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DEW

THE COMPLETE ENERGY JOURNAL

IN PUBLICATION SINCE 1989

INTERNATIONAL EDITION

Volume 20 Number 08

ISSN - 0971 - 7242

dewjournal.com

June 2011

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Recent developments in seismic interpretation

The importance of detail and integration

Paul de Groot, President and CEO, dGB Earth Sciences

Seismic interpretation technologies have made significant strides over the last few years. Attribute analysis, fault mapping and horizon picking, as well as easy to use and graphics-focused software packages, have all contributed to more geologically consistent 3D representations of the subsurface. Although there are a dazzling array of seismic interpretation technologies available, however there remains a potential weaknesses in seismic interpretation. These can be distilled into two key areas: detail and integration.

Detail and Integration – The Challenges in Seismic Interpretation Today

As operators continue to be faced with the twin challenges of increasing returns from their assets while, at the same time, tackling prospective fields of increasing geological complexity, the last few years have seen the spotlight shone on the effectiveness of seismic interpretation technologies. Such technologies are vital to operators today in reducing risk in their exploration and drilling activities.

Yet are these seismic technologies rising to the challenges in generating ever more insightful information about a subsurface where easy-to find structural traps are often a thing of the past? The answer isn't clear-cut either way.

Certainly seismic interpretation technologies have made significant strides over the last few years. Attribute analysis, fault mapping and horizon picking, as well as easy to use and graphics-focused software packages, have all contributed to more geologically consistent 3D representations of the subsurface. If you were at the European Association of Geoscientists and Engineers (EAGE) annual conference in Vienna this year, for example, it would be difficult not to be impressed with the dazzling array of seismic interpretation technologies on display.

This being said, however, there remain potential weaknesses in seismic interpretation. These can be distilled into two key areas: detail and integration.

Firstly, detail.....for all the technology advances over the last few years, many geological models today still remain highly generalised. Gigabytes of seismic data may well be generated from the target area but the actual data that can be interpreted and provided as input into future drilling decisions is often limited to kilobytes and megabytes. There is an inability for interpreters to understand the full structure of the seismic data and gain a clear picture of the data's depositional history.

Secondly, there is a need for greater integration and a more open-source based approach to seismic interpretation.

Despite all the choices on offer today, there remains a lack of integration between these solutions. There is no unified workflow that bridges the geology, geophysics and reservoir modelling domains, a lack of input from users and a lack of open source applications. Technology advances seem to be dominated by just a few players with any new company, planning to bring their software to market, having to spend the majority of their time building an interpretation system rather than focusing on the software itself!

All too often, users today are faced with the cumbersome and time consuming transfer of SEG-Y files between different applications and an inability to view a complete picture of their target fields through a cross-platform interpretation system

Seismic interpretation solutions today need to work together for the greater good and the ultimate goal of generating maximum information and value from the geological information. They also need to be seamlessly integrated with other applications further along the reservoir lifecycle which enable the seismic interpretation to be incorporated into more production-focused reservoir models.

There is no doubt that the whole is greater than the sum of its parts.

For all these challenges, however, there are still grounds for optimism. This article will look at how dGB Earth Sciences is addressing the challenges of detail and integration in seismic interpretation today.

Building in Greater Detail to Seismic Interpretation – Seismic Stratigraphy, Fluid Migration & Attribute Analysis

So how can one build greater detail into seismic interpretation?

Clearly, there are a number of areas where seismic interpreters can focus, particularly in the areas of seismic stratigraphy, fluid migration and attribute analysis.

dGB's seismic interpretation software, OpendTect and commercial plug-ins, such as OpendTect SSIS (Sequence Stratigraphic Interpretation System), for example, can reconstruct the history of deposition in geological time and cross-correlate events between different wells through the tracking of chronostratigraphic horizons. This results in greater detail, improved seismic facies and lithofacies predictions, and more accurate targeting of reservoir, source rock and seal potential.

The growing emergence of chimney cubes – the vertical noise trails that are generated when hydrocarbons migrate upwards – are also playing a key role in tracking fluid migration and adding greater detail to the seismic interpretation process. Chimney cubes enable the interpreter to follow fluid migration paths from deep thermally mature source rocks into the trap and upwards to the surface, thus generating vital information about the petroleum system.

