

Crustal geotherm in southern Deccan Basalt Province, India: The Moho is as cold as adjoining cratons

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ABSTRACT

Deccan basalts have long been considered to be a product of Reunion plume – Indian lithosphere interaction, about 65 Ma ago. However, recent studies call into question their plume origin. In this study, we investigate whether there is or not a thermal signature of the plume in the present-day thermal regime of the Deccan crust. Our study is limited to the southeastern Deccan province, where surface heat flow values are abundant and the radiogenic heat contribution of the underlying crust (~2.7-2.5 Ga old eastern Dharwar craton) can be well constrained from its exposed crustal cross-section. Surface heat flow varies from 33 to 73 mW m⁻² with a mean of 45 mW m⁻². Heat production of the Deccan basalts (tholeiite) is 0.39 μW m⁻³, and heat production of the basement rocks is assigned on the basis of the data from the Dharwar craton. The basement Dharwar crust is composed of middle- to late Archaean greenstone belts, gneisses, granites and granulites, whose heat production has been determined from > 1500 sites, which belong to various crustal depth layers (greenschist, amphibolite and granulite facies) of the exposed crustal section. The data suggest a radiogenic heat contribution of Deccan crust of ~38 mW m⁻², implying a Moho heat flow of ~7 mW m⁻² and Moho temperature of ~280 °C, which are similar to those in the adjoining Archaean Dharwar craton. Therefore, it appears that there is no thermal trace of the supposed plume in the present-day crustal thermal regime of the southeastern Deccan basalt province.

Keywords: heat flow, heat production, crustal geotherm, Deccan basalt, Reunion plume, Dharwar craton, India

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INTRODUCTION

Continental crust affected by a mantle plume would have an elevated surface heat flow and Moho heat flow leading to a perturbed lithospheric geotherm, relative to the adjoining provinces unaffected by the plume. However, such thermal anomaly would decay with time. The Deccan Basalt Province (DBP) (Fig. 1) is a possible example as several

researchers have attributed its origin to ~65 Ma old Reunion plume (or hotspot), although this inference has been severely debated in recent years (see Sheth, 2005). In this study, we aim to understand the nature of present-day crustal geotherm beneath the southern Deccan Basalt Province (DBP), in an effort to assess the possibility of a thermal trace of Reunion plume that was thought to be responsible for the formation of 68-63 Ma old Deccan basalts and their derivatives. Bonneville et al. (1997) determined heat flow across the Reunion hotspot track (Mascarene Ridge located NE of Reunion island) and found a significantly higher heat flow of 6-8 mW m⁻² than the reference heat flow predicted for the seafloor age. Therefore, in this study, we examine whether such an anomalous heat flow (although this is low) can be seen in the present-day crustal thermal regime of the Deccan province. Modeling the present-day crustal thermal structure of the Deccan province is possible as an adequate number of heat flow determinations are available for its southeastern part (Fig. 1), and crustal radiogenic heat production can be estimated from an exposed crustal cross-section of the Dharwar craton (Figs. 2 and 3) that forms the basement of the southern Deccan basalt province.

In the Deccan province, Roy and Rao (2000) presented new heat flow values, in addition to compiling the existing heat flow data (Figs. 1 and 4). Also, Roy and Rao (1999) modeled the present-day crustal geotherm of southeastern Deccan province, on the basis of heat flow measurements from the deep boreholes in the 1993 Killari (or Latur) earthquake area (Fig. 1) and a few heat production measurements from its basement rocks; these authors also did conclude that the surface heat flow of the Deccan province is low, similar to the adjoining areas, and that the thermal transient related to the Deccan volcanic episode had decayed. Subsequent to this study, there have been several improvements to the understanding of the crustal structure, composition and evolution of the basement Dharwar craton (see Kumar and Reddy, 2004). A better understanding of the heat flow, heat production and crustal thermal structure of the Dharwar craton has been possible owing to further studies (e.g., Ray et al., 2003; Kumar and Reddy, 2004). In particular, Kumar and Reddy (2004) have established a new well-constrained crustal radiogenic heat production model for the entire Dharwar craton from the ~30-km-thick exposed crustal cross-section, measuring several hundreds of sites for heat production by all the crustal rocks. These new studies open vistas to refine our understanding of the present-day crustal thermal structure of southern Deccan basalt province. The thermal signatures of hotspot anomalies are usually found to be very low (e.g., DeLaughter et al., 2005), and therefore, the need to have an improved crustal thermal model that can resolve low heat flow anomalies is paramount. Unfortunately, the thermal structure of other parts of Deccan province cannot be modeled owing to too few heat flow and heat production measurements from its basement rocks (e.g., Menon et al., 2003) belonging to the Rajasthan, Bundelkhand, and Bastar cratons (Fig. 1).

GEOLOGY

The Deccan Basalt Province (Fig. 1) is spread over an area of ~500,000 km², which consists dominantly of tholeiitic basalts, with subordinate amounts of alkaline and picritic basalts. A detailed account on the geology of Deccan basalt province can be found in Subbarao (1999). The total thickness of the entire Deccan basalt sequence is ~3.4 km (see Mahoney et al., 2000), containing 3 Subgroups and 11 Formations, of which the basalts of Ambenali Formation are largely exposed on the southern part of the Deccan province (e.g., Mitchell and Widdowson, 1991). Eruption of the Deccan basalts lasted for ~5 Ma, between 63 and 68 Ma ago, with a maximum eruption rate around 66-65 Ma ago (see Pande, 2002). The Deccan basalt sequence is thin (~500 m) along its margins, and it apparently thickens towards its centre. In particular, it is ~4-km-thick along the Narmada-Son region that forms a part of the Central Indian Tectonic Zone (CITZ). The Deccan basalts overlie the Precambrian basement of cratons and mobile belts of the Indian Shield (Fig. 1). The exposed crustal cross-section of the Dharwar craton (Figs. 2 and 3) (e.g., Kumar and Reddy, 2004), composition of granulite xenoliths in the Deccan basalts (e.g., Dessai et al., 2004), borehole studies (e.g.,

Gupta et al., 1999) and other geophysical studies (e.g., Mohan and Kumar, 2004; NGRI, 1978) clearly indicate that the Dharwar craton forms the southern basement of the Deccan province, and probably terminates along the CITZ.

