Adaptive Geobodies™: Extraction of complex geobodies from multi-attribute data using a new adaptive technique

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GeoTeric from ffA

The Problem

Advances in volumetric attribute generation and visualisation have made it possible for us to process seismic data to separate out different aspects of the seismic response, for example, producing volumes that just show amplitude and edge information, to make it easier to see different facets of the imaged geology (Figure 1 & 2).

Using the sophisticated 3D visualisation techniques that are available it is also possible to co-render this information either through opacity blending or use of RGB, CMY and other colour schemes (Figure 3 & 4) to produce composite displays in which we can see geological information with incredible clarity and at a high level of detail.

However, combining attributes in the above manner is effective for visualisation but make poor inputs into conventional geobody extraction mechanisms. Current extraction techniques are also unreliable in the presence of noise and variations in seismic response.

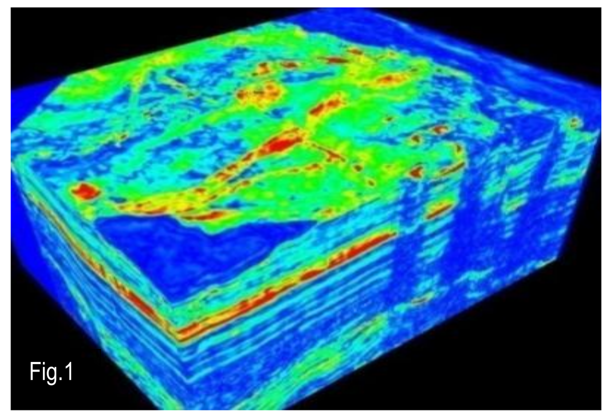
Fig.1

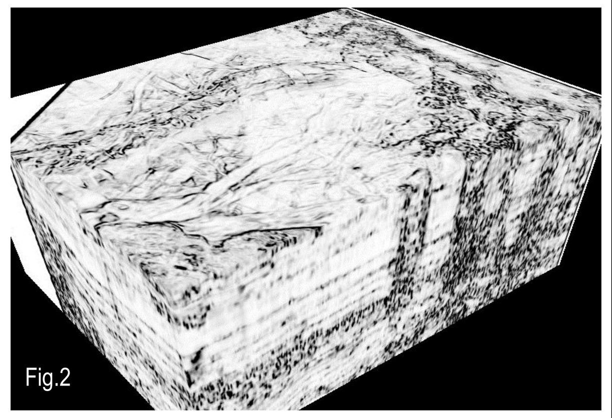
Fig.2

To address these problems, ffA has developed the Adaptive Geobodies™ delineation tool that sets to achieve the following:

1. Flexibility to tackle every situation requiring 3D geobody delineation
2. Generate geobodies based on multiple attribute responses
3. Robust to variations in seismic character
4. Be able to account for the interplay between different elements of the geology
5. Intuitive interaction with and manipulation of geobodies
6. Derive geobody uncertainty metrics

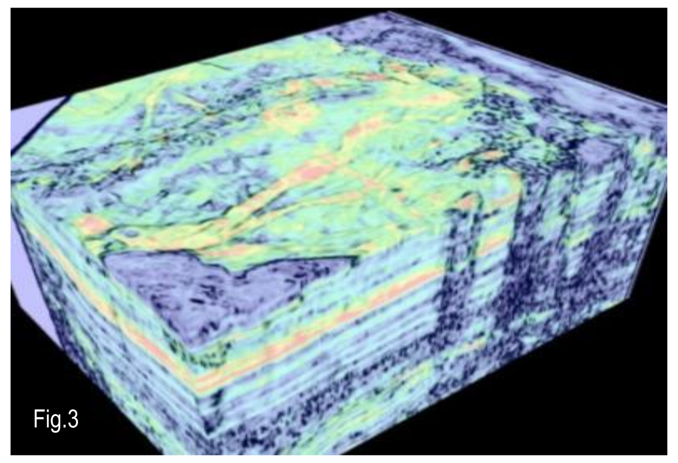
Fig.3

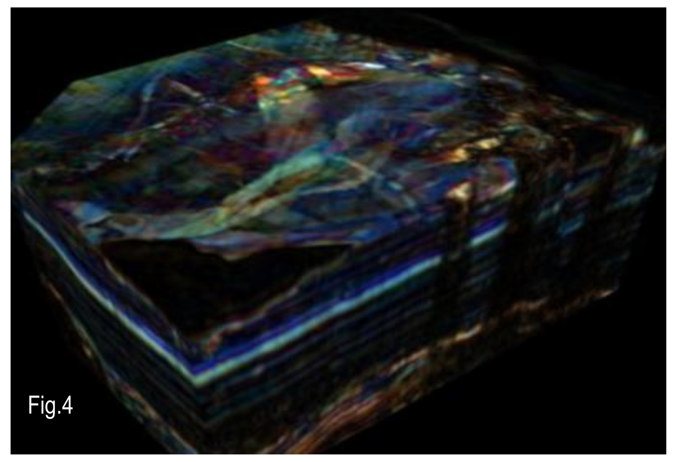
Fig.4

General Principles

The novel Adaptive Geobodies delineation technique that we have produced is based around a method that we have developed that allows the surface of a complex 3D object to be represented by a relatively sparse set of node points without any prior knowledge of the boundary (Fig. 5). This sparse representation is key to making the technique:

- fast,
- interactive and
- tractable to manual manipulation.

This is combined with a method for growing or deforming the surface of a geobody based on analysis of the statistics of one or more input attributes (Fig. 6).

– Region growing is controlled by a n-dimensional classifier.
– The n dimensions relate to different aspects of the one or more input volumes being used to define the geobody
– Initialisation picks define the data statistics that represent the object of interest.
– External points can further constrain the geobody by defining the statistics that represent the surrounding matrix.

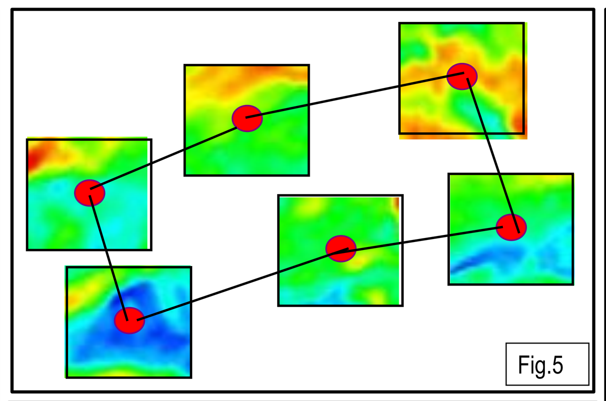
Fig.5

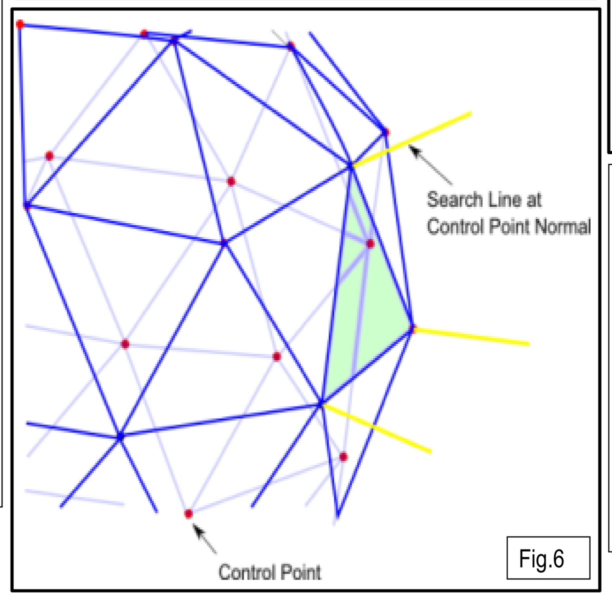

Fig.6

Lockable control nodes enable parts of the model to be secured while still allowing unlocked control nodes to move freely.