Through this, chimney probability cubes can be generated for a qualitative measurement of fault leakage and more accurate information on the spatial relationships between faults, chimneys and trap configurations can result in more accurate prospect ranking for the operator.

The increasing sophistication of multi-volume, interactive attribute analysis, today, is also helping operators gain an insight into geological information that would otherwise have been hidden.

To this end, OpendTect users can target and calculate attributes, test attribute parameters, create their own attributes to find the optimal setting for their data, and access filtering and processing capabilities. Furthermore commercial plug-ins, such as dip-steering, improve multi-trace attributes by extracting attribute inputs along reflectors and our neural networks plug-in combines multiple attributes into meta-attributes that can be used for pattern recognition and inversion along well tracks. The result of these advances is greater detail in seismic interpretation today.

Increasing the Mapping and Density of Horizons

Horizons – the term used to denote the surface in or of a rock or a particular layer of rock that might be represented by a reflection in seismic data – are also a key means of incorporating greater detail into seismic interpretation today.

Accurate seismic horizon tracking can guide well correlations, generate an improved insight into the depositional environment, interpret systems tracts, and improve the chances of finding stratigraphic traps. It can also result in a much more detailed model consistent with seismic measurements being put forward for seismic inversion.

It was with this in mind that we launched the full version of OpendTect 4.2 earlier this year with the key feature being a dip-steered auto-tracker, known as the HorizonCube.

Creating a HorizonCube is simple with the user inputting a steering cube, at least two mapped horizons, and mapped fault planes. Horizons are then created either in a model-driven way (through stratal or proportional slicing, for example) or in a data-driven way via a dip-steered, 3D chronostratigraphy auto-tracker.

Figure 1 demonstrates the power of high density horizon tracking for chronostratigraphic correlation. Here, a random line is created from the 3D volume through the wells to facilitate