The southern DBP is further divided into three sub-provinces, the southwestern (D_{SW}), south-central (D_{SC}), and southeastern (D_{SE}) provinces (Fig. 1), where the rocks of western Dharwar craton (WDC), Clospet Granite batholith (CG) and eastern Dharwar craton (EDC) form the basements, from west to east, respectively (Figs. 1, 2 and 3). The crustal structure of the WDC, CG and EDC have been well constrained in the Dharwar craton (see Kumar and Reddy, 2004). These crustal provinces expose ~ 30-km-thick crust over a lateral distance of > 500 km and likely extend beneath the Deccan basalts up to the Central Indian Tectonic Zone (CITZ) (Figs. 1, 2 and 3). The exposed section consists of greenschist, amphibolite, metasomatized granulite (medium- P granulites) and depleted granulite (high- P granulites) facies layers, which are successively exposed from north to south (Figs. 2 and 3) implying a northward tilting of ~1 to 5°. The thicknesses of these layers have also been well constrained by geothermo-barometric data obtained from metamorphic mineral assemblages. Surface geology, structure, metamorphic P - T data and seismic geophysical data provide constraints to model the crustal lithology of the Dharwar craton (Kumar and Reddy, 2004) as well as the southern DBP (Fig. 3).

CRUSTAL THERMAL STRUCTURE

The main objective of this study is to estimate the crustal radiogenic heat production, Moho heat flow and crustal geotherm of the southern Deccan province, in order to assess the thermal trace of the hypothesized mantle plume. To achieve this, we utilize (1) available surface heat flow measurements, (2) heat production estimates of the Deccan basalt cover and the basement and the rocks of exposed crustal section of the Dharwar craton, (3) the crustal radiogenic heat contribution to surface heat flow, and (4) the pressure- and temperature-dependent thermal conductivity model of Ketcham (1996). These provide a reliable temperature-depth profile of the crust (e.g., Ketcham, 1996).

Surface heat flow

Surface heat flow measurements have been carried out by Gupta and Gaur (1984), and Roy and Rao (2000) for the southern parts of the DBP (Figs. 1 and 4). These authors have determined heat flow values using the geothermal gradient measurements in deep boreholes and the thermal conductivity of associated rocks. We do not consider heat flow values determined through geochemical methods (e.g., Shankar, 1988), due to large uncertainties. In the southeastern Deccan province, surface heat flow varies from 33 mW m^{-2} to 73 mW m^{-2} , with an average of 45 mW m^{-2} (Fig. 4). These values, in general, are restricted to the part (D_{SE}), where the rocks of the Eastern Dharwar Craton (EDC) form the basement (Fig. 1). Only one heat flow value (41 mW m^{-2}) is available from the Koyna region (D_{SW}), where the rocks of the Western Dharwar Craton (WDC) are the likely basement. The heat flow values of Deccan province are broadly similar to those observed in the Dharwar craton (e.g., Roy and Rao, 2000) (Fig. 2).

Heat Production

Heat production of the Deccan basalts and the basement rocks are given in Table 1. Heat production of Deccan basalts (tholeiites) is calculated from the published geochemical data that contain K, U and Th abundance (Chandrasekaram et al., 1999; Mahoney et al., 2000; Sheth et al., 2004). Mean heat production of the tholeiites is 0.39 $\mu\text{W m}^{-3}$, which is similar to heat production of basalts in general. For the basement, we consider that the rocks of the Western Dharwar Craton (WDC), Closepet Granite (CG) and Eastern Dharwar Craton (EDC)

of the Dharwar craton underlie the Deccan basalts in the southwestern (D_{SW}), south-central (D_{SC}) and southeastern (D_{SE}) parts of the southern Deccan province (Figs. 1 and 3), respectively. Heat production of rocks of the various depth levels (e.g., greenschist, amphibolite and granulite-facies layers) of the WDC, CG and EDC has been determined by Kumar and Reddy (2004), and are listed in Table 1. It is evident from Table 1 that, (1) rocks of the WDC and EDC are characterized by distinct heat production characteristics, (2) the greenschist and amphibolite facies level gneisses and granites of the WDC are less heat producing than the EDC counterpart, (3) granites are more heat producing than the gneisses, (4) granulite-facies rocks are the lowest in heat production, (4) heat production decreases with increasing metamorphic grade, specifically, across the amphibolite to granulite facies transition, and (5) heat production in Closepet Granite batholith increases systematically from the deeper (granulite facies) to shallower (greenschist facies) levels, conforming to the evolution of I-type granite magmas, and is represented in Table 1 and Fig. 5.