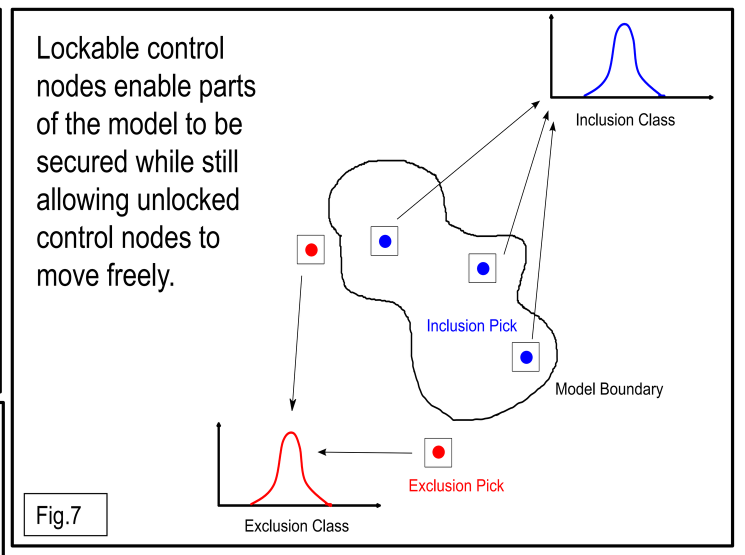

Fig.7

- The number of control nodes can be specified.
- The interval between control nodes can be altered.
- Ability to add / delete control nodes (Fig.7).
- "Draggable" control nodes allows the model to be manually manipulated.
- Both Locked and free nodes can be dragged (Fig.8 & 9)

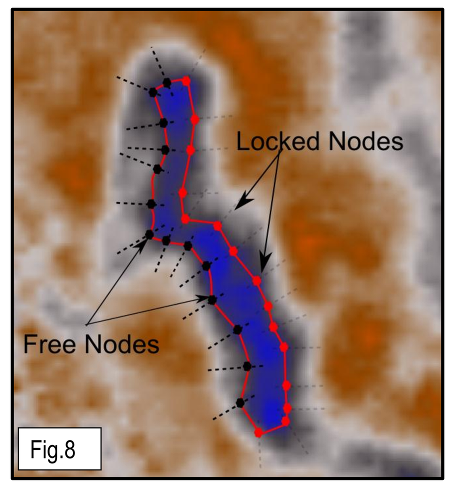

Fig.8

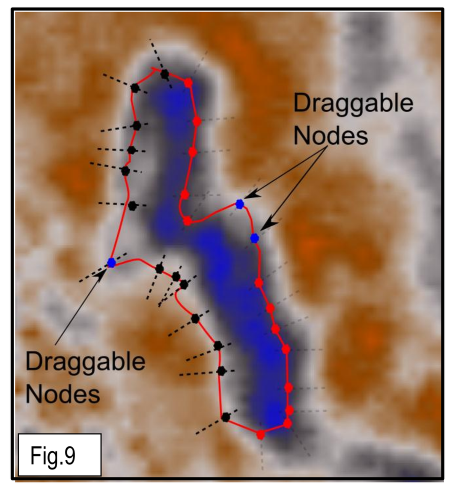

Fig.9

Method

The workflow consists of 4 simple steps:

1. **Select attribute volumes**
2. **Position one or more seed points**
3. **Run and Interact with the deformation process**
4. **Manual manipulation**

One or more attributes can be selected for use as input to the process.

One or more seed points can be placed and a path can be defined along a channel axis to bias growth along a feature.

The user can alter the deformation parameters during the growth process and the geobody will adapt and alter the deformation in an interactive manner.

It is possible to manually manipulate the geobodies. Such as in the example below (Figs.10 to 12) where an unwanted growth that did not constitute part of the object of interest has been cut off.

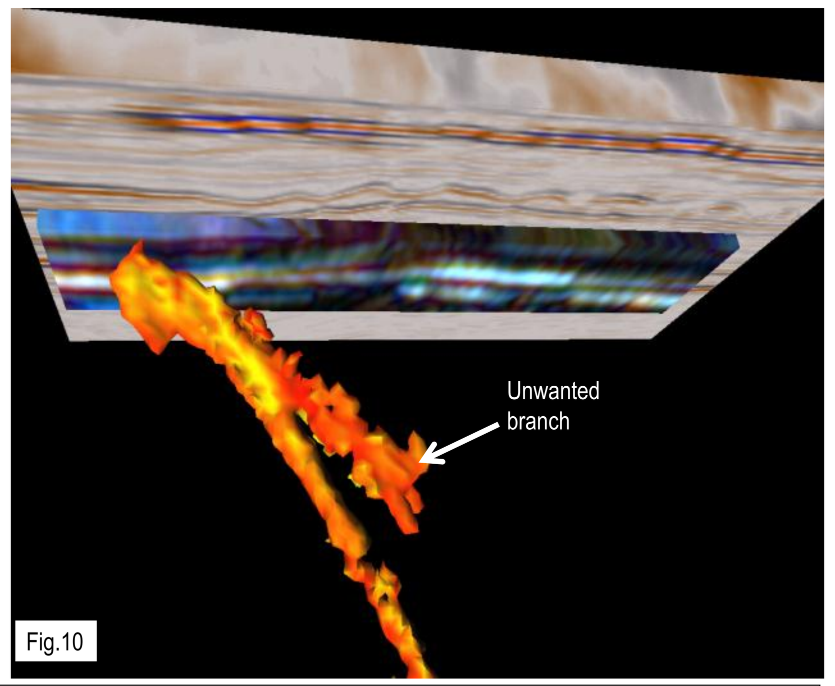

Fig.10

An unwanted branch was detected as the geobody grew. This was thought to be geologically separate from the main system of interest

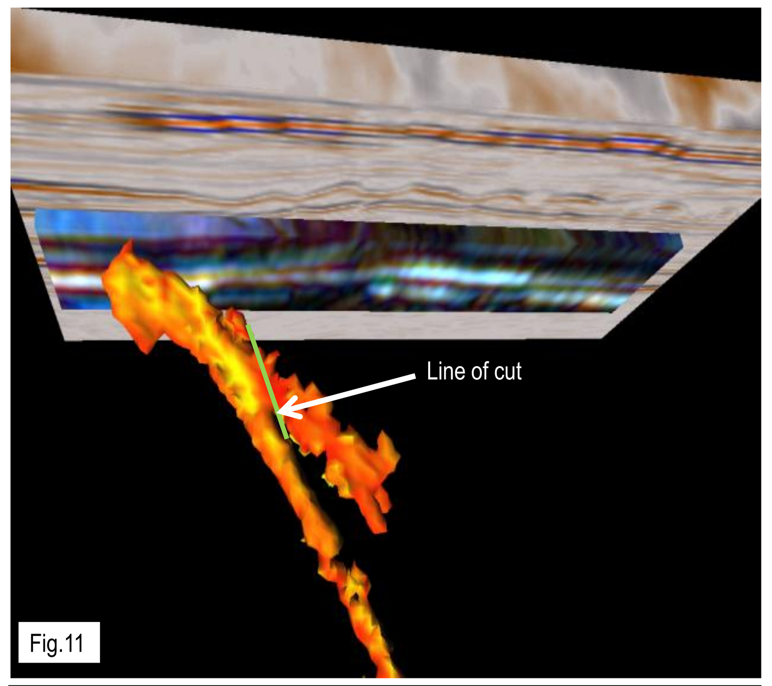

Fig.11

Plane of the cut to be used to excise the unwanted component is drawn across the object.

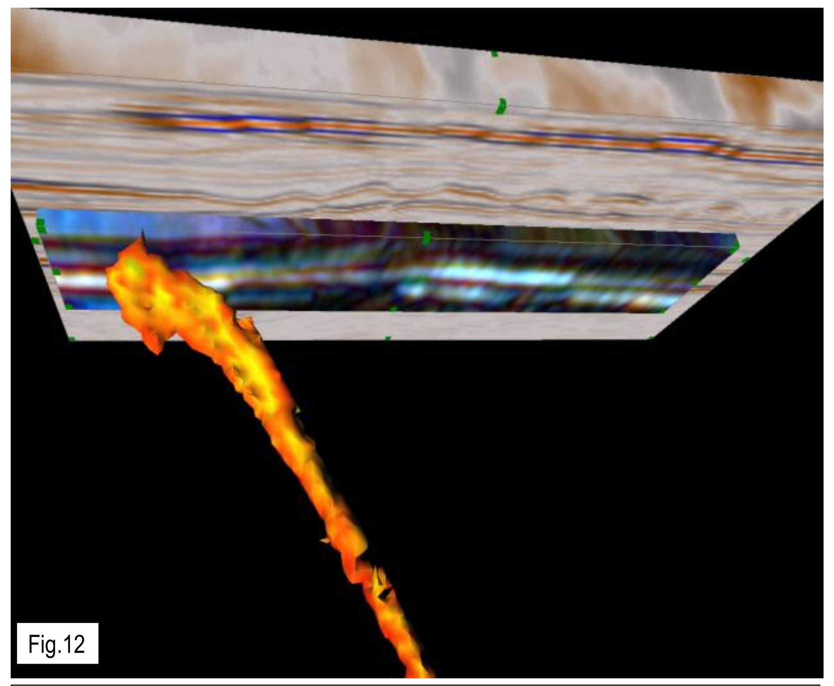
Fig.12

The geobody is divided into sections along the cut plane and individual sections can be deleted or saved as separate geobodies.

Method

Built into the process is a calculation of the "goodness of fit" or the surface confidence values between each point on the surface of a geobody and the data parameters used to control the growth of the geobody. This is shown here by the colour coding on the geobody surface (Fig.13 & 14). So in this instance, the surface of most of the objects is red or yellow indicating that the boundary is well defined by the data parameters.

