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Group velocity dispersion characteristics and one-dimensional regional shear velocity structure of the eastern Indian craton

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ABSTRACT

In the past three years, a semi-permanent network of fifteen 3-component broadband seismographs has become operational in the eastern Indian shield region occupying the Archean (∼2.5–3.6 Ga) Singhbhum-Odisha craton (SOC) and the Proterozoic (∼1.0–2.5 Ga) Chotanagpur Granitic Gneissic terrane (CGGT). The reliable and accurate broadband data for the recent 2015 Nepal earthquake sequence from 10 broadband stations of this network enabled us to estimate the group velocity dispersion characteristics and one-dimensional regional shear velocity structure of the region. First, we measure fundamental mode Rayleigh- and Love-wave group velocity dispersion curves in the period range of 7–70 s and then invert these curves to estimate the crustal and upper mantle structure below the eastern Indian craton (EIC). We observe that group velocities of Rayleigh and Love waves in SOC are relatively high in comparison to those of CGGT. This could be attributed to a relatively mafic-rich crust-mantle structure in SOC resulting from two episodes of magmatism associated with the 1.6 Ga Dalma and ∼117 Ma Rajmahal volcanisms. The best model for the EIC from the present study is found to be a two-layered crust, with a 14-km thick upper-crust (UC) of average shear velocity (V_s) of 3.0 km/s and a 26-km thick lower-crust (LC) of average V_s of 3.6 km/s. The present study detects a sharp drop in V_s (∼−2 to 3%) at 120–260 km depths, underlying the EIC, representing the probable seismic lithosphere-asthenosphere boundary (LAB) at 120 km depth. Such sharp fall in Vs below the LAB indicates a partially molten layer. Further, a geothermal gradient extrapolated from the surface heat flow shows that such a gradient would intercept the wet basalt solidus at 88–103 km depths, suggesting a 88–103 km thick thermal lithosphere below the EIC. This could also signal the presence of small amounts of partial melts. Thus, this 2–3% drop in V_s could be attributed to the presence of partial melts in the upper mantle related to the earlier volcanic episodes viz. back-arc volcanism associated with the Archean/Proterozoic subduction, 1.6 Ga Dalma volcanism, and ∼117 Ma Rajmahal volcanism. The main result of our modeling provides evidences for the absence of Keel or thick lithosphere below the EIC.

1. Introduction

The Archean cratons in the world are characterized by the high velocity lithospheric "keel" down to a depth of 200 km or deeper (Jordan, 1979; James et al., 2003; Polet and Anderson, 1995). Signatures of cratonic keel associated with thickened crust (∼50 km) are also seen below the Dharwar craton in India (Srinagesh and Rai, 1996). However, a thin Indian lithosphere of 100 km thickness is modeled through the S-receiver function study (Kumar et al., 2007). A magnetotelluric study in the eastern Indian craton delineates a thick cratonic crust of 46 ± 6 km and a thin lithospheric thickness of 95 km underlying the Singhbhum granitic complex, which has been attributed to the important role played by the Himalayan orogeny in the delamination of lithospheric roots below the Singhbhum-Odisha craton (SOC) (Shalivahan and Bhattacharya, 2002; Shalivahan et al., 2014; Kent, 1991; Roy et al., 1989). The Eastern Ghats mobile belt (EGMB) occupies the south-western side of our study area, which has undergone episodes of rifting and subsidence followed by uplift during Late Jurassic (Sastri et al., 1974; Fox, 1934). A crustal thinning (35–37 km) associated with a basaltic underplated lower crust below the EGMB has been modeled using gravity and seismic data, which has been attributed to the 117 Ma Rajmahal volcanism related to the Gondwana break-up episode (Behera et al., 2005; Lisker and Fachmann, 2001). This crustal thinning model gets further support from the available high surface heat flow values ranging from 49 to 109 mW/m^2 (Rao and Rao, 1983). In the Chotanagpur Granitic Gneissic terrane (CGGT), the crustal thickness has been estimated to be 41 km, through