Crustal Contribution to Surface Heat Flow

When the heat production of major crustal rocks and their proportions are known, it is possible to calculate the crustal contribution to surface heat flow. The crustal contribution model envisaged by Roy and Rao (1999) for southeastern Deccan province consists of four layers: 8-km-thick migmatite-granite, 9-km-thick gneiss-granite, 3-km-thick transition zone rocks (amphibolite to granulite facies), and 17-km-thick granulite layers, respectively, from the top to bottom. Considering the limited number of heat production data available at that time, Roy and Rao (1999) suggested a crustal radiogenic heat contribution of 31 mW m^{-2} . However, recent studies in the Dharwar craton (e.g., Kumar and Reddy, 2004) mandate improvement to the above crustal model. The exposed crustal section of the Dharwar craton (Figs. 2 and 3) provides the proportion of rocks in the crust beneath the Deccan basalts and their heat production (Tables 1 and 2). We consider an average thickness of the southern Deccan crust of about 36 km (e.g., Rai et al., 2003) containing 1-km-thick basalt cover (although it varies from ~2 km in the west coast to ~0.5 km or less along its boundary) on the top, and followed by a 35-km-thick Dharwar crust. The exposed crustal section suggests that the Deccan basement crust is composed of four metamorphic facies layers – greenschist, amphibolite, metasomatized granulite and depleted granulite (Fig. 3), whose thicknesses are likely to be ~ 4 km, 8 km, 8 km and 15 km, respectively. The greenschist-facies layer beneath the Deccan basalt is likely to be thicker than in the northernmost Dharwar craton, due to the decrease in the amount of uplift and erosion – from south to north. An average thickness of 4 km has been considered for the greenschist facies layer, and the rest are the same as the Dharwar craton. The major rock types constituting each layer are given in Table 2, and their heat production in Table 1. Heat production of various rock types, weighted by their abundances, has been used in arriving at gross heat production for the five layers (including the basalt layer on the top) and is envisaged in Table 2. Gross heat production of these layers and their layer thicknesses have been used to calculate the crustal contribution to heat flow, which is 24 mW m^{-2} for the southwestern part of the Deccan basalt province (D_{SW}), and 38 mW m^{-2} for the southeastern Deccan basalt province (D_{SE}), indicating a significant variation from the D_{SW} to D_{SE} . Also, the estimate for D_{SE} is significantly higher than that of Roy and Rao (1999), who modeled only the D_{SE} crust. Crustal contribution of the south-central part (D_{SC}) has not been determined, where the Closepet Granite batholith may be the basement. The omission is due to the large uncertainty in the nature of depth distribution of heat production as well as the thickness of the batholith beneath the Deccan cover, although heat production has been well determined for the batholith in the exposed craton (Table 1 and Fig. 5). Therefore, our crustal contribution estimates are limited to the D_{SW} and D_{SE} (Table 2).

Crustal Geotherms

Surface heat flow, crustal heat production and P - and T - dependent thermal conductivity constrain temperature variation with depth in the Deccan crust (e.g., Ketcham,

1996), with an assumption of a steady-state thermal condition. The average surface heat flow of the D_{SE} province is 45 mW m⁻² (Fig. 4) and it represents the region where rocks of the EDC form the basement (Fig. 1). Therefore, crustal thermal modeling has been restricted only to the D_{SE} (Fig. 6). The average surface heat flow (45 mW m⁻²) and the crustal contribution to heat flow (38 mW m⁻²), would imply a Moho heat flow of 7 mW m⁻² beneath the southeastern Deccan crust (Fig. 6), which is similar to the lower limits of Moho heat flow inferred in the Dharwar craton (Kumar and Reddy, 2004), as well as in Archaean cratons elsewhere (e.g., Jaupart et al., 1998). Also, the modeled steady-state crustal geotherm of Deccan crust is broadly similar to the Dharwar crust (Fig. 6). The Moho temperature is ~280 °C, which is as low as the Dharwar crust (Fig. 6), and is lower than that estimated (~350 °C) by Roy and Rao (1999). More surface heat flow measurements in the D_{SW} and D_{SC} parts would be required, in order to model the crustal geotherm using the crustal heat production models presented in this work.

DISCUSSION

It is clear from this study that the surface heat flow, Moho heat flow, crustal radiogenic heat contribution and crustal temperatures of the southeastern Deccan crust are similar to the thermal structure of the adjoining Dharwar craton. The Moho of the Deccan crust is as cold as that of the Dharwar crust. Therefore, it appears that there is no apparent thermal trace of a Reunion plume or any other thermal anomaly responsible for the genesis of the Deccan basalts, in the present-day thermal regime. It is possible that the thermal transient might have decayed considering its ~65 Ma age, as suggested by the previous authors (e.g., Roy and Rao, 2000). Alternatively, the thermal anomaly if any would be so low that it cannot be detected in the present-day crustal thermal regime. For this, it is necessary to address the magnitude of thermal anomaly one would expect today, had there been a thermal plume beneath the Deccan province around 65 Ma ago. A close look at thermal scenarios of hotspot swells (which are mostly younger than the Deccan) occurring on the ocean floor, may provide better insights on whether or not to expect a thermal anomaly over hotspots affected by volcanism through time, and is the best way to assess the magnitude of such an anomaly.

DeLaughter et al. (2005) lucidly summarizes the heat flow observations over hotspot swells (e.g., Hawaii, Reunion, and Iceland). Heat flow observations across the Mascarene ridge (near Reunion island), which was probably affected by the Reunion hotspot about 15 Ma ago, point to a very low heat flow anomaly of 6-8 mW m⁻², above the seafloor cooling plate model (Bonneville et al., 1997). Similar studies across the Hawaiian swell also do not indicate any significant heat flow anomaly; the inferred heat flow anomaly being of the order of 5-10 mW m⁻², which is indeed very difficult to resolve considering the uncertainties in the cooling plate models or the off-swell reference heat flow data (Von Herzen et al., 1989). The Iceland hotspot also does not exhibit any significant heat flow anomaly (Stein and Stein, 2003). The same holds true for other hotspots, such as, Bermuda Rise, and Cape Verde (see DeLaughter et al., 2005 and the references cited there). The heat flow anomaly of 5-10 mW m⁻² can be considered characteristic of hotspot swells, based on the above studies. However, these values are very sensitive to the type of reference seafloor heat flow data considered (see DeLaughter et al., 2005, for more discussion). Also, these small anomalies are related to younger hotspot activity than the ~ 65 Ma old Deccan event. Thus, if we do assume that the Deccan province was affected by the Reunion hotspot, arguably, the expected present-day heat flow anomaly should be much less than that inferred (6-8 mW m⁻²) across the Mascarene Ridge. Furthermore, if we assume 2 Ma as the period of stay of the DBP over a Reunion plume (considering the high basalt eruption rates) before the Indian plate drifted northwards (e.g., stationary plume – moving plate situation), the duration of heating would also have been short. In all probability, this would not result in high heat flow anomalies, unlike the stationary plume - stationary plate situations, where the duration of heating is expected to be long.