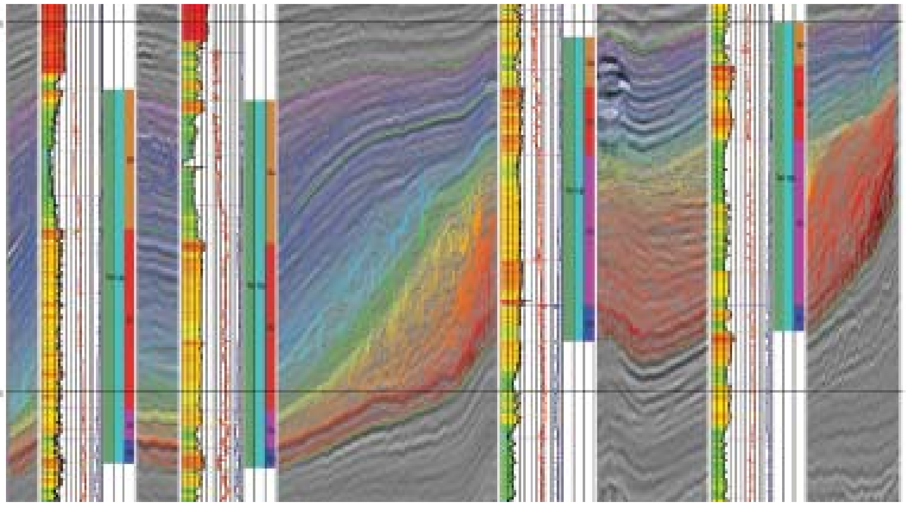

Fig.1

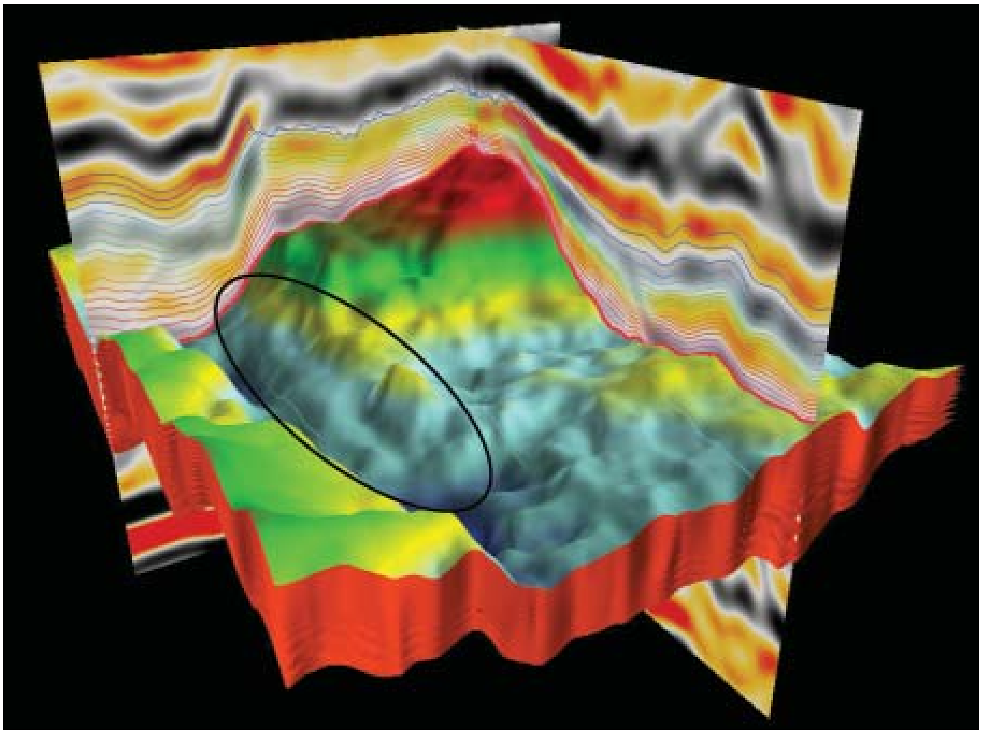

Fig.2

of events which consists of firstly, the incision of a deep channel in older fluvial sediments; secondly a first transgressive channel fill that is subsequently partly eroded again; and thirdly, a second transgressive channel fill

The figure on the right in figure 3 shows the random line along the axis of the incised channel. The figure on the left shows the interpretation overlain on the random line. Here, orange represents the older fluvial section, of which the upper part is eroded. The other colours represent infill of the erosional incisions. Blue represents basal channel fill, green the first channel fill, and yellow the secondary channel fill.

Using this information, one can create a reliable chronostratigraphic framework within the reservoir and estimate where the most favorable rock properties for reservoir, seal or source rock may occur.

correlation and a dense set of horizons is auto tracked. All tracked events are assigned a relative geological age displayed with a corresponding colour with an interactive slider used to add or remove these chronostratigraphic events. In this way, users can isolate depositional elements at any point in the 3D volume, interpret sedimentary elements correctly, and correlate with well logs to create a seismic to well correlation for rock properties.

Figure 2 shows an example of the HorizonCube being applied in a fluvial estuarine depositional system in the Canadian oil sands. The illustration shows a set of horizons from the 3D 'cube' of horizons. The black circle indicates the deep incised channel that is the focus of the interpretation.

A section with an interpretation created from the HorizonCube from the same Canadian field is shown in Figure 3, illustrating the likely order

