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Seismic imaging of crust beneath the Dharwar Craton, India, from ambient noise and teleseismic receiver function modelling

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SUMMARY

We use cross-correlation of continuous 18 months (2009 February to 2010 August) ambient noise data recorded over 35 broad-band seismographs in the Archean Dharwar Craton and the adjoining granulite terrain to generate Rayleigh-wave group velocity maps in the period 5–28 s. This is supplemented with longer period data (40–70 s) from earthquake source. Combined group velocity measurement was inverted jointly with the teleseismic receiver functions obtained at 50 stations (includes 15 stations operated during 1998–2002) to produce shear velocity image of the crust. The velocity image reveals thinner crust (34–38 km) in the late Archean (∼2.7 Ga) Eastern Dharwar Craton (EDC), while all other terrains (mid-Archean and Proterozoic) have crustal thickness from 40 to over 50 km. The mid-Archean (3.36 Ga) greenstone belt of the Western Dharwar Craton (WDC) has the thickest crust (∼50 km). The average crustal V_s beneath the EDC is ∼3.70–3.78 km s^{-1} as compared to 3.80–3.95 km s^{-1} beneath the WDC. We observe significant lateral variation in the thickness of lower crust ($V_s \sim 3.8$–4.2 km s^{-1}): ∼10–15 km in the EDC compared to ∼20–30 km in the WDC. The lowermost part of the crust ($V_s \geq 4.0$ km s^{-1}) is thin (<5 km) beneath the EDC in contrast to more thickness (10–27 km) beneath the WDC. Our analysis suggests intermediate composition for the crust beneath the EDC similar to those for other cratons. In contrast, the mid-Archean exposed WDC crust has more mafic composition and exceptional thickness—a scenario at variance with the global observations. We interpret this thick mafic crust to represent undeformed geological segment of 3.36 Ga. The EDC with a nearly flat Moho, felsic to intermediate composition of crust and thin basal layer may represent a reworked terrain during the late-Archean.

Key words: Tomography; Composition of the continental crust; Cratons; Crustal structure; Asia.

1 INTRODUCTION

Knowledge of the composition of crust and its thickness is critical to understand the origin and evolution of the continent. While, the upper crust is better understood through surface geochemical analysis, our knowledge of the middle and lower crust remains poorly constrained. For example, it is argued that seismic wave velocity in the lower crust could vary significantly ($V_p \sim 6.5$–7.1 km s^{-1}), and may be suggestive of very distinct lithologies and hence the process of evolution. In a recent study, Hacker *et al.* (2011) argue for a more felsic and almost three times more radiogenic lower crust than that estimated earlier (Rudnick & Gao 2003). This has implication for the understanding of the thermal state of lithosphere and emphasizes the need for an accurate description of the thickness and the seismic wave velocity of individual segments of the crust.

One of the primary issues remains to be resolved in understanding the evolution of continental crust is how an andesitic to dacitic crust has formed, when most of the mantle-derived magma is basaltic in nature (Hawkesworth & Kemp 2006; Hacker *et al.* 2011). This requires mapping the compositional similarity or diversity of crust at varying depth and geological time. Equally important is defining the nature of Moho, conventionally defined as a first-order compositional discontinuity, where seismic wave velocity increases sharply from normal felsic–mafic crust ($V_p < 7.0$ km s^{-1}, $V_s < 4.0$ km s^{-1}) to a typical mantle value with $V_p > 7.8$ km s^{-1} and $V_s > 4.3$ km s^{-1} representing ultramafic peridotites (White *et al.* 1992; Christensen & Mooney 1995). This scenario suggests a thin 1- to 2-km-wide transition at the Moho (Collins 1991; Korenaga & Kelemen 1997). Griffin & O'Reilly (1987) and Mengel & Kern (1992) argue that the Moho does not necessarily correspond to the crust–mantle