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FWI and Q-Tomography on broadband processed data - SE Asia case study

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SUMMARY

Imaging below shallow gas bodies is one geophysical challenge encountered in offshore Southeast Asia basins. There are two key components in addressing this challenge: 1) the derivation of an accurate, high-resolution, geologically consistent velocity model and 2) compensating for the loss in signal strength and frequency bandwidth due to absorption of the signal as it propagates through the gas bodies.

In this study, we present the application of FWI and Q tomography to a shallow-water, shallow-gas dataset from offshore Southeast Asia. We demonstrate the successful ability of FWI and Q tomography to resolve the low P-wave velocities and high attenuation of shallow gas bodies and subsequently compensate for the complex kinematics and absorption during depth migration.

Introduction

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Theory

An accurate Earth model in the overburden will not only improve imaging in the shallow section but will also facilitate subsequent model building and improve deeper reservoir-level imaging. Ray-based velocity model building techniques, either in the data domain, for example refraction or diving-wave tomography, or in the image domain, such as reflection traveltime tomography, cannot fully spatially resolve localized gas features. Full-waveform inversion (FWI) velocity model building operates in the data domain and presents the capability of creating the desired high-resolution velocity model through a wavefield-consistent solution (Tarantola, 1984).

In addition to velocity model building challenges, the presence of gas in the shallow overburden often results in significant loss of signal strength and frequency bandwidth, thereby obscuring the underlying seismic image. This results in distortions to the phase and amplitude information at the target level which can lead to poor identification and interpretation, errors in amplitude versus offset analyses and inaccuracies in inverting to rock properties. Q tomography and Q imaging address the Earth’s attenuation effects by first deriving a spatially and temporally variant 3D interval 1/Q model using ray-based reflection tomography techniques and then incorporating this model within a migration operator (Cavalca et al., 2011).

Conclusions

In the FWI feasibility study, the velocity model derived by FWI showed improved resolution and led to enhanced gather flatness and sharper fault definition when compared to the reflection traveltime tomography results.

Q tomography and Q imaging were successfully applied to compensate for the absorptive effects of the shallow gas anomalies. By mitigating the complex overburden effects, reservoir-level imaging is improved, potentially leading to a more robust AVO analysis.

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