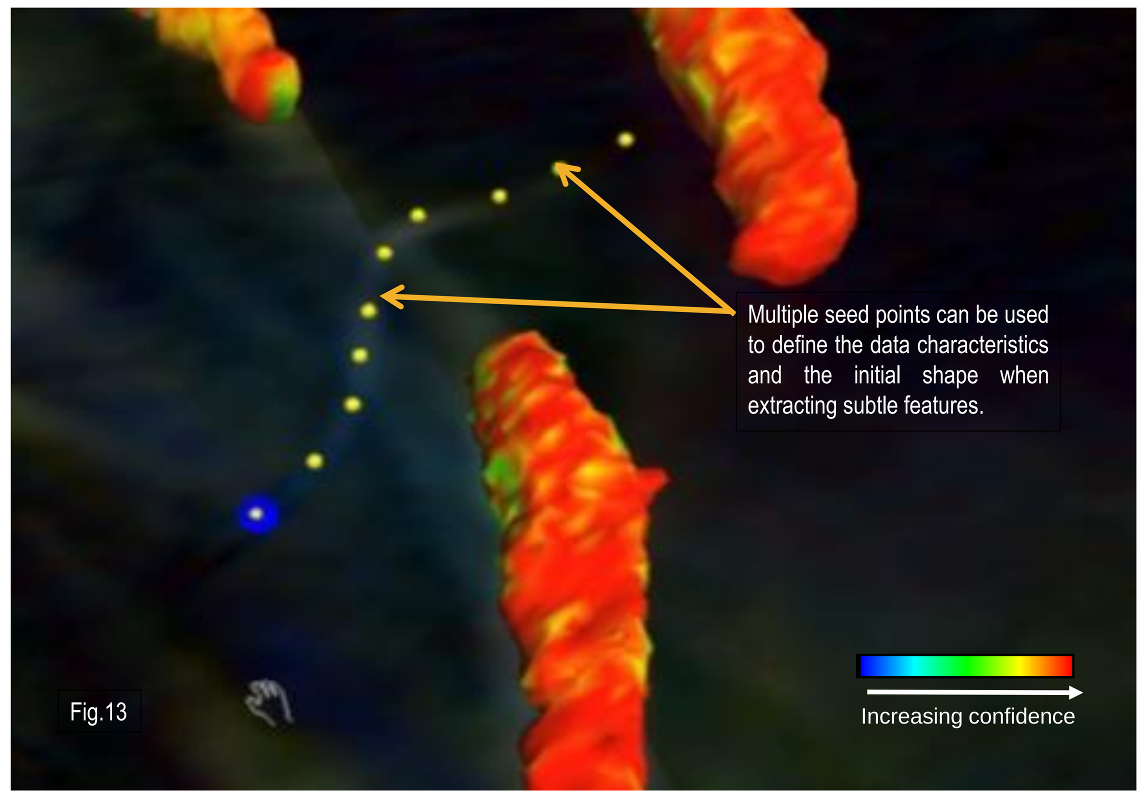

Fig.13

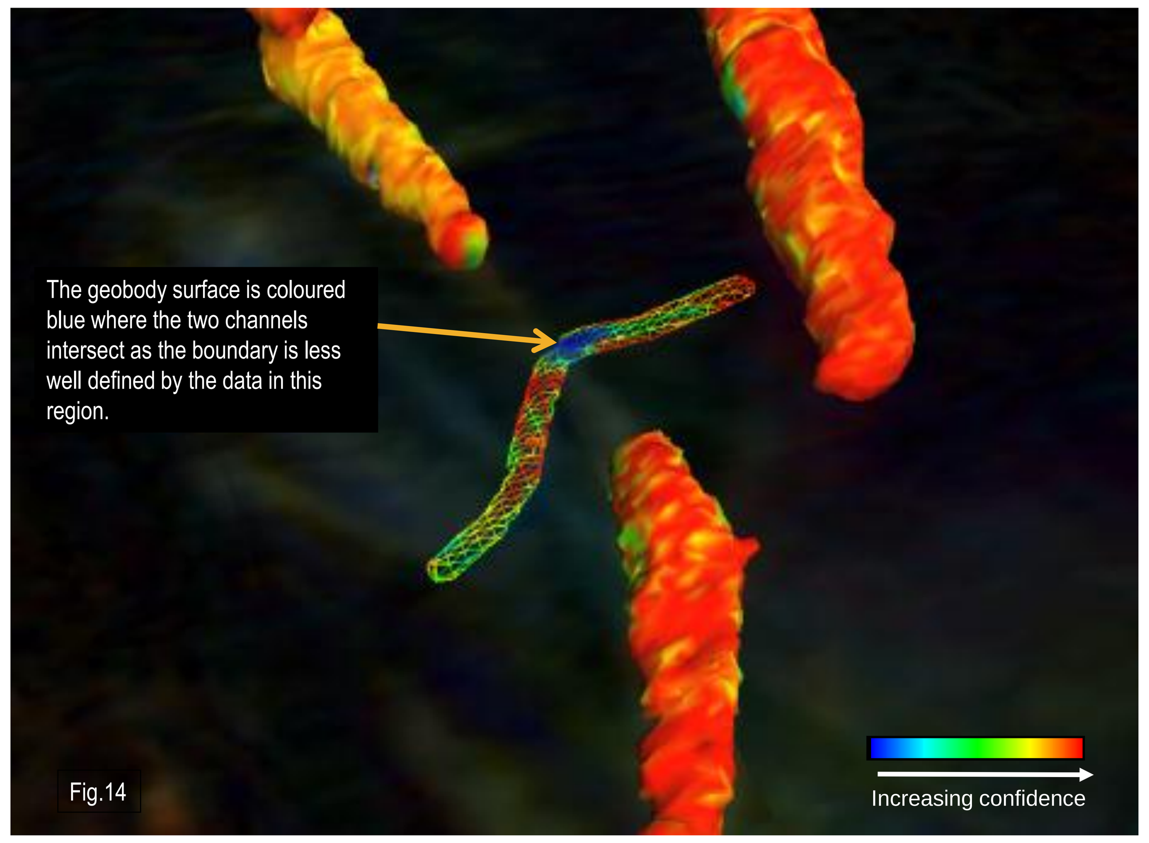

Fig.14

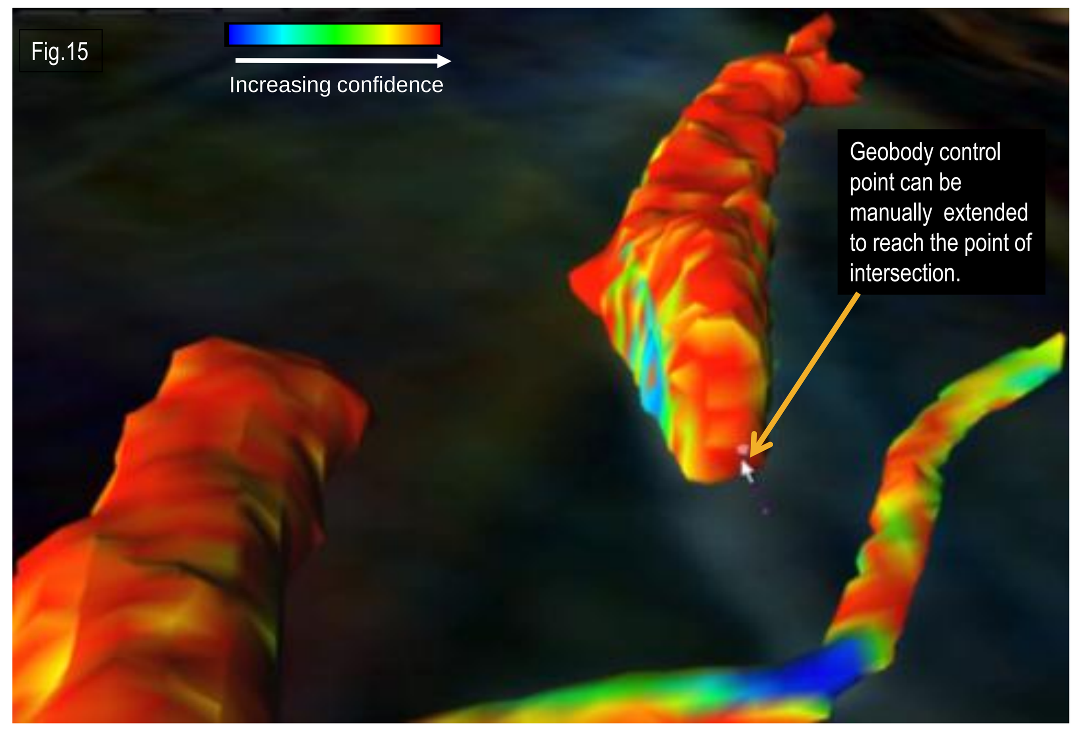

Fig.15

The geobody surface is colour coded blue or green in the area where the geobody surface has been positioned manually as it is less well defined by the data in this region (Fig.16).