The Moho heat flow inferred for the southeastern Deccan province (7 mW m^{-2}) is very low and is similar to the lower bounds of the Moho heat flow inferred for the Dharwar craton (Kumar and Reddy, 2004). Also, this Moho heat flow value is lower than that inferred for the exposed Eastern Dharwar craton ($\sim 17 \text{ mW m}^{-2}$) located to the south of southeastern Deccan province. This apparent difference appears to be due to the thickening of the high-heat producing greenschist facies layer in the Deccan province. Even if one contends that the Moho heat flow of the Deccan province bears the thermal trace of the plume (7 mW m^{-2} plus 6 or 8 mW m^{-2}), one cannot distinguish this from the inferred Moho heat flow values of the adjoining cratons. Furthermore, the underlying uncertainties in the crustal heat production and thermal conductivity models and the errors in the surface heat flow determinations, reduce our ability to resolve the low heat flow anomaly of $6\text{-}8 \text{ mW m}^{-2}$ or less, in the crustal thermal regime of the Deccan Basalt Province.

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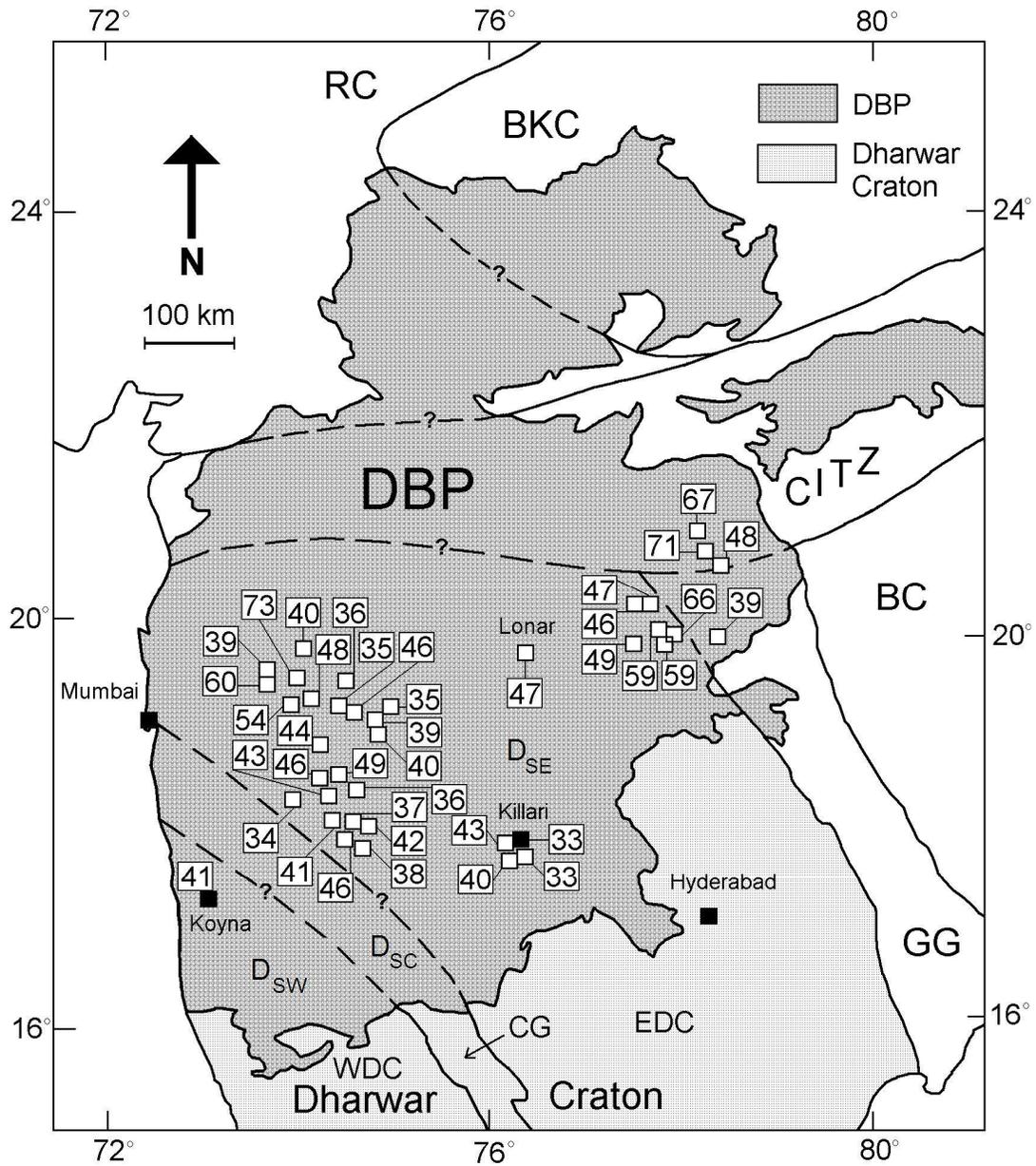


Figure 1: Map showing the Deccan Basalt Province (DBP) and surface heat flow values. The basalt cover is underlain by the Dharwar (WDC, CG and EDC), Bastar (BC), Bundelkhand (BKC), Rajasthan (RC) cratons and the intervening Proterozoic fault systems (GG – Godavai graben, and CITZ – Central Indian Tectonic Zone). Surface heat flow values shown inside the boxes have been determined by Gupta and Gaur (1984) and Roy and Rao (2000). The various crustal provinces of the Dharwar craton, such as, Western Dharwar Craton (WDC), Closepet Granite batholith (CG) and Eastern Dharwar Craton (EDC) form the basements of southwestern (D_{SW}), south-central (D_{SC}), and southeastern (D_{SE}) Deccan Basalt Province, respectively, from west to east.

