Analysis of Fault Seals Using Complex Seismic Trace Attributes Calibrated to Artificial Neural Networks

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Abstract

A fault zone can provide an effective barrier to hydrocarbon migration if the fault gouge material has a high capillary entry pressure. A method of assessing gouge development potential, and hence sealing risk, is by calculation of the shale gouge ratio (SGR). SGR is a quantification of the amount of fine grained material incorporated in the fault zone, and can be derived simply from log calculations of shale volume in offset wells and fault throw determined from 3D seismic data. This approach can be problematic however, especially in areas with sparse well control and laterally varying stratigraphy, where wireline shale information must be interpolated from many kilometers away. An alternative approach is presented here whereby the SGR near the fault is computed using stratigraphic information estimated from complex 3D seismic trace attributes trained to an artificial neural network. The method is data driven and does not require a prior model.

Rock properties such as porosity can be estimated from sample-based seismic attributes using for example, inverted acoustic impedance. These physical relationships can be assessed simply by cross plotting the two variables and fitting a linear transform function. This approach is not straightforward when predicting shale information seismically, and instead requires a nonlinear function. This can be accomplished using a probabilistic artificial neural network (or PANN) which fits a smooth nonlinear curve to the pairs of data points representing the shale volume log measurements and seismic attributes extracted from traces nearest the wellbores. The PANN-based function is used to transform seismic attributes to shale volume information , enabling SGR near the fault to be calculated.

This new method was used recently in the onshore Tuscaloosa trend of southeast Louisiana to evaluate a downthrown fault bounded gas trap with sand-on-sand juxtaposition. Before reaching a total depth of over 19,000 feet in October 2008, an exploration well successfully tested five separate sands, four of which are commercially productive. As hydrocarbon accumulations world-wide continue to decline, riskier untested fault bounded traps are increasingly being drilled in hopes of further extending the life of a maturing field. This method can provide detailed information on the near-fault stratigraphy and can enable the exploration team to assess with higher confidence the risks involved in drilling such prospects.