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Velocity structure of the Southern Chilean subduction zone (37° and 39°S) revealed by the TIPTEQ local seismic network

Ch. Haberland (1), A. Rietbrock (2), D. Lange (1,3), K. Bataille (4), T. Dahm (3), TIPTEQ Research Group

(1) University of Potsdam, Institute of Geosciences, Potsdam, Germany (haber@geo.uni-potsdam.de), (2) University of Liverpool, Dept. of Earth and Ocean Sciences, Liverpool, UK, (3) University of Hamburg, Institute of Geophysics, Hamburg, Germany, (4) Universidad de Concepcion, Departamento de Cs. de la Tierra, Concepcion, Chile

The largest earthquakes are being generated at convergent plate boundaries, where oceanic plates subduct beneath other tectonic plates. Understanding the factors leading to these earthquakes in the coupling zone of convergent margins and their interrelation with surface deformation are the main aims of the international and interdisciplinary research initiative TIPTEQ (From The Incoming Plate To megaThrust EarthQuake Processes). High resolution images of the seismogenic zone and the forearc structure form the base for identifying the processes involved.

Within this project a dense, temporary seismological network was installed in southern Chile between November 2004 and October 2005, covering the forearc between 37° and 39° S from the trench to the recent volcanic arc. In this region the Mw=9.5 1960 Chile earthquake, the worldwide largest instrumentally ever recorded earthquake, nucleated. The network consisted of up to 120 digitally recording and continuously running seismic stations equipped with short period sensors. The network was complemented by 10 ocean bottom seismometers/hydrophones covering the offshore forearc.

More than 10.000 manually picked traveltime observations (P and S picks) of about 300 local events were used for the simultaneous inversion for the 3-D velocity structure (vp and vp/vs), hypocenters, and station corrections (tomography, damped least squares inversion). Additionally, observations of 44 artificial shots of an accompanying reflection/refraction profile were added to the dataset. We employed a staggered

inversion approach utilizing the previously calculated minimum 1-D model and subsequently coarse and fine 2-D velocity models as starting models. Grid spacing of the final model is 15 and 20 km (horizontally) and 5 km (10 km) vertically down to a depth of 50 km (100 km). Extensive synthetic tests give estimates for the resolution and reliability of our key observations.

The central forearc crust (between the coast and the longitudinal valley (LV) down to a depth of 50 km) is relatively uniform with average P velocities (vp) of between 6.3 and 6.9 km/s, and only little vertical structuring. Reduced vp beneath the LV can be associated with the shallow sedimentary fill. Low vp and a high P to S velocity ratio (vp/vs) reflect the presence of offshore forearc basins and possibly overpressured (sedimentary) rocks within the recent and permo-triassic accretionary wedge. The subducting plate is imaged down to a depth of 50 km by a pronounced dipping layer of high vp. Down to a depth of 30-40 km elevated vp/vs is found in the slab thus indicating the hydratation of the oceanic plate. Mantle velocities already at a depth of 40 km beneath the LV are in contrast with low vp at the same depth range directly W of it. These low P velocities in this deep zone West of the LV might indicate a serpentinized mantle wedge. It seems, however, that no significantly elevated vp/vs is found in this zone.