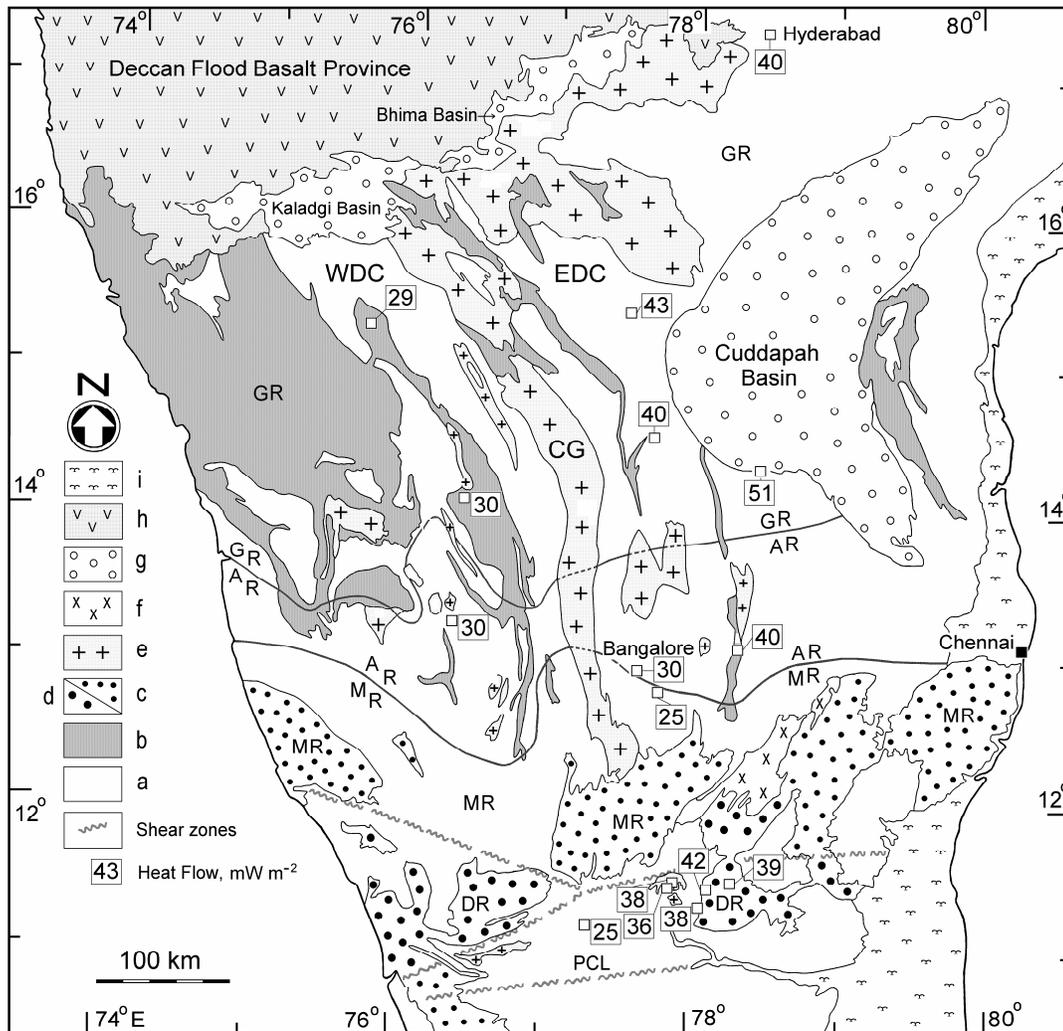


Figure 2: Geological map of the Dharwar Craton (DC) showing ~30-km-thick oblique crustal cross-section. The four metamorphic facies regions (GR, AR, MR and DR) exposes the rock types belong to four metamorphic facies – greenschist, amphibolite, metasomatized granulite (composed of medium-*P* granulites) and depleted granulite facies (composed of high-*P* granulites), respectively, from north to south. The rock types: (a) Gneisses, (b) greenstone belts or supracrustal belts, (c) medium-*P* granulites composed of high-grade gneisses and enderbites with subordinate amounts of mafic granulites and high-grade metasedimentary rocks, (d) high-*P* granulites composed dominantly of enderbites with little mafic granulites, (e) granites, (f) alkaline rocks, mainly syenites and carbonatites, (g) Proterozoic sedimentary rocks, (h) ~65 Ma old Deccan basalts, and (i) alluvial cover. The DC is divided in to Western Dharwar Craton (WDC) and Eastern Dharwar Craton (EDC) with the Closepet Granite batholith (CG) marking their boundary. The Palghat-Cauvery lineament (PCL) defines the southern boundary of the DC. Also, the DC forms the basement of the southern Deccan flood basalt province (see also Fig. 3). Surface heat flow values were determined by Gupta et al. (1991), Roy and Rao (2000) and Ray et al. (2003).