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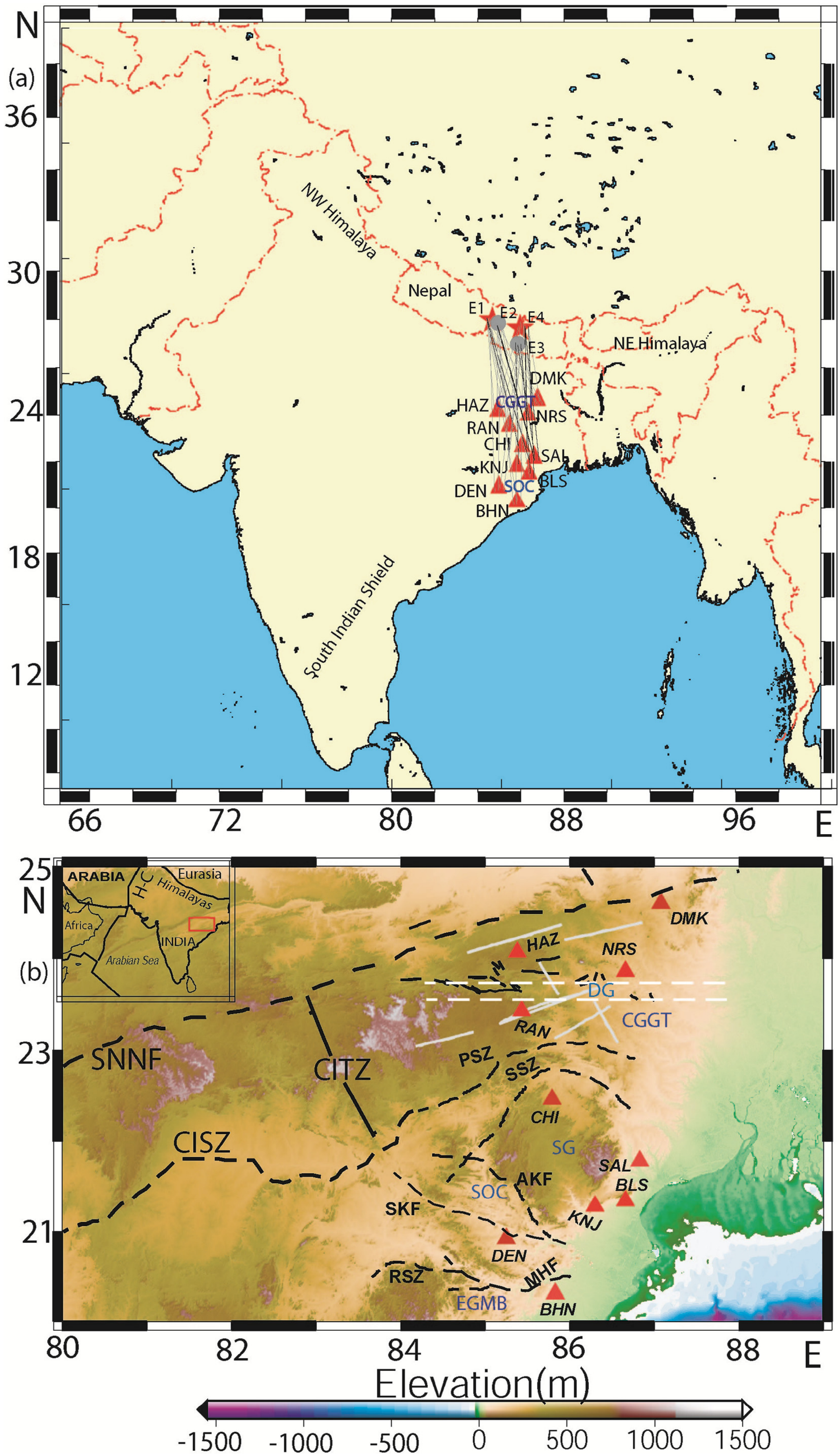
(a)
N
36
30
24
18
12
66
72
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88
96
E
NW Himalaya
Nepal
NE Himalaya
South Indian Shield
E1
E2
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E4
DMK
HAZ
CGGT
NRS
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CHI
SAL
KNJ
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SOC
BLS
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(b)
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1000
1500