Geophysical Research Abstracts
Vol. 17, EGU2015-1649, 2015
EGU General Assembly 2015

High-resolution fault detection at the CO_2CRC Otway Project site using shear-wave reflection seismics

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In the framework of the project PROTECT (PRedition Of deformation To Ensure Carbon Traps) shear (SH) wave reflection data were processed and interpreted that had been collected at the CO_2CRC Otway Project Site, Australia in November 2013. The aim was to supplement the existing 3-D exploration seismic data set in the uppermost 400 m targeting the upward continuation of interpreted faults at larger depth, and the detection of possible small-scale faults.
Using LIAG's equipment for SH-wave seismic acquisition (hydraulic vibrator MHV4S with source point spacing of 4 m, and SH-geophones mounted on a 240-m-long land streamer with 1 m spacing), three profiles were acquired. Data processing comprised geometry setup, elevation statics, surface-wave noise suppression via fk-filtering, velocity determination after DMO-correction, pre-stack time migration, and 1-D depth conversion. Fundamental steps of data pre-processing turned out to be spectral balancing and fk-filtering. Surprisingly, the application of refraction statics partly improved the data quality on one of three profiles drastically, even though the survey had been carried out on road pavement. However, this probably can be attributed to the relatively high refractor velocity of more than 700 m/s in the survey area.
The interpretation of profiles PROTECT 1 and PROTECT 2 shows that the deep fault zones do in fact reach the surface. In the case of PROTECT 1, a reverse fault structure is evidenced, that can be linked to the expected normal fault structure at ca. 400 m depth. This reverse fault seems to correlate with a step in surface topography. In the case of PROTECT 2 the expected near-surface extrapolation of the interpreted deep normal fault could be imaged. PROTECT 3 reveals an unexpected fault zone above 400 m depth, which does not seem to be linked to greater depth.
Pre-stack time migration and subsequent depth conversion yielded the best images so far, with a vertical resolution of ca. 5 m in the upper part. Nonetheless, pre-stack depth migration including reflection tomography will be tested in the future since tomographic velocity models are more horizon-oriented than DMO-/NMO-based ones, which may lead to better resolved depth sections.