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Seismic imaging of the subduction zone in Southern Central Chile

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We present the results of a three-component reflection seismic survey across the seismogenic coupling zone in the area of the 1960 Valdivia earthquake in Southern Central Chile (38.2 deg S). This data set has been acquired within the framework of project TIPTEQ (from The Incoming Plate to megaThrust Earthquake Processes) which aimed at deriving the structural and petrophysical properties of the hypocentral area as well as the surrounding crust and mantle.

Our main focus was on the application of advanced seismic imaging techniques in order to obtain a high-resolution structural image. We have applied Kirchhoff-Prestack-Depth-Migration (KPSDM) and Fresnel-Volume-Migration (FVM) to enhance the structural image as well as Reflection-Image-Spectroscopy (RIS) to characterize the subsurface in terms of its scattering properties.

The KPSDM and FVM sections show varying reflectivity along the subducting Nazca plate. Below the coast the plate interface can be observed at 25 km depth as the sharp lower boundary of a 2-5 km thick, highly reflective region which we interpret as a subduction channel. The plate interface itself can be traced down to depths of 50-60 km where we observe strong reflectivity along the plate interface as well as in the continental mantle wedge above it. The sections show a segmented forearc crust and major features in the accretionary wedge like the Lanalhue fault zone can be identified. At the eastern end of the profile a bright west-dipping reflector appears almost perpendicular to the plate interface.
The same processing sequence has been applied to the horizontal wavefield components of the seismic reflection data set. The S-wave image (SS) shows basically the same features as the P-wave image (PP) with only slightly more diffuse reflectivity. The subduction channel appears in both images at almost the same depth with a similar thickness along the plate interface.

The application of RIS distinguishes between the frequency-selective seismic response of the different parts of this subduction environment. The variable reflectivity along the plate interface appears to be a high-frequency effect mainly caused by the heterogeneous overburden and is probably not a property of the interface itself. In the intermediate-frequency image the Lanalhue fault zone clearly separates the subsurface into an almost transparent western part and a highly reflective eastern part. Finally a combination of the different frequency-selective images shows additional structural details and demonstrates the main benefit of the RIS approach in terms of an improved subsurface characterization.

Finally, we present a comparison of the obtained seismic images with other geophysical data sets (local earthquake tomography, magnetotelluric images, etc.).