Statistical Classification and Wavelet-Transform Analysis for Volumetric Estimates

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Seismic data are used in exploration situations to infer rock-property information about the subsurface, but the data are typically incomplete, ambiguous, and noisy. However, quantitative interpretation techniques are intended to encompass these inadequacies to provide descriptions of complex geology. This is becoming more important, especially for characterization of heterogeneous but economical reservoirs. The work presented here is a seismic-based method to obtain volumetric estimates of fluid in place for these types of reservoirs. The technique includes modeling the geologic heterogeneity and examines how this heterogeneity affects reservoir properties including porosity, sand volume (net-to-gross), thickness, and saturation. It is a statistical method that inputs prior distributions of these properties and then uses a classification scheme and wavelet transforms to provide estimates of the properties.

Data from a calibration well provides the starting points for the rock properties of interest.

A series of modeling steps based on these data establish statistical classification parameters. Steps include facies modeling, statistical rock-property assignments, rock-physics transforms, and full-waveform synthetic seismic computation. Estimates of porosity, saturation, and net-to-gross come from classifying real seismic amplitudes. Coupled to the classification scheme is a comparative method based on wavelet-transform coefficients from real and synthetic seismic data. These comparisons provide estimates of the interval thickness.

The method was applied as an exploration tool to seismic data containing a calibration well from offshore Norway. Within the well data was an interval of interest comprised of alternating sand and shale layers fully saturated with brine. The modeling included constructing facies models with ranges of thickness and net-to-gross that bounded the quantities in the well with both brine- and gas-saturated scenarios. Results included distributions of net-to-gross and thickness around the measured values in the well and correct porosity and saturation predictions. These results indicate that the technique can be used in an exploration setting to obtain volumetric estimates and associated uncertainty of fluid in place. They also demonstrate that the geologic heterogeneity must be modeled to understand how it affects the reservoir properties of interest.