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Active seismic and microseismic reflection imaging of the Precordilleran crust, fore-arc of the North-Chilean subduction zone (Central Andes)

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In the fore-arc of the Chilean subduction zone, prominent trench-parallel fault systems can be traced for more than thousand kilometers in north-south direction. These fault systems possibly crosscut parts or the entire crust and are expected to have a close relationship to transient processes of the subduction earthquake cycle. With the motivation to image and characterize the structural inventory and the processes that occur in the vicinity of these large-scale fault zones, we are currently performing a combined analysis of active and passive seismic data sets. The active-seismic data analysis is intended to provide images of the faults at depth and allow linking surface information to subsurface structures. The correlation of the active seismic data with the observed seismicity around these fault systems complements the imaging and potentially reveals the origin and the nature of the seismicity (incl. tremors) bound to these fault systems. Furthermore, reflection information extracted from passive-seismic waveform data has the potential to complement the active seismic imaging.

In 1996, an approximately 350 km long west-east running reflection seismic profile was acquired to image the entire crust of the Central Andean fore-arc system (North Chile; ANCORP96 seismic line). Several features such as the downgoing plate (Nazca reflector) and the Quebrada Blanca Bright Spot at mid-crustal level were clearly imaged using both standard CMP processing and Kirchhoff prestack depth migration. The latter proved to be more successful in coping with the low data coverage and varying data quality. However, the original images were not providing conclusive information on the upper crust (< 10 km depth) due to the sparse acquisition geometry and the partly insufficient removal of source-generated noise. The major goal of our current re-processing of the ANCORP96 reflection seismic data set using adapted noise-suppression schemes and a novel prestack depth migration technique (Kirchhoff and Coherency Migration) is to provide improved images of the upper and middle crust, thereby, resolving the shallow and perhaps steeply dipping segments of the major fault systems, which were not detected by the original processing.

The re-processed and migrated depth sections reveal improved images of the upper and middle crust (< 20 km depth) containing significantly more details compared to the previous results. Some interesting structures were resolved but no unambiguous reflections from steeply dipping fault segments have been clearly identified yet. With the motivation to obtain complementary structural images of the upper crust, we processed reflection information extracted from passive seismic waveform data recorded around the area, where the ANCORP profile crosses the West Fissure Fault System (WFFS; around 21°S, 69°W). Even though the passive seismic data provide a limited illumination of the subsurface, the resultant microseismic-reflection images exhibit a dominant frequency of several Hz, which provides a resolution capability that is only moderately inferior to the one of the active-seismic images. The combined interpretation of the active-seismic and passive-seismic reflection images as well as the distribution of the seismicity allows deepening our understanding of the tectonic structures and related processes of the North-Chilean fore-arc.