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Seismic evidence of crustal heterogeneity beneath the northwestern Deccan volcanic province of India from joint inversion of Rayleigh wave dispersion measurements and P receiver functions

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The northwestern Deccan volcanic province (NWDVP) of India, encompassing the Saurashtra peninsula and the adjoining Gulf of Cambay, is investigated through joint inversion of surface wave dispersion measurements and teleseis- mic P receiver functions, to estimate the crustal and shallow upper mantle shear wave velocity (Vs) structure. The Mw $\sim$ 7.7 Bhuj earthquake and the post Bhuj regional events, recorded during the period 2001–2010 at 7 stations along 37 source-receiver paths were used along with 35 teleseismic events. A joint curve fitting inversion technique is applied to obtain a best fit for the fundamental mode Rayleigh wave group velocity dispersion curves for time periods 5–50 s and high quality crustal P wave receiver functions obtained at each station. Significant crustal heterogeneity is observed within the study region with the average crustal Vs ranging from 3.5 km/s to 3.8 km/s with the paths cutting across the Gulf of Cambay exhibiting large reduction in shear wave velocities. Utilizing the average crustal Vs $\approx$ 3.66 km/s estimated for Saurashtra, together with the average crustal P wave velocity (Vp) $\approx$ 6.54 km/s derived independently through deep seismic sounding studies, yields a bulk Vp/Vs ratio of 1.786 or an equivalent crustal Poisson's ratio of 0.271. A major contribution to the high Poisson's ratio comes from the 12 to 16 km thick lower crustal layers with shear velocities ranging from 3.8 km/s to 4.19 km/s suggesting widespread magmatic underplating due to emplacement of mafic cumulates in the lower crust. The shallow uppermost mantle shear velocities are in the range 4.2–4.5 km/s averaging 4.36 km/ s, which is less than that observed for the Indian shield, indicating the effects of residual thermal anomaly. The variation in the crustal Vs, high Poisson's ratios and low upper mantle shear velocities reflect the thermal and compositional effects of the Deccan volcanism which are manifested in terms of pervasive presence of mafic dykes, volcano plutonic complexes, lower crustal mafic cumulates and possible partial melt due to elevated geotherms. The significant crustal alterations are possibly a result of weakening of the lithosphere by a mantle thermal source, leading to a thin and weak lithosphere which facilitated the Deccan volcanism through the rift zones of northwestern India.