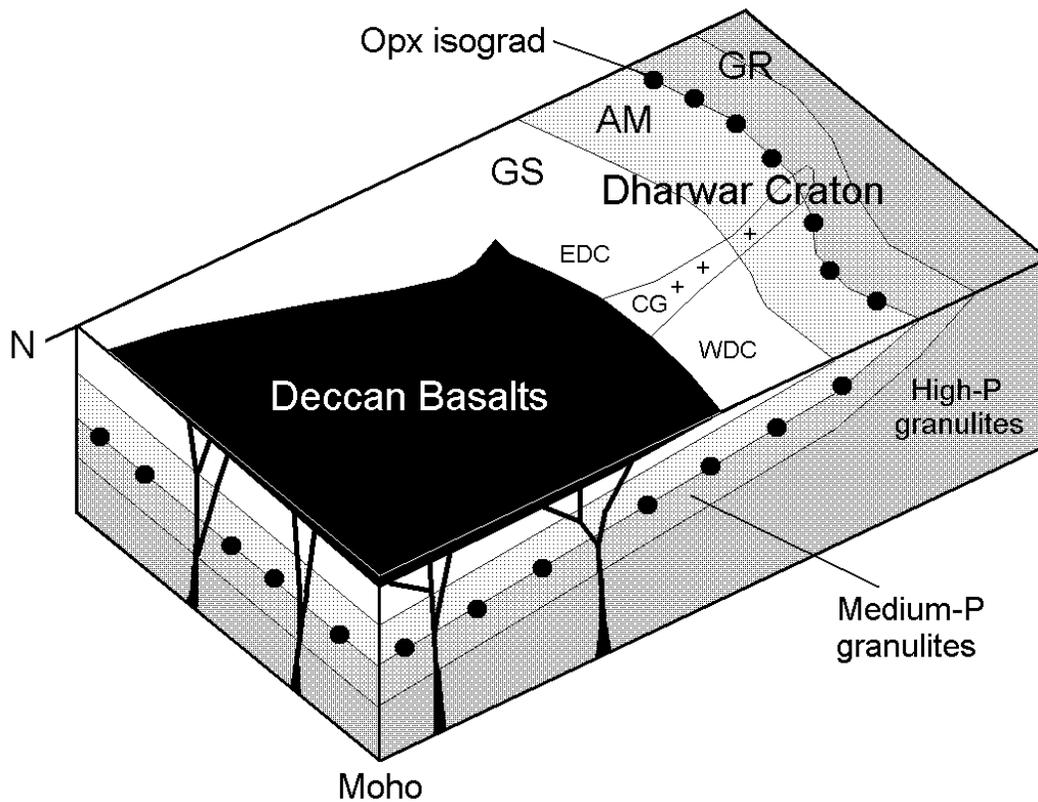


Figure 3: Schematic crustal structure of the Deccan Basalt Province and Dharwar craton. Note that the various metamorphic facies layers of the Dharwar craton underlie the Deccan basalts. WDC – Western Dharwar Craton, CG – Closepet Granite batholith, and EDC – Eastern Dharwar Craton form the basements to the southwestern (D_{SW}), south-central (D_{SC}) and southeastern (D_{SE}) Deccan provinces, respectively (see also Fig. 1). Metamorphic facies layers, greenschist (GS), amphibolite (AM), and granulite (GR) layers dip northwards. The GR is composed of two layers, the medium-*P* granulites (also known as the metasomatized granulites) and the high-*P* granulites (also known as the depleted granulites). The orthopyroxene (Opx) isograd marks the diffuse boundary between amphibolite-facies and granulite-facies rocks.

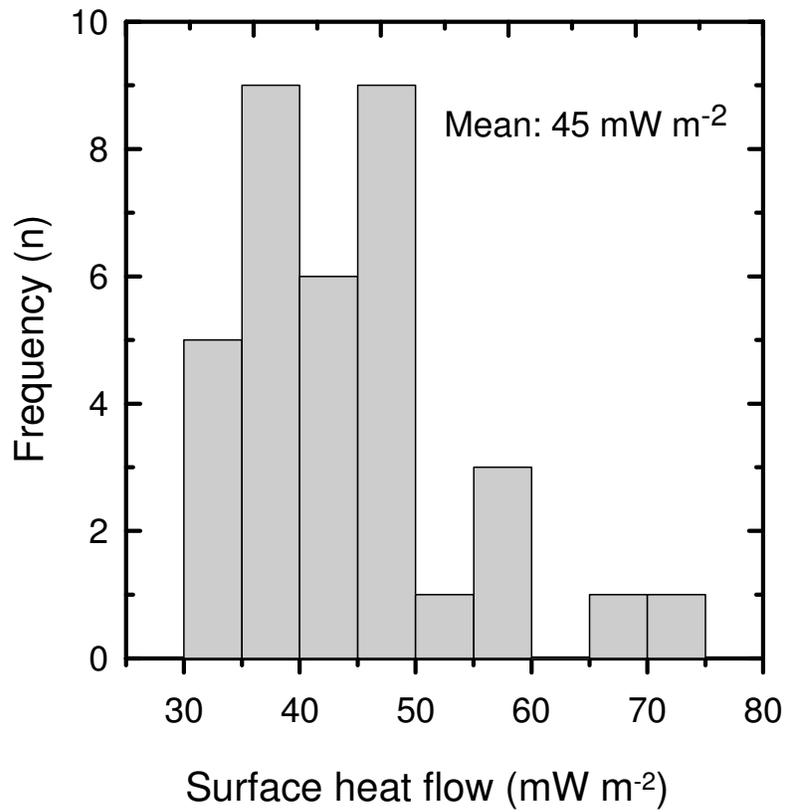


Figure 4: Surface heat flow distribution in the southern Deccan basalt province (Gupta and Gaur, 1984; Roy and Rao, 2000). See Fig. 1 for the locations of surface heat flow determinations. Except one, all measurements belong to the southeastern Deccan province (D_{SE}).

