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Seismic Attribute Analysis and the Use of Unsupervised Neural Networks and Principal Component Analysis in Unconventional and Conventional Reservoirs

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Abstract

Interpretation of seismic reflection data involves powerful multiple-CPU computers, advanced visualization techniques, and generation of numerous seismic data types and attributes. Even with these technologies at the disposal of interpreters, there are additional techniques to derive even more useful information from our data. Over the last few years, there have been efforts to distill numerous seismic attributes into volumes that are easily evaluated for their geologic significance and improved seismic interpretation. Seismic attributes are any measureable property of seismic data. They can be measured at one instant of time or depth or over a time or depth window. They are measured on a single trace, on a set of traces, or on a surface - all interpreted from the seismic data. Commonly employed categories of seismic attributes include instantaneous, geometric (coherency, curvature), amplitude accentuating (relative acoustic impedance, sweetness, etc.), AVO, spectral decomposition, and inversion. Principal component analysis (PCA), a linear quantitative technique, has proven to be an excellent approach to understand which seismic attributes or combination of seismic attributes have interpretive significance. PCA reduces a large set of seismic attributes to indicate variations in the data. The combination of seismic attributes contributing to these variations quite often relate to geologic features of interest. PCA, as a tool employed in an interpretation workflow, can help determine meaningful seismic attributes. In turn, these attributes are input to self-organizing map (SOM) training. SOM, a form of unsupervised neural networks, has proven to be an excellent method to take many of these seismic attributes and produce meaningful and easily interpretable results. SOM analysis reveals the natural clustering and patterns in data and has been beneficial in defining stratigraphy, seismic facies, DHI features, and sweet spots for shale plays. With modern visualization capabilities and application of 2D color maps, SOM routinely identifies meaningful geologic patterns. Recent work utilizing SOM and PCA has revealed geologic features that were not previously identified or easily interpreted with the seismic data. The ultimate goal in this multi-attribute analysis is to enable the geoscientist to produce a more accurate interpretation and reduce exploration and development risk.