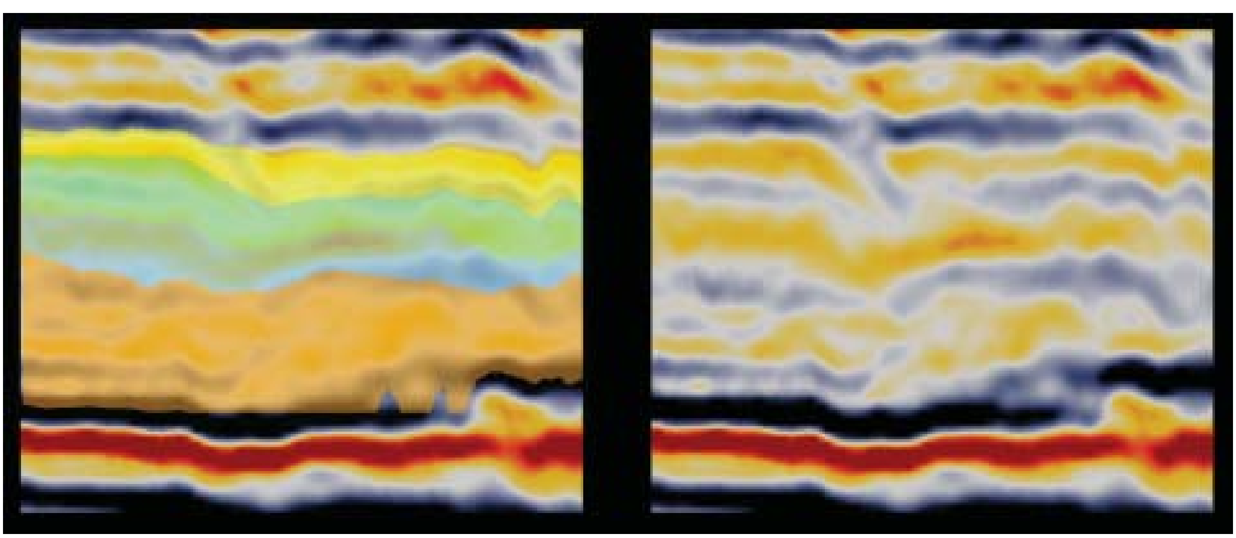

Fig.3

What one is seeing here is how seismic interpretation software is generating improved quantitative rock property estimations, clearer definitions of stratigraphic traps, and more accurate and robust geological models. The result is greater detail in seismic interpretation today.

Improving Integration in Seismic Interpretation

The second key challenge mentioned in this article is that of improving integration in seismic interpretation. Again, dGB is leading from the front through its open source interpretation software, OpendTect.

OpendTect, which was first made available in 2003 and which came under the General Public License (GPL) in 2009, is free and provides users with a truly open platform for seismic interpretation. OpendTect has had over 55,000 downloads as of May 20th 2011.

While supplemented by a variety of commercial plug-ins related to specialist areas, such as sequence stratigraphy, fluid migration, and rock property predictions, OpendTect contains all the features and tools the majority of geophysicists and seismic interpreters require for carrying out highly sophisticated interpretations.

There are a number of key benefits to this open source approach.

The open source software of OpendTect provides the ideal platform for other oilfield services companies to develop their own interpretation tools. UK-based seismic geophysics specialists, ARK CLS, for example, have developed seismic spectral blueing (SSB) and seismic coloured inversion (SCI) plug-ins for the OpendTect software. The tools allow users to shape the spectra of seismic data to be consistent with the Earth's reflectivity (SSB) as well as providing a fast track method for the inversion of seismic data (SCI).

Outside the commercial world, dGB is also working with the geoscientists of the future to enable academic students to deploy their ideas and new techniques within a professional seismic interpretation environment. To date, dGB has established relationships with over 220 universities worldwide dispensing well over 1,750 free licenses of its commercial plug-ins which link into OpendTect. Through the sharing of ideas (and source code), people can be inspired and better interpretation technologies generated.

As a means of fostering greater integration and a seamless workflow, dGB also recently announced a direct data link between OpendTect and the Petrel* seismic to simulation software using the Ocean* software development framework.