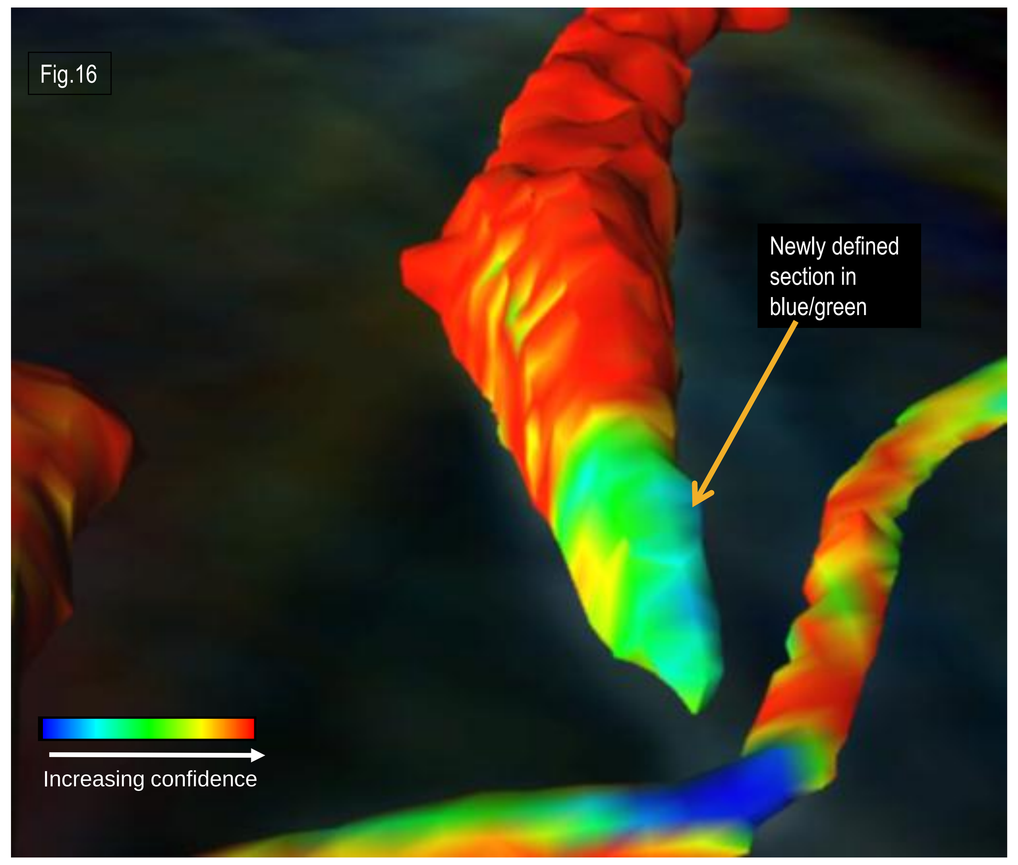

Fig.16

By allowing the interpreter to manually edit the growth of the geobody and also to interactively change parameters while the process of growth is active, this technique makes maximum use of both the available data and expert knowledge of the interpreter.

Application in Channel Delineation

The example in Fig.17 & 18 shows beaches and channel features that have been delineated using the Adaptive Geobodies technique. The features represent a complex system of channels extracted from a RGB blend of three frequency magnitude response volumes which greatly aid interpretation of the depositional environment and reveal additional details of channel structure, overbank deposits and splays.

Extracting a geobody representing these channels would be extremely difficult if not impossible using conventional methods, however with the Adaptive Geobodies technique it is straightforward to define the different, independent elements such as the cross cutting channels .

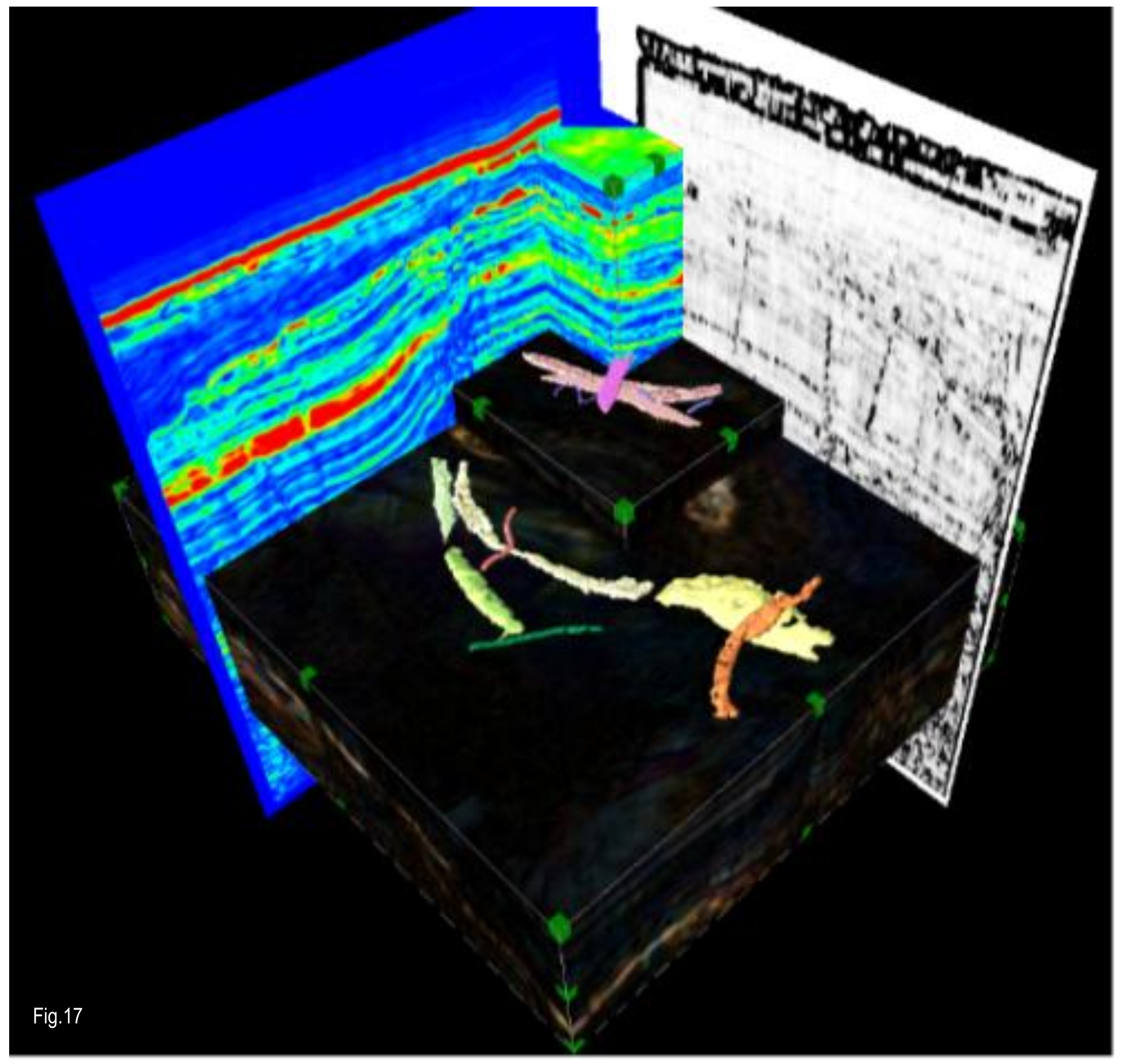
Fig.17

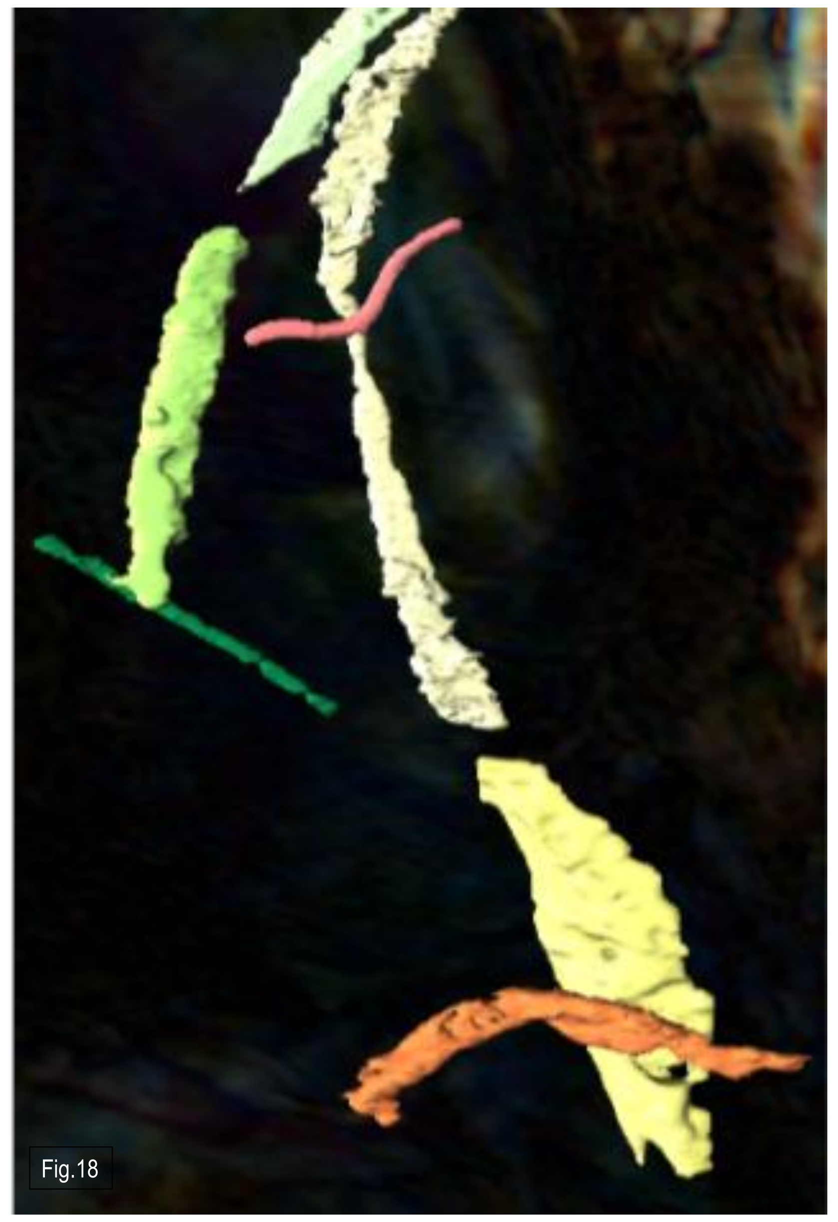
Fig.18

Adaptive Geobodies™: Extraction of complex geobodies from multi-attribute data using a new adaptive technique

