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Seismic-reflection imaging of the crust using earthquake waveform recordings – A case study from the Central Andes

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Processing earthquake waveform recordings into seismic-reflection images has the potential to complement and extend controlled-source seismic imaging of the crust. Within the Central Andean forarc system, large fault zones such as the West Fissure Fault System (Precordillera, North Chile, around 21°S 69°W) are responsible for the frequent release of seismic energy within the upper crust. With the motivation to image the structure of the upper crust (< 35 km) of the Chilean Precordillera using reflections contained in passive-seismic waveform recordings, we developed a novel workflow to process passive-seismic data into reflection images. We processed the waveform recordings of several hundred earthquakes using signal processing and imaging techniques adapted from active seismic-reflection surveying. Specifically, we took advantage of the fact that the passive seismic recording geometry with the sources located at depth and the receiver placed at the surface resembles a vertical-seismic profiling (VSP) experiment. Key data processing steps included precise hypocenter parameter estimation, compensation for time-delays due to, for example, location errors and near-surface effects, removal of signal variations due to source radiation patterns, identification and extraction of reflections, and transformation of the processed reflection data into subsurface reflectivity images. A comparison with the active-seismic ANCORP data reveals that similar features were resolved and highlights the potential of our novel approach to obtain crustal-scale images from earthquake waveform data in a resolution comparable to active-seismic experiments.