The OpendTect Connector Plug-In for Petrel software (see figure 4),

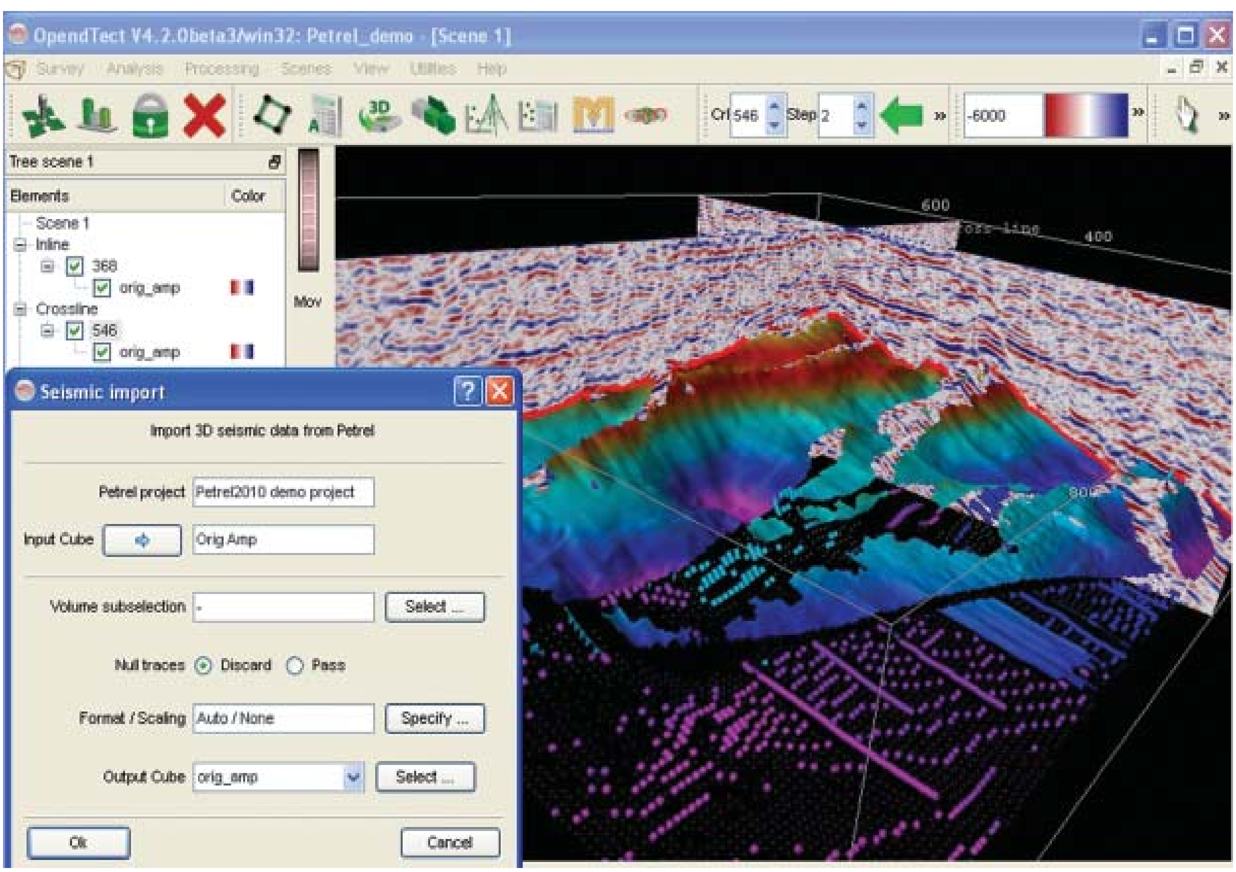

Fig.4

developed by ARK CLS, will provide the Petrel user community with access to all OpendTect's industry commercial plug-ins. 3D horizons, including time/depth horizons, and high quality attribute volumes generated by OpendTect, can all be incorporated into Petrel software, enabling users to build robust reservoir models, maximize their geological data, and bridge the gap between seismic quantitative interpretation and more production-focused reservoir models.

And in all cases, interpreters will be able to seamlessly export and import seismic data between the Petrel workflow manager and OpendTect with no need to move separate SEG-Y files back and forth between applications as was described previously.

The result will be a capitalising on the best features of both systems – the powerful seismic interpretation tools of OpendTect alongside the mainstream interpretation and modelling capabilities of Petrel software. It will also lead to a seamless workflow from the acquisition and interpretation of seismic data through to reservoir modelling and simulation.

For all the potential limitations in seismic interpretation today, it's encouraging to see that progress is being made both in building greater detail into seismic interpretation and ensuring a more integrated and seamless seismic interpretation workflow that covers geology, geophysics and reservoir modelling.

By knowing the complete structure of their reservoir data and by utilising the best features of a plethora of different software packages, seismic interpreters will be able to generate more geological information from seismic than ever before and reduce risk in their drilling and exploration operations. dewjournal.com

about the author

Paul de Groot is President & CEO of dGB. He worked ten years for Shell where he served in various technical and management positions. Paul subsequently worked four years as a senior research geophysicist for TNO Institute of Applied Geosciences before co-founding dGB in 1995. He has authored many papers covering a wide range of geophysical topics and co-authored a patent on seismic object detection. Together with Fred Aminzadeh, Paul wrote a book on Soft Computing techniques in the Oil Industry. Paul holds MSc and PhD degrees in geophysics from Delft University of Technology.