Finding the balance between automated and manual interpretation

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A new technique aids in interpretation of any stratigraphic feature.

Advances in seismic attribute analysis and color visualization reveal the geology imaged within 3-D seismic data with unprecedented clarity. As a consequence, the industry can develop a level of understanding of petroleum systems and reservoirs that was previously unobtainable. Many of the geological features that become apparent in this way have complex 3-D geometries that need to be captured if they are to be represented appropriately in a reservoir model. Accurately incorporating such 3-D geometries into a reservoir model can have a significant impact on volumetrics and reserves estimation and lead to better well planning.

Therefore, extraction of 3-D geobodies has become fundamentally important in seismic interpretation. Currently, geobody delineation uses volumetric threshold-based extraction techniques or auto-tracking/region growing from a seed point. These techniques are not robust as they are sensitive to noise and cannot accommodate the variations in the expression of a geological feature.

To address this issue, ffA has developed a technique that allows geobodies to be grown that is more reliable than existing geobody delineation methods while still being extremely simple to apply. This is achieved by bringing together data-driven techniques and interpreter guidance using intuitive manual manipulation tools, which are unique in enabling on-the-fly 3-D editing of geobodies. Confidence values computed at every point on the geobody surface are displayed to provide direct visual feedback to the interpreter on how well the geobody is fitting to the data, which in turn helps the interpreter edit the geobody more accurately.

A channel and fan system barely visible in the reflectivity data (a) becomes apparent in an RGB blend of three frequency responses (b) and is extracted as an adaptive geobody (c) despite the variable expression. (Images courtesy of ffA)

The challenge of delineation

In complex geological environments, a single attribute is often not effective at delineating a feature in the data. Combining multiple volumes using color-blending techniques (such as RGB and CMY) is an effective way of improving the definition of features. With color blending,
features that were previously very difficult to detect become apparent, although often they will
have a highly variable signature.

With the new adaptive geobodies technique, a variable character and multiple inputs within a
feature are handled using analysis of local data statistics. This mathematical sophistication is
important in giving the reliability required for efficient interpretation, but it also is one of the
factors that make the adaptive geobodies so easy to use. This simplicity is a critical factor if a new
technology is to deliver on its value proposition.

Data-driven

Multiple attributes can be used in the geobody extraction process so that each individual attribute
does not need to fully define the area of interest and each one can define a different characteristic
of the feature (such as combining edge and envelope attributes for channel definition). The
statistical process is initiated simply by defining a number of seed points.

The seed points represent the starting points for the extraction as with conventional autotracking.
Seed points can be placed to identify areas within the feature and also to identify exclusion zones.
Examination of the data statistics around each seed point ensures that as the seismic character of
the feature is changing, the tracking statistics change with it. This allows the adaptive geobodies to
"adapt" to changes in expression. This is just one way in which the adaptive geobodies technique
deviates from conventional attribute analysis techniques through replicating the way the human
visual system works.

Interpreter-guided

However, seismic provides an abstract and ambiguous representation of the subsurface geology
that is subject to artifacts and noise, which means there are often cases when the data do not
adequately represent the geology that is being imaged. In these cases, it is necessary for the
interpreter to extend or reposition areas of the geobody to fit with knowledge based on the user's
experience. This workflow accommodates that need and allows the interpreter to manually adjust
parts of the geobody as desired. It is this use of both the available data and expert knowledge in
creating accurate 3-D representations of geological elements that gives the adaptive geobodies
method its power. A result is guaranteed, and that result will match the data as much as possible
while not being constrained by data imperfections. Two areas in which adaptive geobodies can
turn tasks that were often impractical or impossible into something that can be done easily are in
interpretation of channel systems and carbonate dissolution features.

Channel delineation

In hydrocarbon plays associated with channel systems, the use of RGB blends of three frequency-
magnitude response volumes has become an accepted interpretation technique. Primarily this is
because RGB frequency blends greatly aid interpretation of the depositional environment and
reveal additional details of channel structure, over-bank deposits, and splays. The problem is that
reservoirs associated with channel systems often are extremely heterogeneous and therefore have a
highly variable character, making geobody extraction of most channel systems extremely difficult
if not impossible using conventional methods. However, with the adaptive geobody technique it is
a straightforward process that can be applied in minutes.
An adaptive geobody defines a collapse structure. a) The reflectivity data (gray scale) is displayed with an RGB blend of three frequency response volumes that highlight the circular collapse feature in the center. Note the similarity in the response within the collapse to that of the surrounding area. b) The adaptive geobody grown using the RGB blend displays the confidence value on the surface (red is high confidence; blue is low confidence).

**Interconnected dissolution features and collapse structures**

Dissolution features and collapse structures are usually highly complex interconnected features that represent a significant drilling hazard in carbonate plays but can be close to impossible to interpret conventionally. Extracting them as 3-D geobodies gives a much better understanding of the shape and geometry and of the interaction between neighboring features than can ever be achieved using surface-based horizon interpretation. The adaptive geobody technique can rapidly extract such features as geobody objects, allowing much more well-informed wellpath planning.

**Unique approach**

The adaptive geobodies method is a unique approach to defining the 3-D geometry of geological features from seismic data. The use of local data statistics and multiattribute inputs allows the adaptive geobodies to replicate some of the power of the human visual system while maintaining an objective analysis approach. Combining this with interpreter guidance means that geobodies can be extracted in a data-driven manner in almost any geological situation. Crucially, the adaptive geobody technique allows the geobody to continue growing in a stable manner as the data characteristics are changing while the interpreter remains in control of the extraction. This maximizes the use of both data and external knowledge to give unprecedented robustness. In the exploration projects in which it has been applied, the adaptive geobodies technique has added significant value through enabling the extraction of multiple individual but overlying channel systems, complex fan geometries, or subtle karst features. The adaptive geobodies technique has improved the understanding of and derisked these projects by refining the geological models, defining potential prospectivity, and delineating drilling hazards.