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Distinguishing Water Saturation Changes from Porosity or Clay Content Changes Using Multicomponent Seismic Data

Abstract

It is difficult to predict whether gas saturation is low or high in reservoir pore spaces prior to drilling. When reservoirs include lateral porosity or clay content changes, this task is even more difficult. However, the problem is easier to address with high-quality multicomponent seismic data. This paper proposes to use DRps/DRpp as a partial gas indicator (PGI), where DRps and DRpp are defined as the change in the P-SV and P-P reflection coefficients, respectively. The target portion of the reservoir is compared with an inferred background portion of the reservoir, which is assumed to be 100% water saturated.

The DRps/DRpp ratio behaves quite differently for high and low gas saturations, as shown by theoretical reflection coefficient computation for a range of examples using the Zoeppritz and Gassmann's equations. The responses of DRps/DRpp to porosity and clay content changes are computed using empirical relationships among velocities, porosity and clay content (Wang and Nur, 1992; Han et al., 1986; Eberhart-Phillips et al., 1989; Castagna et al., 1985). The ratio is insensitive to the magnitude of porosity or clay content changes, and this behavior is very different from the variations in the ratio associated with changes in gas saturation.

Theoretical reflection coefficient computation, modeling, and synthetic seismograms show that DRps/DRpp is an effective direct hydrocarbon indicator and PGI for all three classes of gas reservoirs (Rutherford and Willams, 1989) at both shale/sand and sand/shale interfaces. The three classes of reservoirs are classified based on their acoustic impedance contrasts with their overlying shales. The DRps/DRpp ratio can distinguish water saturation changes from porosity or clay content changes and separate regions of high gas saturation from low saturation areas.

Biographical Sketch

FUPING ZHU received her PhD degree in geophysics from Texas A&M University in 2000, MS in geology from Research Institute of Petroleum Exploration and Development, China, in 1989, and BS in geology from Beijing University, China, in 1986. She worked on sedimentology and stratigraphy before she started attending Texas A&M University in 1996. She has worked on seismic processing with Shell and seismic interpretation with Unocal Corp. as a summer intern. She is now working on seismic interpretation and AVO with Shell Deepwater Services and is a member of SEG and AAPG. □

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