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Teleseismic P-wave tomography of the crust and upper mantle beneath the Malani Igneous Province in Northwestern India

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The Malani Igneous Province (MIP) is a result of the second largest volcanic episode to affect the Indian Subcontinent and is characterised by acid volcanics. It represents an intraplate anorogenic felsic event covering an area of about 50,000 km^2 in northwestern India. The MIP hosts the Barmer and Sanchor rifts in the west, the 850 Ma Erinpura Granites in the east that adjoin the Aravalli mountain belt, and also alkaline rocks of age 68 Ma which pre-date the Deccan volcanism in the center. The genesis of the 750 Ma MIP, based on surface geological observations is debatable with theories supporting extensional, plume or subduction processes. The present study attempts to provide constraints on the prevalent hypothesis by mapping the three dimensional P-wave velocity perturbations (%) in the crust and upper mantle beneath the MIP using teleseismic P-wave tomography. During the period 2012 - 2016, a network of 15 broadband seismographs were deployed in phases at 26 locations, with an average operational period of two years per station. They cover an area of 300 x 300 km^2 encompassing the MIP. The dataset consists of 1558 P-phase arrivals, picked from 240 teleseismic events with magnitudes greater than 5.5 within the epicentral range of 30-90 degree. P-wave residual data is prepared with respect to the ak135 theoretical Earth model and inverted using a damped least square method. Numerous models have been prepared with a different combination of layers and grids to optimise a model that best compromises between resolution and standard errors. Resolution of the velocity perturbations is confirmed with the help of checkerboard resolution tests, with velocity perturbations of $\pm$ 6%. A 3-layer model is obtained that is completely resolved up to a depth of 300 km. Large crustal velocity perturbations of up to -5% are observed over the Barmer and Sanchore rift zones in the western region, accompanied by a high velocity perturbation of +5% observed over the Erinpura Granites in the eastern part of the study area. The strong velocity perturbations are spatially more extensive with depth, extending upto 150 km and reflect the striking contrast between the lithosphere beneath the MIP and its adjoining region. This observed low velocity zone extending down to 150 km may possibly reflect the influence of a thermal anomaly beneath the rift systems of northwestern India. This can be attributed to the reworking of the lithosphere during the Deccan episode or a possible compositional imprint of the Proterozoic Malani volcanism. The tomograms beyond the 150 km depth level, indicate P-velocity perturbations of $\pm$ 3%, with a high velocity continuing up to 300 km beneath the Erinpura granites, plausibly representing the root of the Aravalli Craton