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A Review of Seismic Attenuation Mechanisms, Measurements, and Inversion Strategies

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Summary

This segment of the Seismic Inversion for Marine Overburden Characterization workshop discusses the physical mechanisms responsible for intrinsic and scattering attenuation, rock physics models for intrinsic attenuation, common methods for measuring attenuation from seismic reflection surveys, and inversion strategies to estimate soil and fluid properties from attenuation measurements.

Abstract

This segment of the Seismic Inversion for Marine Overburden Characterization workshop discusses seismic attenuation, from both theoretical and practical perspectives. Starting with a definition of attenuation, and differentiating intrinsic attenuation from scattering attenuation, the segment will then cover the physical mechanisms of attenuation and review some of the rock physics models for intrinsic attenuation. Particular attention will be paid here to the sensitivity of various soil and rock parameters on intrinsic attenuation, as well as the large effect on attenuation from the presence of gas. Discussion of the rock physics models will pertain to both P- and S-wave attenuation.

From a practical perspective, this workshop segment will discuss data processing steps for isolating intrinsic attenuation measurements from the effects of scattering attenuation. Examples will illustrate the difficulty of reliably estimating attenuation using popular signal processing approaches (e.g., spectral ratio, centroid frequency shift, and peak frequency shift methods), and the relationship of these methods to those employed in seismic interpretation software, namely Petrel and OpendTect, will be discussed. More advanced methods of estimating attenuation will be reviewed, including full-waveform inversion. Assuming reliable estimates of attenuation, in the form of quality factor (Q), a procedure to Q-compensate seismic reflection data will be discussed.

The workshop segment will then present inversion strategies for estimating rock/soil and fluid properties from Q estimates. These strategies all involve the inversion of a rock physics model for attenuation, but differ in the sorts of seismic data being used (reflection versus OBS), the geologic setting, and the algorithm for handling the inversion. The non-linearity and high-dimensionality of the rock physics models make inversion challenging by precluding an analytical solution and enabling the possibility of multiple solutions. Thus, algorithms involving repeated forward runs of the rock physics models are demonstrated, with preference for a Bayesian inversion approach which accounts for multiple solutions (as opposed to an optimization approach which gives a single solution). Furthermore, strategies for dimensionality reduction and constraining of the sampling space are discussed.