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Shallow Marine High-Resolution 3D Seismics for Above-Zone CO₂ Monitoring: A Case Study in Offshore Japan

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Abstract Text:

Shallow marine high-resolution 3D (HR3D) seismic utilizes a novel seismic acquisition technology for imaging fine geological features not revealed by conventional 3D surveys. HR3D technology has been previously used for shallow subsurface studies, however is rarely implemented for monitoring injected fluids, and has not previously been used to monitor an active CO₂ storage project. In this study, we for the first time demonstrate the acquisition, processing and initial interpretation of a HR3D seismic survey in Tomakomai, offshore Japan, where a large-scale CO₂ storage project is being undertaken. As a seismic monitoring tool, the HR3D survey images the geologic overburden (< 1000 ms), aiming to detect potential CO₂ leakage pathways above the injection reservoir. The HR3D acquisition system comprises a 210 in³ GI air gun and 4 streamers that are 25 m in length with 10 m inline separation. Each streamer has 8 channels with a 3.125 m group interval, yielding a very small final bin size of 3 x 3 m. The short offset and low-fold coverage of the HR3D data creates new challenges in seismic data processing, which demands a different data processing workflow tailored to the HR3D acquisition. We present a data processing workflow involving multiple software processing packages, which tackled high-resolution related static issues and significantly reduced various noise elements. Dip-steering and structural filtering were employed on the stacked volume to further enhance the lateral coherence and to remove random noise and suppress acquisition footprints. The final volume shows flat and coherent above-zone stratigraphy, suggesting a good seal quality above the CO₂ reservoir. The successful implementation of HR3D acquisition and the customized processing workflow verify the feasibility of HR3D seismics for the above-zone monitoring of offshore CO₂ injection and storage projects.

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