High Resolution Characterization of Reservoir Heterogeneity with Cross-well Seismic Data – A Feasibility Study

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Abstract

Characterizing reservoir heterogeneity is important for the understanding and optimization of production of oil and gas reservoirs. Reservoirs can contain impermeable lithological units and heterogeneous porosity/permeability distributions that are further affected by complex fault systems that significantly affect fluid flow paths and distribution. Reservoir heterogeneity occurs at the metre-scale, where heterogeneities are controlled by bedding, fluid changes, and diageneitc effects. Heterogeneities occur at larger scales also, but at the metre-scale heterogeneities affect fluid flow behavior the greatest (Grammer, et. al, 2004). Traditionally, well log data and surface seismic data are used to characterize reservoir features, but both lack in their resolution capabilities that limit the effectiveness of characterization. Well log data has a sufficiently small vertical sampling interval (cm scale), but samples a very small portion of the entire reservoir near the borehole. Surface seismic data resolution suffers both vertically and spatially. Large areas are surveyed in 2-D or 3-D with a spatial sampling normally around 10 – 30m (depending on acquisition geometry), and vertical sampling typically 30 – 50m at the reservoir interval (Yilmaz, 1999). Between well log data and surface seismic data a resolution gap exists, hindering reservoir characterization methods.

Appropriate temporal and spatial resolution necessary for characterization of reservoir heterogeneities can be achieved through cross-well seismic imagining. Cross-well seismic data avoids near surface effects that drastically attenuate high frequencies, allowing high resolution sampling (~1m) at the reservoir interval (Lazaratos, 1993). Bridging the resolution gap between seismic and well log data provides reservoir engineers the opportunity to more accurately define reservoirs using flow simulations.

This study aims to evaluate the effectiveness of borehole to borehole seismology for providing high resolution reservoir images and extraction of geostatistical information that can be used in reservoir simulation. Two synthetic cross-well seismic datasets are created using velocity models derived from an offshore petroleum reservoir, built to simulate lithologic detail and reservoir heterogeneities at detectable cross-well seismic scales. The geostatistical information extracted from the processed cross-well seismic data adds new information for reservoir characterization.