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Application in Carbonates

Case study from the Forth Worth Basin, Texas

Here, dissolution of deeper Ellenburger carbonates caused the later collapse of overlying sediments, forming collapse columns. These columns have been seen to cause compartmentalisation in the overlying productive conglomerate zone (Fig.19).

The objective here was to define the relationship between the collapse features, the underlying cavern system and the surrounding and capping carbonate build ups. Each of these elements have a different seismic response associated with it. This requires each element to be built separately into a 3D geobody.

A unique strength of the Adaptive Geobodies technique is that it enables information contained in the data to be combined with the expertise of the interpreter.

The different elements have been delineated using the Adaptive Geobodies technique (Figs.20 to 22).

The relationship between the underlying cave system caused by dissolution and the collapse chimneys above the caves was examined by creating individual geobodies representing the different elements. The top build up horizon was also delineated using the adaptive geobodies technique (Fig.22).

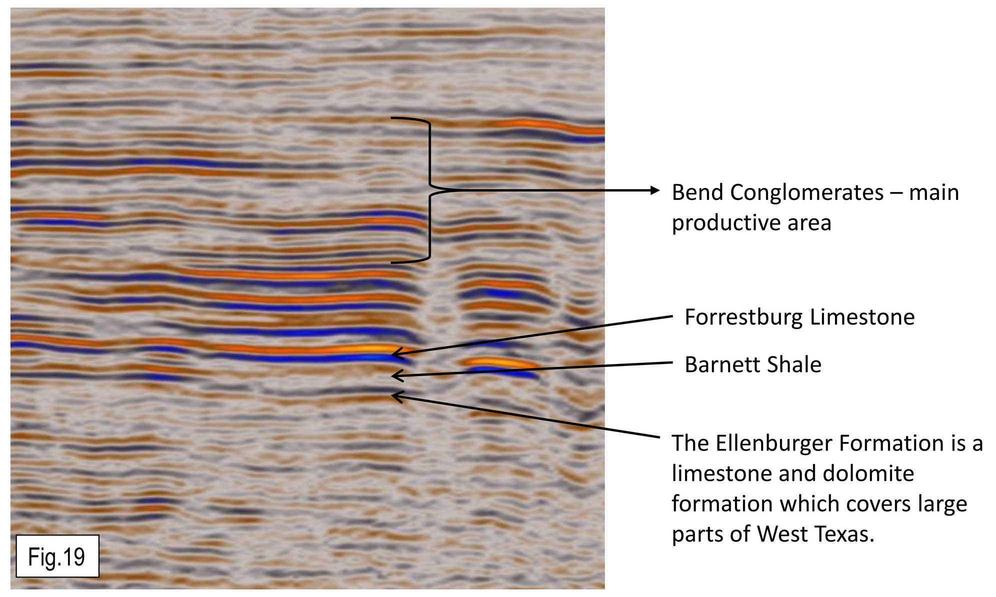


Fig.19

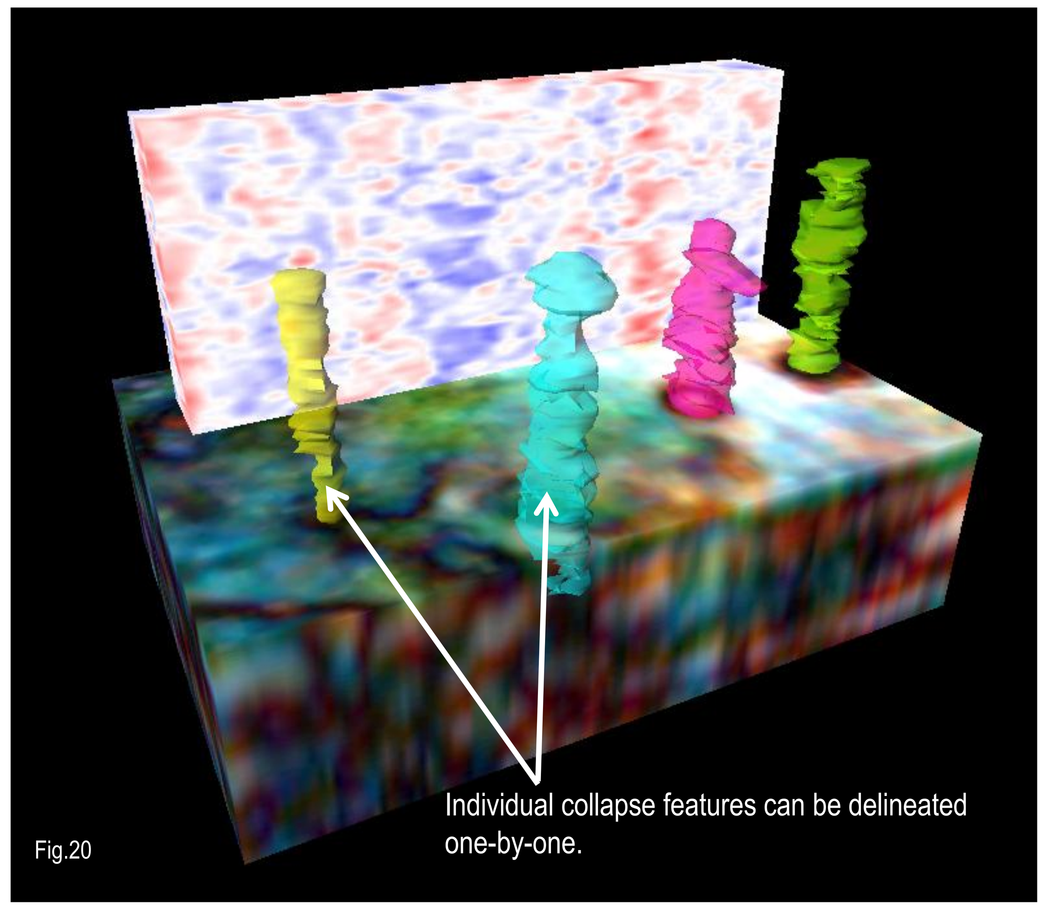


Fig.20

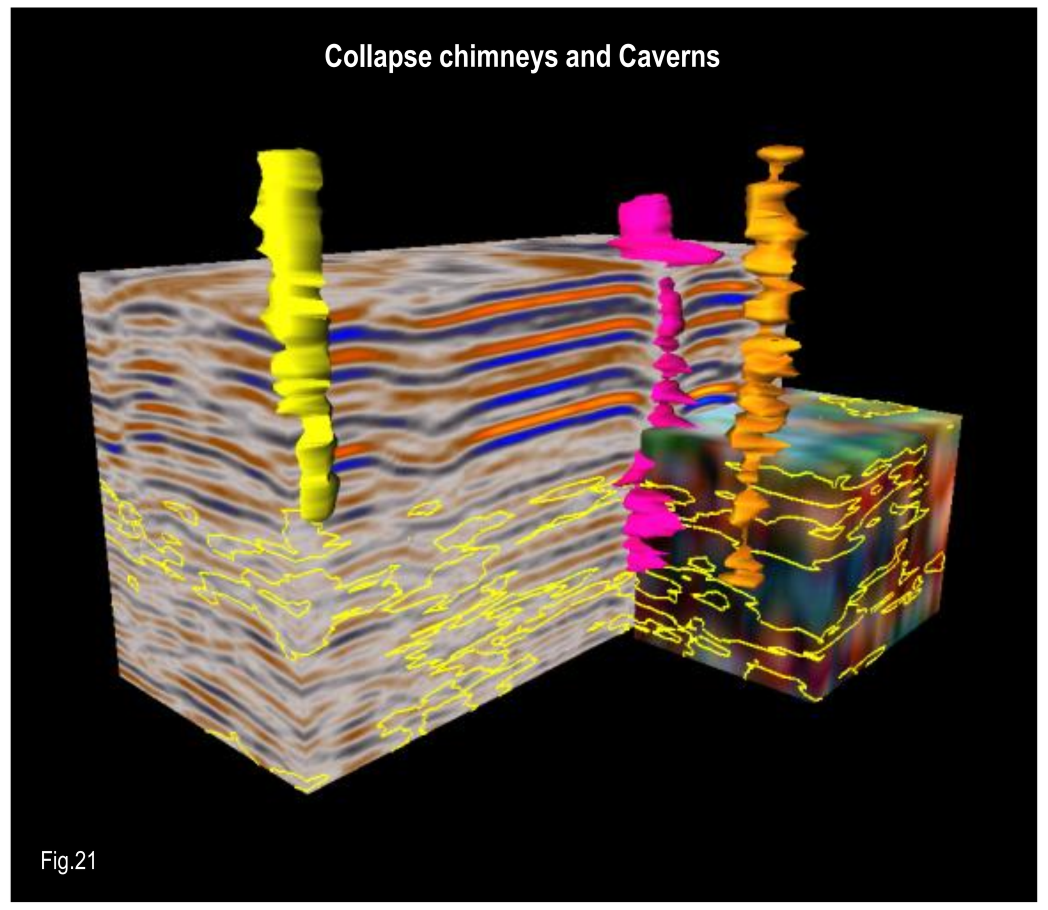


Fig.21

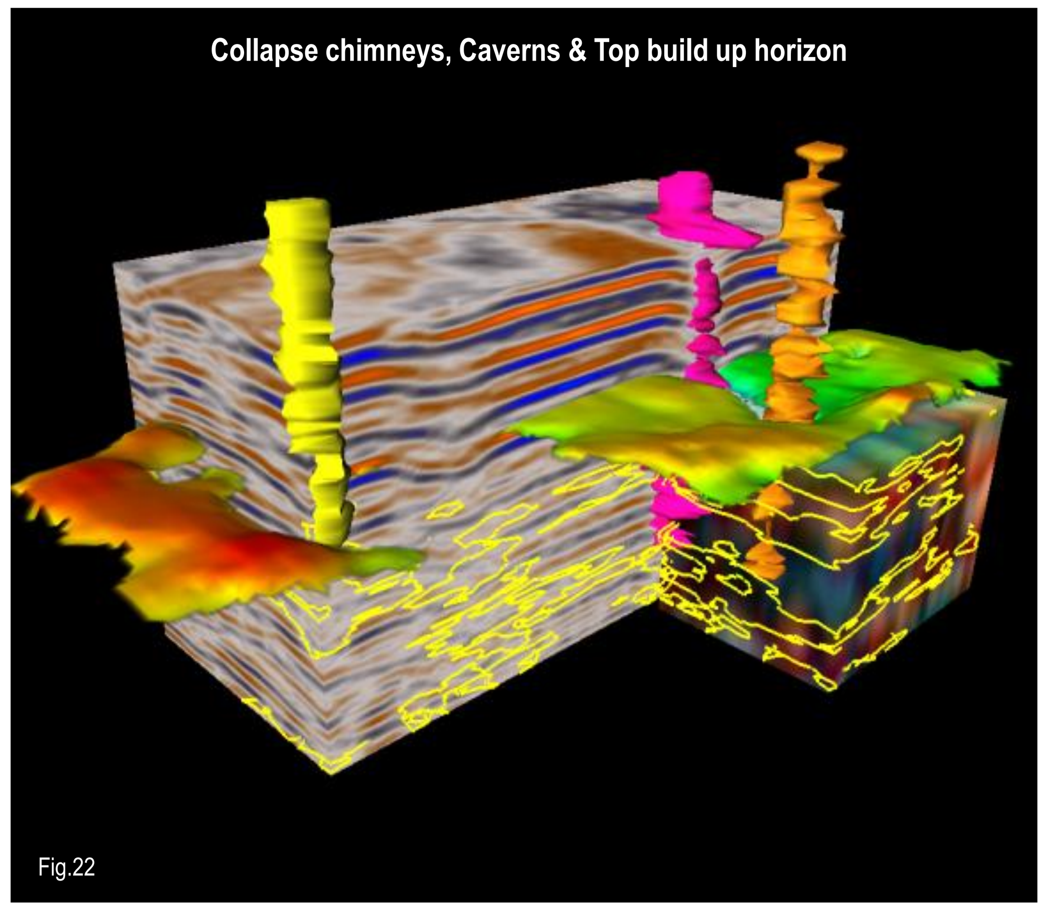


Fig.22

Application in Salt Delineation

The Adaptive Geobodies technique has been found to be successful in the delineation of salt features. In this example a salt diapir has been extracted using data characteristics from two attributes, instantaneous amplitude and chaos. The extraction was based on a several seed points within the salt feature (Fig.23) and took just a couple of minutes to grow.

In this case the two attributes are not blended or co-visualised but the Adaptive Geobodies can use the data from both without the need for the interpreter to pre-process or work out how to combine the attributes into a single volume. The geobody can be watched as it grows and edited if neccessary (Fig.24).

