Adaptive Geobodies: Data driven, interpreter controlled geobody delineation of Channel and Carbonate features

Jesus Nunez*, Nicholas McArdle, James Lowell, Dale Norton and Gaynor Paton, ffA

Abstract

The accurate extraction of 3D geobodies that represent geological features is a fundamental aspect of seismic interpretation. Currently this can be achieved using volumetric threshold based extraction techniques, or autotracking / region growing from a seed-point and tracked on a threshold limit or range. Advances in colour blending techniques (such as volumetric RGB) have allowed the extraction of geobodies utilising three volume channels. This has enabled greater control over the extraction process but can still be unreliable in the presence of noise or variations in the expression of a geological feature.

To address this issue we have developed an innovative technique which allows geobodies to be grown on single or multi attribute data that is many times more reliable than existing geobody delineation methods whilst still being extremely simple to apply. The technique is based on a sophisticated analysis of local data statistics that is robust to changes in expression and noise. This data driven technology is combined with intuitive manual manipulation tools that enables on the fly 3D editing of geobodies in data areas where data driven techniques alone are not sufficient. 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.

This unique technique (patent pending) has enabled accurate extraction of geobodies in areas where all other commercially available techniques have failed. This includes braided channel systems and interconnected karst systems. In this paper we will present a selection of results from different geological settings which illustrate the interpretive advantage of this technique.

Introduction

In complex geological environments a single attribute is often not effective at delineating a feature in the data. Combining multiple volumes together using colour blending techniques (such as RGB and CMY) can improve the definition of features. Combining attributes which identify different parts of an object (such as edge and infill) are effective for visualisation but make poor inputs into conventional geobody extraction mechanisms. With this new Adaptive Geobody technique, such inputs are handled by using multi-attribute local statistics, and allows the user to specify both internal and external seed points to control the growth of the geobody.

The workflow consists of 4 simple steps:

- Select attribute volumes
- Position one or more seed points
- Run and Interact with the deformation process
- Manual manipulation

Method

Selection of Attribute Volumes

One or more attributes can be selected for use in the geobody extraction process. Each individual attribute does not need to fully define the area of interest as they are used in combination. Likewise each attribute can define a different characteristic of the feature (such as combining Edge and Envelope attributes for channel definition).

Position one or more seed points

The seed points represent the starting point for the extraction as with conventional autotracking. One or more seed points can be placed and a path can be defined along a channel axis to bias growth along a feature. This technique examines one or more statistics of the data within a sphere around the seed point to enable more robust definition of the attribute signatures that define the geobody than simple threshold based autotracking.

Run and Interact with the deformation process

Once initiated the spheres around the seed points deform, or grow, in a data driven manner according to the probability density functions (PDF's) for each volume and seed point. This means that where there is variation in the attribute expression of the feature, the geobody will still track it because of the local seed point. The geobody will therefore *adapt* to the change in expression of the feature. The user can alter the deformation parameters during this process and the geobody will adapt to the new parameters and alter the deformation interactively. The deformation process uses both internal and external forces to control the deformation, so seed points that are placed in "background" areas will apply an external force keeping the geobody out of the background area, and seeds placed on the feature itself will apply an internal force to deform the geobody along the feature.

Manual manipulation

There are times when the data does not adequately represent the geology that is being imaged, for example, where there are acquisition or processing artefacts, or due to overburden effects (velocity pull-ups etc). In these cases it is necessary for the interpreter to extend or re-position areas of the geobody to fit with knowledge based on their experience. This workflow accommodates that need and allows the interpreter to manually adjust parts of the geobody as desired to maximise the use of both the available data and expert knowledge in creating accurate 3D representations of different elements of the subsurface.

Results

Channel Delineation

In a complex channel environment RGB blends of three frequency magnitude response volumes can greatly aid interpretation of the depositional environment and reveal additional details of channel structure, overbank deposits and splays. In the case of spits and beaches, the overall geometries are better defined and, by analysing the variation in frequency response, an improved understanding of expected density and thickness variation within these landforms is also achieved (Figure 1). Extracting a geobody representing these channels would be extremely difficult if not impossible using conventional methods, however with the Adaptive Geobody technique it is straightforward to define the different, independent elements such as the cross cutting channels (Figure 2).