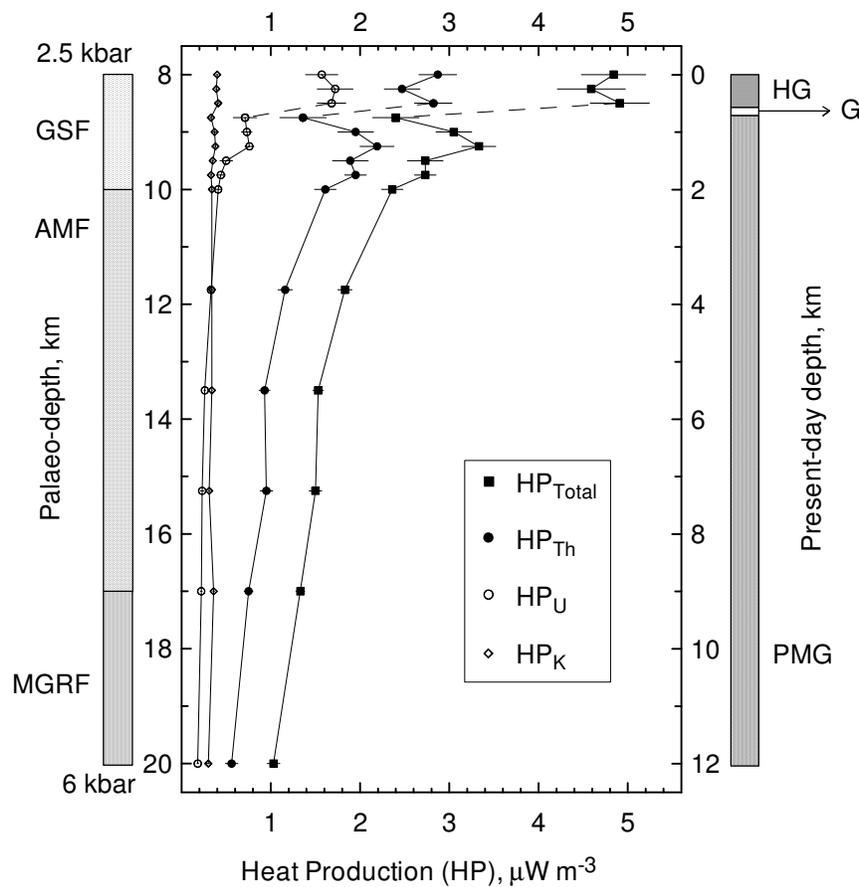


Figure 5: Heat production variation with depth in the Closepet Granite batholith, which may be applicable to the heat production of the upper to middle crust of the south-central Deccan province (D_{SC}). Note that the heat production decreases gradually with increasing depth, which is characteristic of I-type granite batholiths. Heat production of the anatectic granites shown in Table 1 are not considered here, as these are small plutons occurring along the boundary of the batholith. The ~12-km-thick granite batholith is exposed over strike length of ~300 km cutting across the greenschist (GSF), amphibolite (AMF) and metasomatized granulite (MGRF) facies host gneisses and greenstone belts (see also Fig. 1). The batholith is composed dominantly of porphyritic monzogranite (PMG) and less amount of homogeneous granite (HG) that occurs in the upper level of the batholith. Field observations suggest that the PMG gives rise to HG by filter-pressing petrologic process through the fracture zones in the gap (G), where host gneisses are dominant. For more details, see Kumar et al. (2003) and Kumar and Reddy (2004).

