Salt-Flank Delineation Using Refraction Seismic Imaging of Borehole Seismic Data

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Abstract

Salt-flank delineation is quite challenging in frontier exploratory areas and essential to perform proper subsurface seismic imaging and interpretation. Surface seismic imaging often provides poorly resolved salt-flanks due to the poor subsurface illumination. Steeply dipping flanks cannot be easily illuminated by single-scattered seismic events (i.e., primary reflections). To rectify this problem, borehole seismic acquisition can be utilized to illuminate salt-flanks by placing the receivers inside the borehole to capture the refracted and/or reflected wavefield off the steep salt boundary. Borehole seismic acquisition such as offset VSP and salt proximity surveys have been utilized to image flanks of salt structures close to a nearby well. Due to the fast salt velocity of about 5 km/s compared with the surrounding sediments, the seismic wavefield tend to refract along the salt boundary and travel with the fast velocity. Subsequently, the refracted wavefield is recorded by downhole receivers. Therefore, refraction imaging can potentially help resolve salt flanks in complex subsurface environments. We applied refraction imaging to a borehole seismic dataset (walkaway vertical-seismic-profiling data) to delineate a steeply dipping flank in a deep ocean environment. Prior to imaging, we initially windowed around the refracted events. We also ran ray-tracing modeling using a surface-seismic velocity field that shows the anticipated refracted energy. The migrated image shows a high-resolution depiction of the salt-flank when migrated using a smooth background velocity model based on surface seismic data analysis. We concluded that walkaway borehole seismic acquisition helps illuminate a steeply dipping salt flank. Our imaging focused on migrating refraction energy that grazes the boundary between the salt and adjacent sediments travelling with the fast velocity. The result demonstrated the ability of borehole refraction migration to obtain a highly-resolved seismic imaging of the salt flank that yields better interpretation of the complex subsurface geology.