Low Saturation Gas Reservoir Discrimination Using Self-Organizing Maps, Deep Water Gulf of Mexico

Julian Chenin, Heather Bedle
University of Oklahoma

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Abstract

The discrimination of low-saturation (fizz) gas reservoirs from commercial quantities of gas remains a challenging problem in petroleum exploration. A low-saturation gas reservoir will have similar seismic amplitude and rock physics responses to that of a commercial, high gas saturation reservoir. Therefore, an effective method of identifying and discriminating undersaturated gas accumulations remains unsolved, resulting in uncertainty in hydrocarbon exploration. To address this problem, an unsupervised machine learning multi-attribute analysis is performed on 3D post-stack seismic data within Green Canyon, deepwater Gulf of Mexico, over several blocks. The analysis uses principal component analysis (PCA) methods, applied to a selected set of seismic attributes to identify meaningful combinations of attributes which provide insight into the seismic data. The PCA results in key attribute combinations that are difficult to interpret due to their multi-dimensional nature. To aid in this visualization, self-organizing maps (SOMs) are employed.The ambiguity of fizz gas is primarily due to the elastic properties of gas, particularly the bulk modulus. Due to the elastic properties of the gas’s bulk modulus on the bulk rock, a small, uneconomical, amount of hydrocarbon gas included in the pore space of the reservoir rock will reflect seismic energy back to the surface in a similar manner as a larger, and more economic, accumulation of gas in the pore space. Therefore, these properties will cause a low gas saturation reservoir and a high gas saturation reservoir to have similar seismic amplitude responses (O’Brien, 2004; Batzle, 2006). In this region of the Gulf of Mexico, the seismic reflection in both low-saturation

and high-saturation gas accumulations will create a bright amplitude anomaly within certain lithology and pressure regimes. Optimized SOM results reveal that fizz gas reservoirs can be discriminated from high saturation reservoirs when using a combination of instantaneous attributes sensitive to attenuation, frequency, and small amplitude anomalies. Although these results may not give a quantitative saturation estimation, they do highlight a stark difference between both prospects. Individually, some of these attributes have minimal success in differentiating between low and high gas saturation reservoirs. However, employing multi-attribute analyses such as PCA and SOMs, provide clearer insight into the subsurface responses needed to distinguish between both reservoirs. Additionally, this combination of attributes is currently being tested in other fizz prone regions to validate this methodology as a universal technique, such as in the Ursa Field, offshore Gulf of Mexico and in the Scarborough Field, offshore Australia.