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The transition zone below the Chile-Argentina flat subduction region

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We study the fine structure of the upper mantle (below 200 km depth) beneath the western margin of South America, within an area known as the Chile-Argentina flat subduction zone (between 26°S and 36°S). Unlike what happens in most subduction zones, in this region the Nazca Plate subducts with an angle close to the horizontal -initially dips underneath the continent and flattens at a depth of approximately 100 km, remaining almost horizontal for about 300 km before descending more steeply into the mantle. Moreover, the flat slab follows the path of the subducting Juan Fernández Ridge, a hot spot seamount chain on the Nazca Plate. The complex tectonic setting makes this region an excellent laboratory to explore and quantify the relative contributions of thermal and compositional heterogeneities to the mantle discontinuity structure.

In this study we combine data available from four past temporary experiments: 18 seismic stations from CHARGE; 43 from SIEMBRA, 12 from ESP and 30 from PUDEL. The research tools are the Pds phases (the direct P wave converted to an S wave while passing through a seismic discontinuity at depth d). These signals arrive in the coda of the P-phase in the radial component and are expected to be coherent with the waveform of the first arrival for conversion at discontinuities thinner than one half of the P-wavelength. In order to extract these converted phases by means of waveform similarity, we use the receiver function (RF) technique, i.e. the deconvolution of the vertical from the radial component in the frequency domain. The Pds phases are then detected on stacked RF (globally and by common conversion point) in the relative time-slowness domain. Since the incidence angle of converted phases is larger than the incidence angle of the P phase, they are expected with negative slowness. This permits to separate them from the multiples, which are instead expected with positive slowness.

We measure amplitudes and arrival times for the converted phases at the well-known 410 and 660 discontinuities and at a discontinuity at a depth of about 210 km, which we interpret as the Lehmann discontinuity. The abrupt amplitude decrease for the P660s phase at frequencies larger than 0.12 Hz indicates that the velocity jump at 660 km occurs in a depth interval as wide as 40 km. Besides, the amplitudes of P410s and P660s are similar at the lowest frequency (0.08 Hz). This analysis suggests that the velocity jump at both discontinuities is similar or, alternatively that the 660 may not occur as a discontinuity but as a gradual transition across a layer of about 40 km. We also identify a negative amplitude signal between P410s and P660s arrival times, with negative slowness, which we interpret as a converted phase at a negative discontinuity (a decrease in velocity with depth) at a depth of about 590 km. We also present a map of the Transition Zone Thickness (TZT) showing lateral variations in the study area.