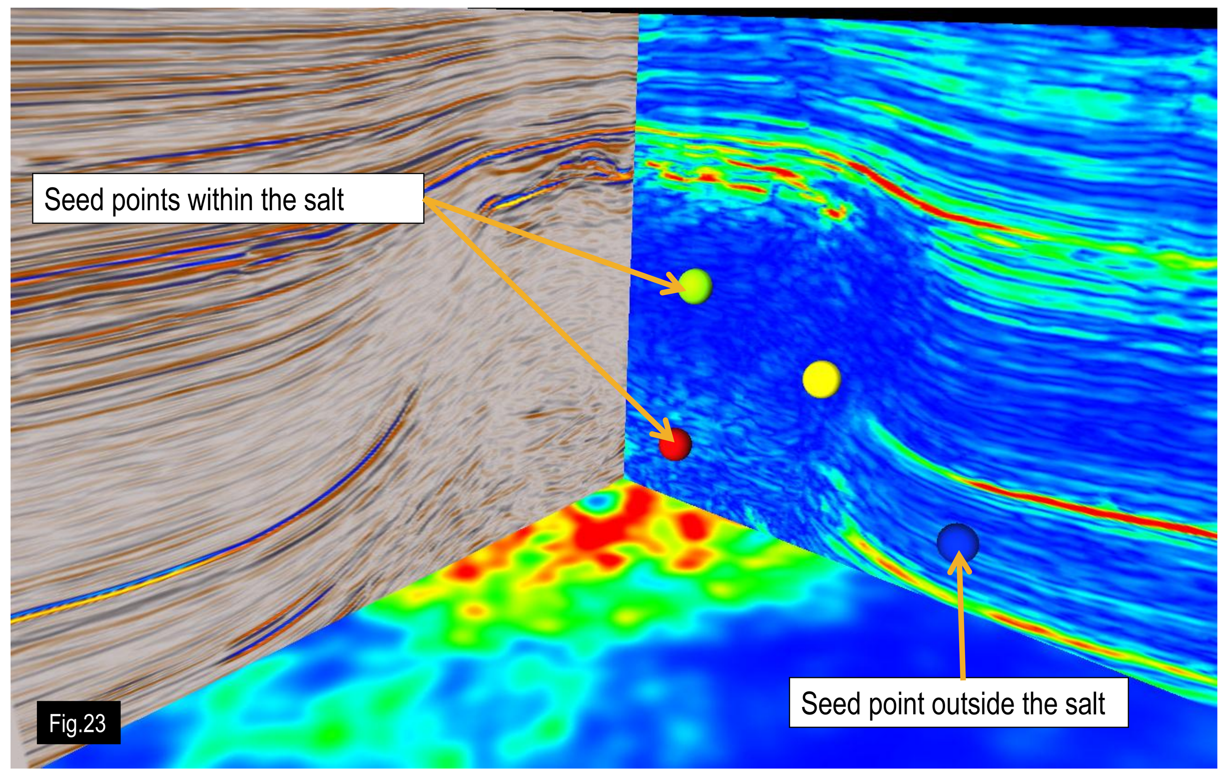


Fig.23

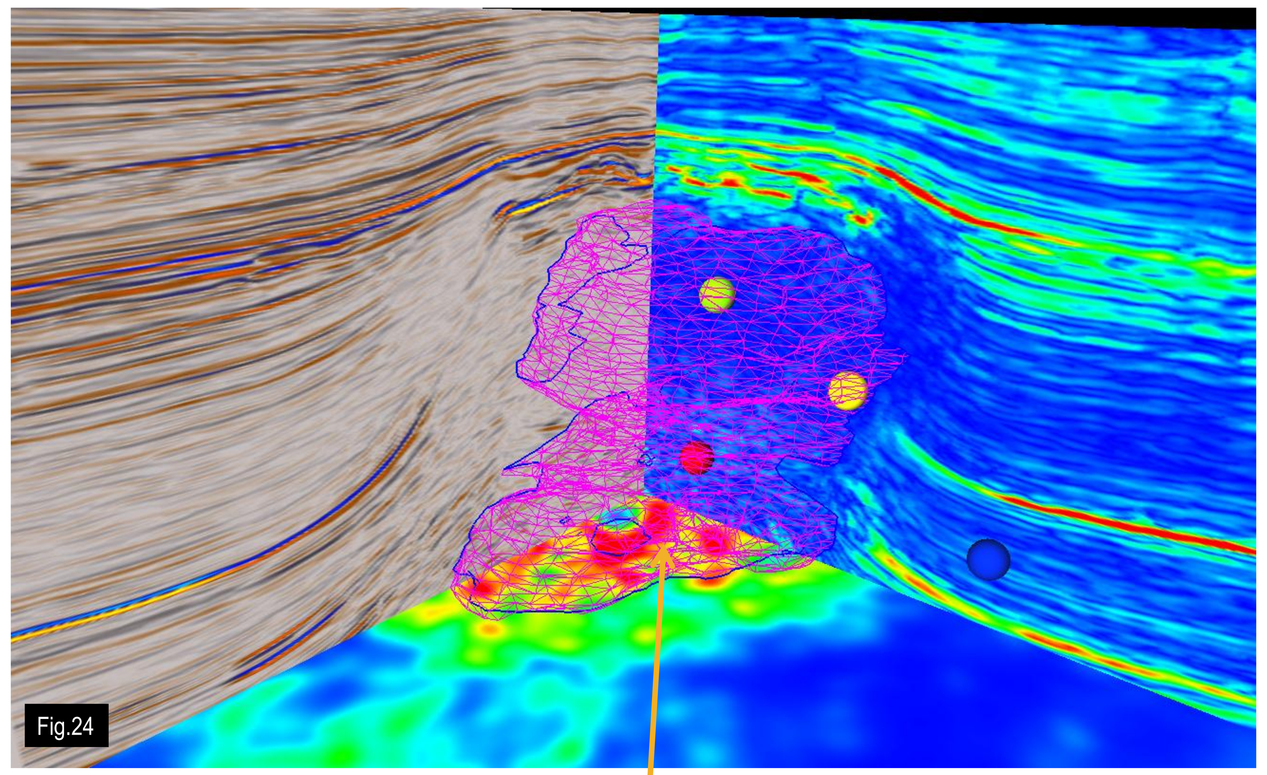


Fig.24

Geobody can be seen growing and stopped if need be or edited.

Application in Salt Interpretation

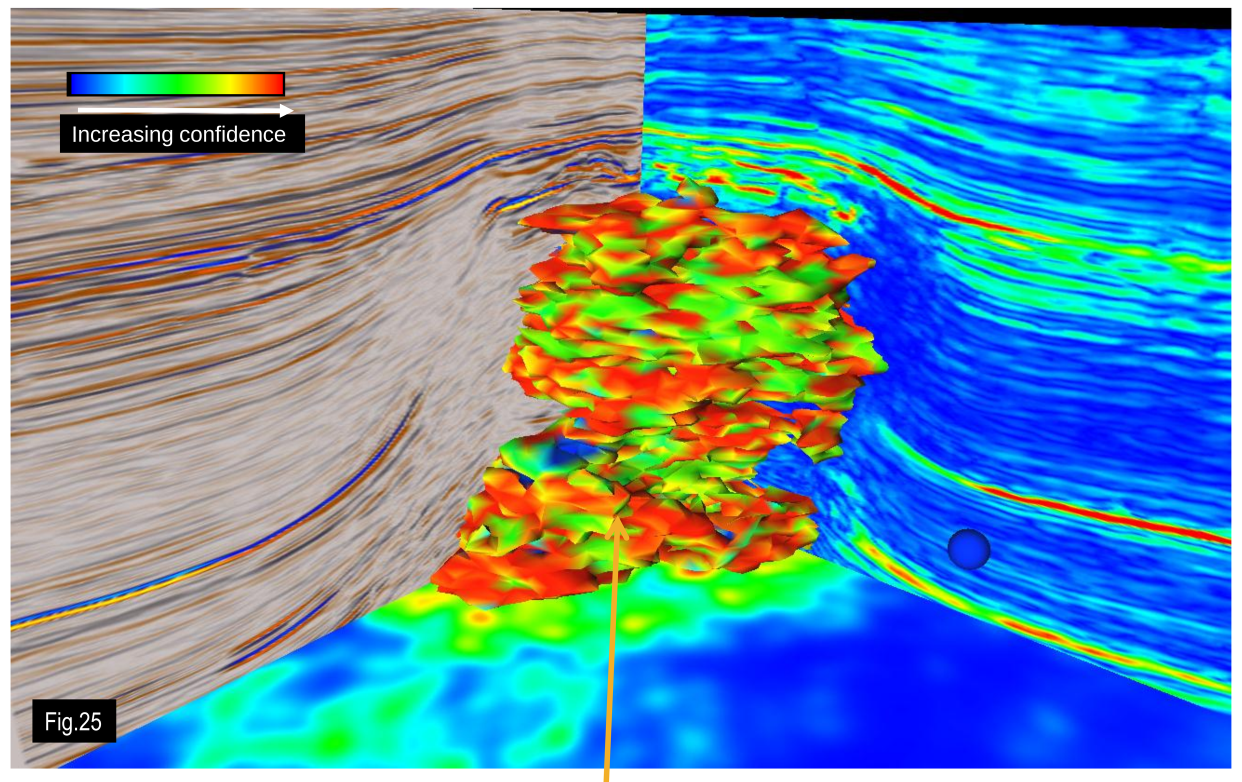


Fig.25

Geobody displayed with confidence values

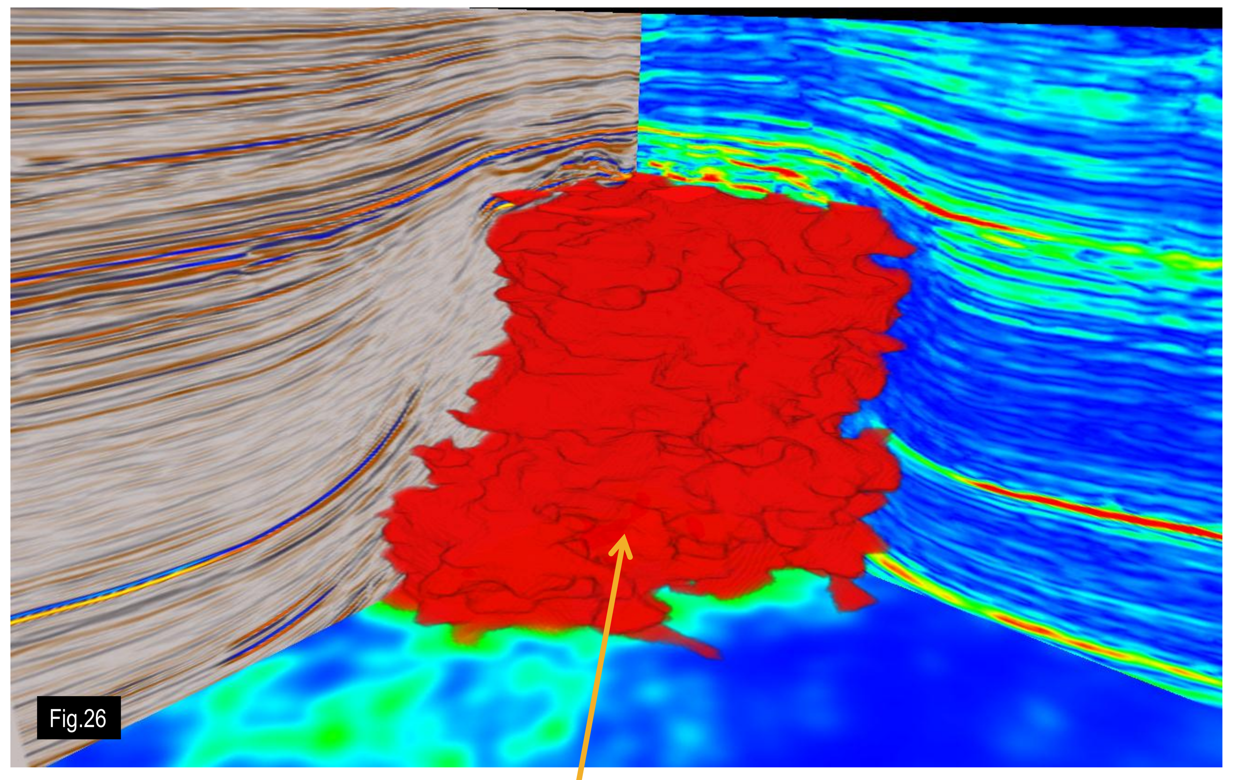


Fig.26

Geobody displayed as a binary volume can serve as input to modelling applications.

Application in Horizon Interpretation

Although the technology was designed for 3D geobody delineation, as shown in the previous examples, the Adaptive Geobodies technology is also showing great potential as an auto-tracker which can be used to define surfaces from attributes or multi-attribute blend data as well as conventional reflectivity data (Figs. 27& 28)

Therefore the same technology has the potential to be used to define layered systems and major sequence boundaries as well as non-conformant structures such as channels, chimneys, salt bodies, dissolution features and intrusives.

