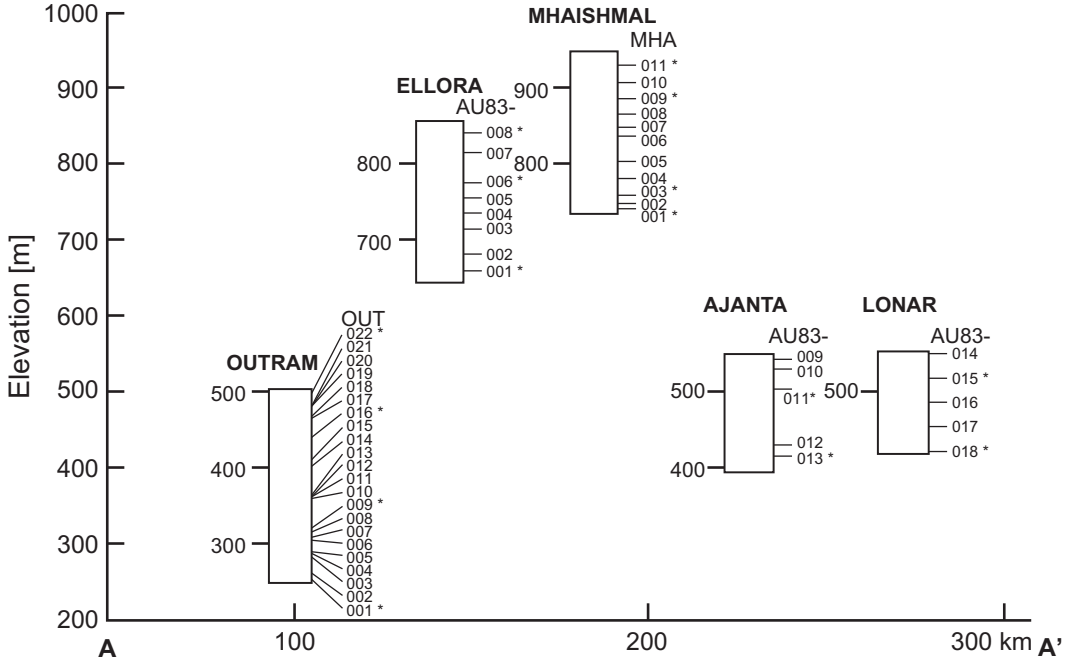

Fig. 2. Stratigraphic sections of the central Deccan projected to line A–A′ in Fig. 1, with approximate elevations of samples. Asterisks (*) indicate samples analyzed for Sr, Nd and Pb isotopes.