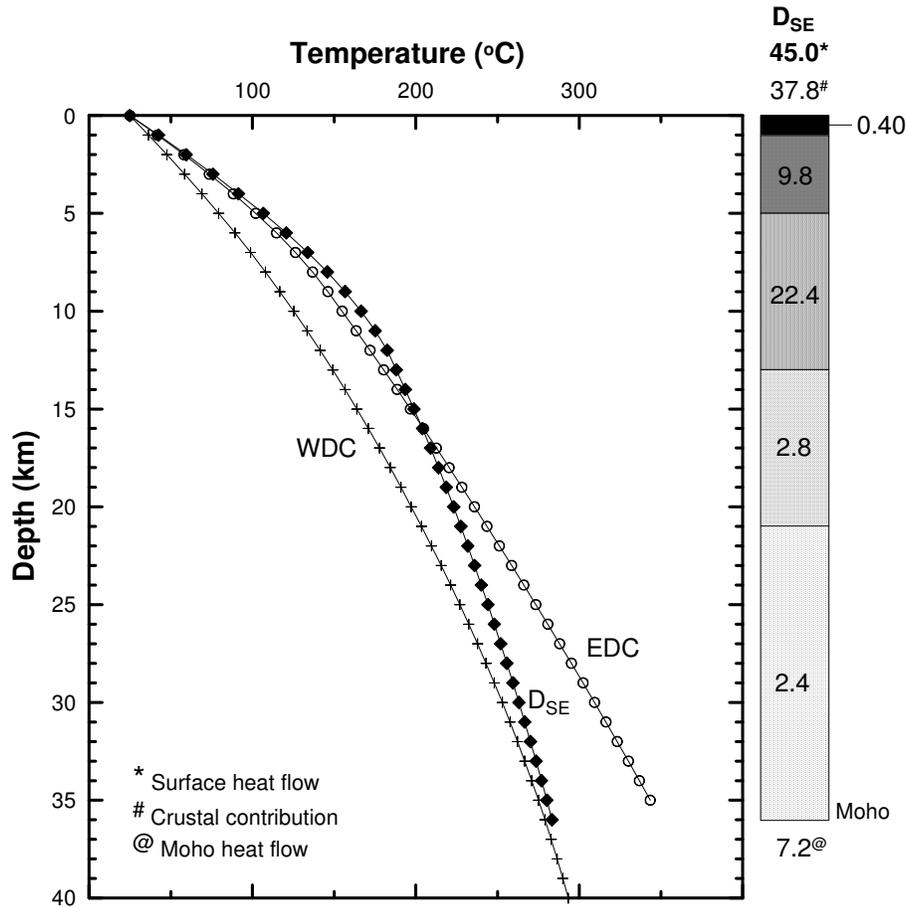


Figure 6: Crustal contribution to surface heat flow and the crustal geotherm of the southeastern Deccan crust (D_{SE}). The crustal geotherms of the WDC and EDC (Dharwar craton) are modeled using the data of Kumar and Reddy (2004) and are shown here for comparison. Note that the Deccan geotherm is no different from the Dharwar craton geotherms. The crustal contribution to surface flow (shown right-side) is modeled using Table 2. The average surface heat flow (45 mW m^{-2}) and the crustal contribution (38 mW m^{-2}) predict the Moho heat flow of 7 mW m^{-2} .

Table 1: Heat production data used in this study (authors' published data: Kumar, 2002; Kumar and Srinivasan, 2002; Ray et al., 2003; Kumar and Reddy, 2004; other published geochemical data: 1. Chandrasekharam et al., 1999; 2. Mahoney et al., 2000; 3. Sheth et al., 2004; 4. Naqvi et al., 1988; 5. Naqvi et al., 1983; 6. Atal et al., 1978; 7. Hanuma Prasad et al., 1997; 8. Naqvi et al., 2002; 9. Roy and Rao, 1999. Heat production was calculated from K, U and Th data using the conversion factors of Rybach (1988). (* metasomatized granulites; @ depleted granulites)

Depth levels	Rock types	Number of analysis	Heat production, $\mu\text{W m}^{-3}$
Deccan Basalt Province (DBP)			
Surface layer	Tholeiitic basalts ^{1,2,3}	48	0.39
Western Dharwar Craton (WDC)			
Greenschist facies			
	Greywackes ⁴	35	1.13
	Gneisses	47	1.01
	Granites	72	2.59
Amphibolite facies			
	Mafic volcanic rocks ^{5,6}	21	0.19
	Felsic volcanic rocks	5	1.51
	Gneisses	89	1.13
	Granites	78	1.65
Granulite facies			
	Enderbites (low P)*	68	0.66
	Enderbites (high P) [@]	16	0.34
Closepet Granite Batholith (CG)			
Greenschist facies			
	Porphy. Monzogranite	215	3.53
	Anatectic granites	120	3.41
Amphibolite facies			
	Porphy. Monzogranite	123	1.78
	Anatectic granites	8	2.67
Granulite facies*			
	Porphy. Monzogranite	31	1.26
	Anatectic granites	5	5.16
Eastern Dharwar Craton (EDC)			
Greenschist facies			
	Mafic volcanic rocks ^{7,8}	22	0.09
	Felsic volcanic rocks ⁸	6	1.34
	Gneisses	25	2.40
	Granites ⁹	24	2.60
Amphibolite facies			
	Mafic volcanic rocks	5	0.09
	Felsic volcanic rocks	15	2.24
	Gneisses	228	2.36
	Granites	43	4.19
Granulite facies			
	Enderbites (medium P)*	33	0.35
	Enderbites (high P) [@]	32	0.16

Table 2: Heat production distribution and crustal contribution to heat flow of the southwestern and southeastern Deccan Basalt Provinces, where the crustal rocks of the western (WDC) and eastern (EDC) parts of the Dharwar craton form the basement, respectively.

Rock types	SW Deccan Basalt Province (D _{SW})			SE Deccan Basalt Province (D _{SE})		
	Heat production ($\mu\text{W m}^{-3}$)	Volume (%)	Weighted heat production ($\mu\text{W m}^{-3}$)	Heat production ($\mu\text{W m}^{-3}$)	Volume (%)	Weighted heat production ($\mu\text{W m}^{-3}$)
Surface layer (SL) (0-1 km) (1-km-thick)						
Deccan basalts	0.39	100	0.39	0.39	100	0.39
Gross heat production:			0.39	0.39		
Greenschist-facies layer (1-5 km) (4-km-thick)						
Supracrustal belts:						
(a) Greywackes	1.13	40	0.45	--	--	--
(b) Mafic volcanic rocks	0.19	7.5	0.01	0.09	9	0.01
(c) Felsic volcanic rocks	1.51	7.5	0.11	1.34	1	0.01
Granites	2.59	5	0.13	2.60	10	0.26
TTG gneisses	1.01	40	0.40	2.40	90	2.16
Gross heat production:			1.10	2.44		
Amphibolite-facies layer (5-13 km) (8-km-thick)						
Supracrustal belts:						
(a) Mafic volcanic rocks	0.19	7.5	0.01	0.09	4.5	0.004
(b) Felsic volcanic rocks	1.51	7.5	0.11	2.24	0.5	0.01
Granites	1.65	5	0.08	4.19	30	1.26
TTG gneisses	1.13	80	0.90	2.36	65	1.53
Gross heat production:			1.10	2.80		
Metasomatized granulite-facies layer (13-21 km) (medium- <i>P</i> granulites) (8-km-thick)						
Enderbites	0.65	100	0.65	0.35	100	0.35
Gross heat production:			0.65	0.35		
Depleted granulite-facies layer (21-36 km) (high- <i>P</i> granulites) (15-km-thick)						
Enderbites	0.34	100	0.34	0.16	100	0.16
Gross heat production:			0.34	0.16		
Total crustal contribution (mW m^{-2}):			23.9	37.8		