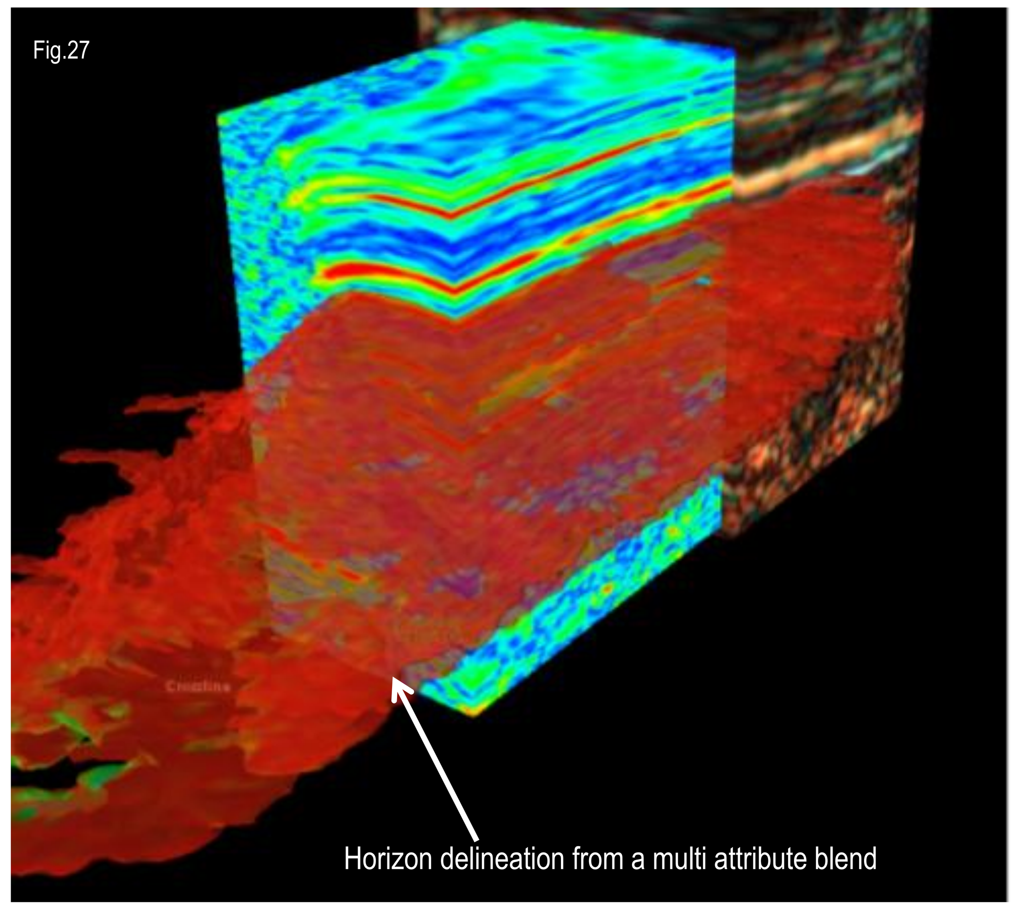


Fig.27

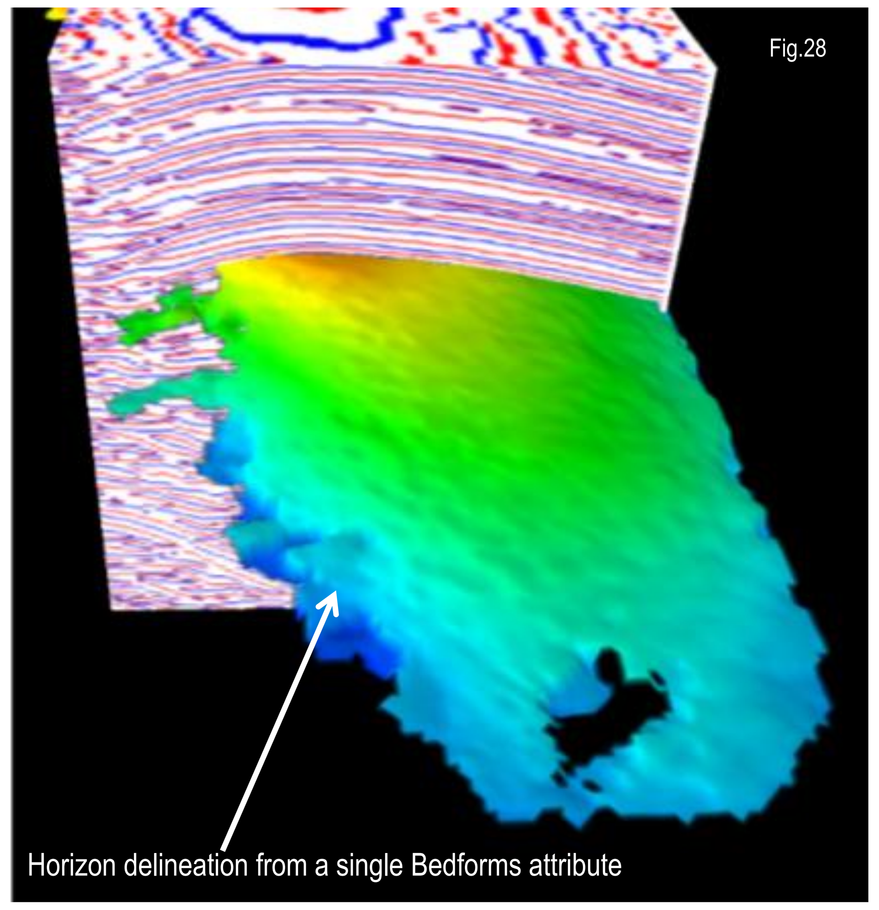
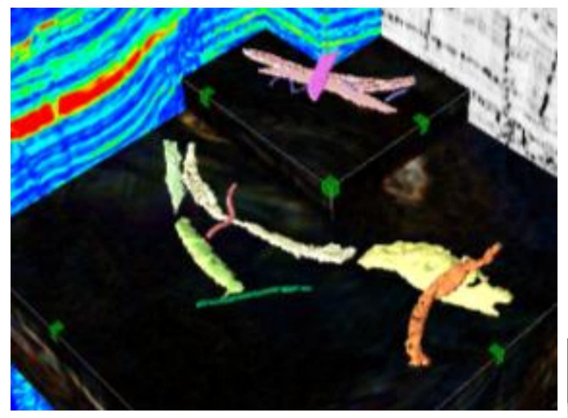


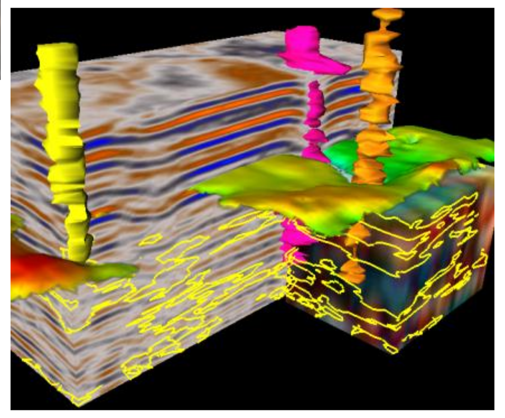
Fig.28

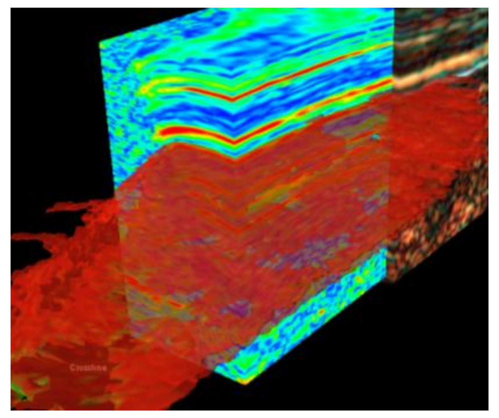
Conclusions

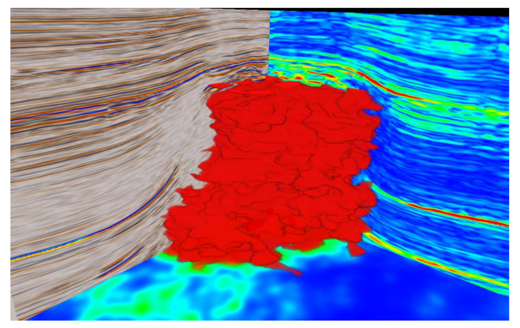
A new system for Geobody Delineation

- Takes into account variation in seismic expression
- Intuitive utilisation of multiple seismic characteristics
- Highly visual and interactive
- Data driven but interpreter guided to give 100% reliability
- Ability to isolate interconnecting elements as individual geobodies.
- Provides indicators of positional and volumetric uncertainty









Acknowledgements

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Fig 26: Image processed on Netherlands **TerraCubeREGRID** ™ data supplied by Fugro Data Services AG