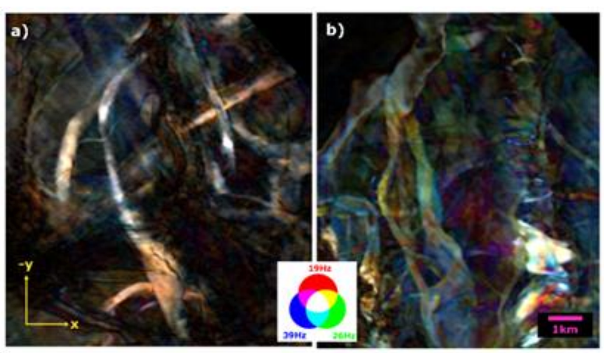

Figure 1 *Frequency Decomposition RGB blend showing a) Triassic spit system b) Jurassic channels.*

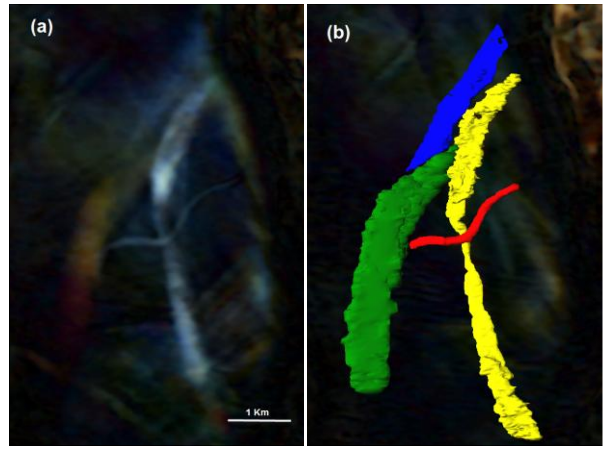

Figure 2 *Adaptive Geobody extraction of overlapping channels (b), extracted from an RGB blend of 3 frequency magnitude response volumes (a).*

Interconnected Sinkholes and Cavern systems

Dissolution features are often highly complex interconnected features which are very difficult to interpret conventionally. Extracting them as 3D geobodies gives an understanding of their shape and geometry and also improves the understanding of the interaction between neighbouring features away from surface based horizon interpretation. The Adaptive Geobody technique can rapidly extract such dissolution features as geobody objects (Figure 3) and provides information as to the confidence the interpreter should have in the positional accuracy of each point on the surface of the geobody.

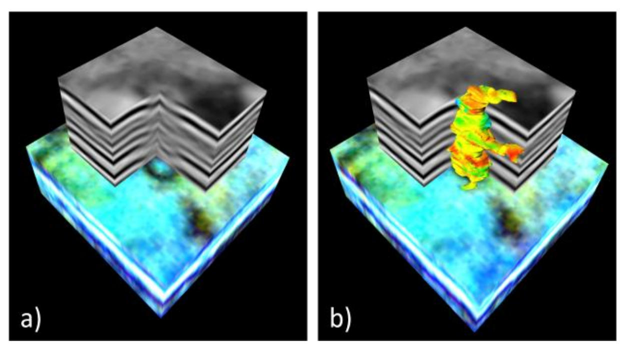

Figure 3 *Adaptive Geobody defining a dissolution feature. a) The reflectivity data (greyscale) displayed with an RGB blend of 3 frequency response volumes which highlight the circular sinkhole feature in the centre. Note the similarity in the response within the sinkhole to that of the surrounding area. b) The Adaptive Geobody grown using the RGB blend displaying the confidence value on the surface (red is high confidence, blue is low confidence).*

Conclusions

This unique approach to defining geobodies has successfully extracted 3D geobodies in situations where conventional techniques fail. The use of local data statistics and multi-dimensional probability density curves gives very accurate control to the extraction of geobodies from multiple attributes highlighting different characteristics of the data. This technique now means that geobodies can be extracted in a data driven manner in almost any geological situation. Crucially, this adaptive geobody technique allows the geobody to continue growing in a stable manner as the data characteristics are changing. The interaction of the interpreter during the deformation process has ensured that the interpreter remains in control of the extraction whilst maximising the information contained in the data for guiding the process.

Acknowledgments

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