Attribute-Assisted Stratigraphic Interpretation

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Summary

Mapping stratigraphic detail in complex reservoirs can often be augmented through the use of selected seismic attributes to infer reservoir properties and limits. Seismic attributes are now broadly available to interpreters; and while some are widely used, others have received less attention and application in routine workflows. Illustrations of attributes enhancing the interpretation of Kiskatinaw sandstones of Western Canada, Frio sandstones of Texas and Balmoral sandstones of the North Sea are presented in this paper. The diverse depositional environments and geological details of these reservoirs comprise a very small subset of settings for which interpreters will extract enhanced interpretive information through selected attribute analysis.

Introduction

One goal of geophysical interpretation is to estimate porosity, lithology and fluid characteristics from seismic data. A full elastic inversion to well log curves would be a wonderful tool but, unfortunately, available seismic data often doesn't enable that full inversion. Interpreters are left with the challenge of creating their best estimates of reservoir parameters from imperfect seismic data sets. Post-migration, interpretive workstation-based attribute analysis such as spectral decomposition, complex trace analysis and volume curvature calculations can produce visualizations of the seismic data that better illustrate desired reservoir characteristics. Visualizing attributes, or combinations of pertinent attributes, in colour cubes at a stratigraphic level of interest, enhances the understanding and clarity of the stratigraphy. As many attributes are calculated over an interval, they may be less affected by errors or uncertainty in the exact position of the estimated stratigraphic observation surface than a strata slice of the seismic volume.

Examples

Kiskatinaw

The Kiskatinaw Sandstone is an estuarine to shallow-marine sandstone in the Peace River Arch region of Western Canada that is a prolific but elusive reservoir. The reservoir sits just above Mississippian carbonates. When estuarine deposits are present, the reservoir's acoustic impedance can be either less or greater, depending on reservoir quality and cementation, than surrounding siltstones and shales. As a result the impedance is an unreliable indicator of reservoir presence or quality, and estimating impedance has its usual difficulties in this often marginal data quality area. Differential compaction of the siltstones and shales, in contrast to reservoir sandstones, can result in positive curvature associated with the thicker reservoir, independent of reservoir impedance. The volume curvature attribute, shape index (reference Roberts), illustrates the axis and probable extents of a sand body when displayed along a surface proximal to the strata. This mapping is confirmed by wells A, B, and C; and is more clearly defined than I was able to accomplish without the assistance of the attributes. In this case each volume curvature value was calculated within a cell of nine inlines by nine crosslines and 32 ms in time. The thin bed indicator attribute, which is based on the anomalous response of instantaneous frequency to beds less than ¼ of the wavelet period (Robertson and Nogami, 1981), defines a probable edge trend for the sand body.

Stratton

The Stratton gas field of Texas was documented by Hardage, *et al.,* in 1994. The field produces from multiple laterally- and vertically-separated compartments of the fluvial Frio Sandstone. As presented by Hardage *et al*., amplitude displays along quasi-stratal surfaces illustrate some of the stratigraphy. Decomposing the data into its spectral elements and recombining selected spectral elements as primary colour modulators yields improved definition of sand distribution. For some of the thicker sands in the field area, the Sweetness attribute defines the seismically thicker parts of the sand bodies.

There are often many pertinent attributes that can be calculated or decomposed, introducing additional complexity to the interpretation problem; though mentally comparing and contrasting more than three maps at once is a challenge for me! Neural Networks offer a convenient method of dealing with several variables and classifying them into groups based on many characteristics. A Neural Network classification of the Frio based on instantaneous amplitude; instantaneous frequency ;and spectral decompositions at 30, 40 and 50 Hz illustrates the sands clearly and conforms to well control.

MacCulloch

The MacCulloch field is a Tertiary, Balmoral turbidite sandstone reservoir in the UK sector of the North Sea, as described by Gunn *et al*. (2003). The field has produced about 90 MM bbls to date. Reservoir quality is excellent, with porosity averaging 28% and permeability up to 2 Darcys. Through a combination of seismic attributes and published interpretations, interesting details of the stratigraphy emerge; leading to a map of the field with important differences from the published map. If this attribute-assisted mapping correctly defines stratigraphic details of the reservoir distribution, there may be potential reserves not being drained by the current producing wells.

Conclusions

Mapping important reservoir properties and limits has been enhanced in three diverse geological settings through use of selected seismic attributes. These examples comprise a very small subset of the many settings for which interpreters have and will extract enhanced interpretive information through attribute analysis.

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