Seismic attribute analysis with well to seismic validation

Eileen Huang, Landmark Graphics, Calgary, Canada

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Abstract

Seismic attributes are routinely used for predicting the qualitative or quantitative distribution of well properties. There are many success stories, but there are also unsuccessful ones. Factors resulting in an unsuccessful prediction are various but include: failing to calibrate well to seismic, failing to evaluate seismic geologic conditions, failing to choose the most appropriate set of attributes, and failing to validate the correlations between the attributes and the well properties. This paper addresses ways to avoid each of these pitfalls, and help the interpreter answer the question, "Which, if any, attributes can help me understand my reservoir?".

The problem

Seismic data is the complex response of lithology, fluid, bed stacking pattern, bed thickness and other factors. As such, it is incredibly rich in amplitude, frequency, phase, geometry and texture information. The purpose of seismic interpretation is to find geobodies with favourable reservoir properties. The only guide to what favourable reservoir properties look like in the seismic data is the well dataset, and the link between these two sets of data is seismic attribute analysis.

For a variety of reasons, however, it may not always be possible to establish statistically significant relationships between seismic attributes and well properties. The reasons for this may include geologic conditions (such as incoherent beds, thin beds, or anisoptropic velocities), seismic data quality, or the methodology applied. It is not necessary for interpreters to study the theoretical reasons for failure where the relationships between seismic attributes and well properties can not be found. But it is necessary for interpreters to establish which, if any, seismic attributes are expected to be indicative of variations in stratigraphy, lithology, or fluids in the area. In other words, to answer the question, "Which, if any, attributes can help me understand my reservoir?".

The solution

Seismic forward modeling can give the seismic intperpreter significant insight into the structural and stratigraphic aspects of their interpretation. Moreover, in most cases, attributes extracted from the seismic model can be used to verify ones extracted from the real seismic data. 'Closing the modelling gap' in this way gives an indication of the confidence in the predictions of the attribute analysis.

This paper discusses how to approach seismic attribute analysis in a comprehensive way, and to avoid some of the pitfalls described above. A practical five-step workflow is presented:

(1) well-to-seismic calibration using synthetics, and study of the energy distribution in the synthetic by reflection decomposition;

(2) forward modeling to create 2-D models with fluid substitution or interval velocity substitution;

(3) attribute extraction from the seismic model;

(4) qualitative and /or quantitative comparison of seismic with model;

(5) multi-attribute analysis.

To illustrate the workflow, examples are presented from a variety of datasets from the Western Canadian Sedimentary Basin and North China Basin.