Derived Seismic Attributes Underpin Reservoir Characterization in Data-Driven Methodologies

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Abstract

Reservoir characterization is the process of calibrating or mapping reservoir thickness, net-to-gross ratio, porosity, permeability and water saturation. Well logs have habitually provided the source of the data to generate the maps, but piecemeal seismic attributes have gained popularity when calibrated with extant well control. The seismic data can be used to interpolate and extrapolate between and beyond sparse well control that provides only localized knowledge. Let us enumerate those seismic attributes that are most conducive for reservoir characterization. One methodology to classify seismic attributes is to cluster them into the following four categories:

1) Qualitative attributes such as coherency and perhaps instantaneous phase or instantaneous frequency are ideal for identifying spatial patterns such as faults or facies changes. It is essentially impossible to map these attributes directly to a reservoir property such as porosity, and consequently these attributes are not implemented to quantify reservoir properties.

2) Quantitative attributes: The most fundamental quantitative attribute is amplitude on zero phase data, relative impedance data or absolute impedance data. Traditionally we identify these three attributes as the most pertinent for quantitative reservoir characterization.

3) Interval attributes are those that quantify a lens into the seismic data that windows more than one peak or trough. The majority of seismic attributes can be categorized in this manner. An interval attribute is analogous to a well log cross-section with a number of thin, discontinuous sands that cannot be correlated with any certainty.

4) AVO attributes are those that are generated using a reflection's pre-stack amplitudes. Examples of pre-stack attributes are AVO gradient, AVO intercept, near amplitude and far amplitude. 3D pre-stack attributes have only become available recently with the advent of affordable pre-stack time migrations.

This article explores an array of soft computing data-driven methodologies that lend credence and support reservoir characterization by adopting advanced analytical methodologies on seismic attributes. We shall define workflows integrating seismic data and derived attributes as input space for Principal Component Analysis (PCA) and Self-Organizing Maps (SOM) in a closed iterative loop. We shall also touch upon the implementation of nested neural networks as part of a Deep Learning (DL) methodology.