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Application of Viscoacoustic Full Waveform Inversion to Shallow-Water, Shallow-Gas Data

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Abstract

Successful imaging in geological environments with shallow gas infused overburden anomalies requires an Earth model and migration operator that provides the simultaneous corrections of the complex kinematics and the intrinsic attenuation that are present. In order to fully resolve the compartmentalized nature of the gas bodies, a wave equation-based method to derive the Earth model is required. Many current implementations of FWI are acoustic only, in this example we describe the use of a Q-FWI techniques.

Full waveform inversion (FWI) model building is applied in the data domain and is capable of creating a high-resolution Earth models through a wavefield-consistent solution. FWI derived velocity models have improved the imaging of marine and land datasets, with acquisitions ranging from narrow azimuth (NAZ) to wide azimuth (WAZ) to full azimuth (FAZ) to dual-coil and ocean-bottom cable. In all cases, the uplift in reservoir-level imaging was facilitated through recovering a high-resolution velocity model within a heterogeneous overburden.

A kinematically precise velocity model combined with the appropriate migration algorithm can focus the recorded energy to its true subsurface locations. However, the anelastic nature of the real earth can also significantly affect the amplitude and phase of the recorded seismic signal and the migrated image. To facilitate earth model building, improve imaging, and improve the fidelity of the amplitude versus offset/angle (AVO/A) responses, those anelastic effects must be characterized and compensated for. The first step in addressing the Earth's absorption effects is to derive a spatially and temporally variant interval 1/Q model in three dimensions, where the quality factor Q is used to characterize the anelastic effects. This is conventionally achieved using ray-based reflection tomography techniques. However, to overcome the limitations of the ray-based methods, two-way wave equation-based methods that derive a high-resolution attenuation model should be implemented. The second step in addressing the Earth's spatially variant absorption effects is to correct for these effects by embedding the amplitude and phase corrections within a migration operator.