Full-waveform VSP Imaging in Desert Environment

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Abstract

Desert environment features extremely heterogeneous low-velocity near surface. Synthetic SEAM Arid benchmark model was specifically designed to simulate seismic imaging challenges in desert environment. Imaging of land seismic data with conventional surface seismic profiling methods is sensitive to errors in the near-surface model used for imaging. Vertical Seismic Profiling (VSP) reduces the impact of near-surface as the receivers are located at depth in the borehole. Typically, VSP data are utilized to constrain the velocity model and seismic images generated using surface seismic. Here we investigate resolution and accuracy of images that can be obtained directly from VSP data by reverse time migration and full-waveform imaging. We investigate effects of seismic vibrator and geophone positioning and imperfect knowledge of the near-surface model on imaging of 3D visco-elastic anisotropic VSP data simulated for the SEAM Arid data using 2D acoustic imaging. This setup of much higher fidelity of the simulated data than the data that can be simulated by the inversion engine allows us to establish a highly realistic example where the ground truth reflectivity is known. For all experiments, reverse-time migration with inverse scattering imaging condition is compared with deep-learning-based acoustic full-waveform inversion of upgoing field. We observe that main reflectors and fault can be imaged with a single step reverse-time migration, while full-waveform imaging can provide better quantitative true reflectivity estimates.