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Moho offsets beneath the Western Ghat and the contact of Archean crusts of Dharwar Craton, India

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ABSTRACT

We present the Moho depth variation along a 600 km long profile from the west to the east coast of South India covering the passive continental margin, and the Western Ghat escarpment created during India–Madagascar separation at ~85 Ma; Archean western and eastern Dharwar Craton, and Proterozoic basin. The image is generated through three different approaches: H-v_P/v_S stacking, common conversion point (CCP) migration and inversion of teleseismic receiver functions at 38 locations. The Moho depth along the profile varies smoothly between 34 and 41 km, except beneath the Western Ghat and at the contact of east and west Dharwar Craton, where it is offset by up to ~8 km. The study suggests (i) the possible differential uplift of the Western Ghat, as a consequence of India–Madagascar separation and the prominent role of deep crustal structure in the location of the escarpment, compared to the surface process and (ii) presence of long-lived steeply dipping fault separating the two distinct Archean crustal blocks indicative of mechanically strong continental lithosphere beneath the Dharwar Craton.

1. Introduction

The Mohorovičić discontinuity (or Moho) is the most important compositional boundary between felsic–mafic rocks in the crust and ultramafic peridotites in the upper mantle (Green and Ringwood, 1972). The discontinuity, first discovered by Andrija Mohorovičić on the basis of regional earthquake wave propagation, primarily refers to a depth, where P-wave velocity increases rapidly or discontinuously to 7.6–7.8 km/s (Steinhart, 1967; Jarchow and Thompson, 1989). A global compilation of the images of Moho suggests that the boundary could be both, undulating or flat. However, a sharp offset in the Moho is observed beneath both the young orogenic terrains (Hirn et al., 1984; Wittlinger et al., 2004; Zhu and Helmberger, 1998) and old Precambrian domains (Diaconescu et al., 1998; Dahl-Jensen et al., 1990; Calvert et al., 1995; Goleby et al., 1990). Precise nature of these offsets, if substantiated, would help in discriminating the nature of deformation: a discrete narrow zone of deformation that continues throughout the crust (Zhu, 2000; Wittlinger et al., 2004) or distributed deformation over a wider diffusive zone in the lower crust (Wilson et al., 2004; Pedrera et al., 2010). Equally significant is the issue of long term preservation of such Moho offsets (Kusznir and Matthews, 1988) that implies mechanically strong continental lithosphere (Chen and Yang, 2004). Most of the studies mentioned above suggest the Moho offset by 5 to 10 km. The existence of such Moho offsets has been questioned due to inadequate data analysis and modeling (Mcbride, 1995; Gibbs, 1986). In a recent study, Schulte-Pelkum and Ben-Zion (2012) show that a velocity contrast of 10% across the fault in the upper crust can bias the Moho depth calculation by ~5 km and hence inferred that the Moho offset could be apparent than real. A similar effect is also shown due to the presence of pervasive anisotropy in the lower crust (Wilson et al., 2004).

In this study, we map the Moho topography along a 600 km long profile from the west to the east coast of South India using three different approaches: H-v_P/v_S stack, inversion and common conversion point (CCP) migration of receiver functions computed from teleseismic waveforms recorded over 38 seismographs located with an average separation of 10–20 km. The results show (i) the Moho depth varying from 34 to 41 km, and (ii) the Moho offset of up to ~8 km at two prominent locations along the profile: one coinciding with the Western Ghat — an escarpment along the west coast of India resulting from its separation from Madagascar at ~85 Ma; and the other beneath the contact of Mesoarchean and Neoarchean segments of Dharwar Craton. Elsewhere, it is either flat or dipping at low angle.

2. Geology and crustal studies

Along the seismological profile (Fig. 1), the most prominent geological units are Archean Dharwar Craton (DC) and the Proterozoic

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