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Rising to the challenge

Improved Rock Property Predictions

Conventional Workflow

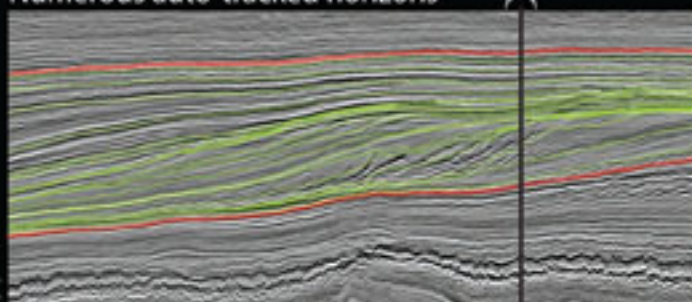
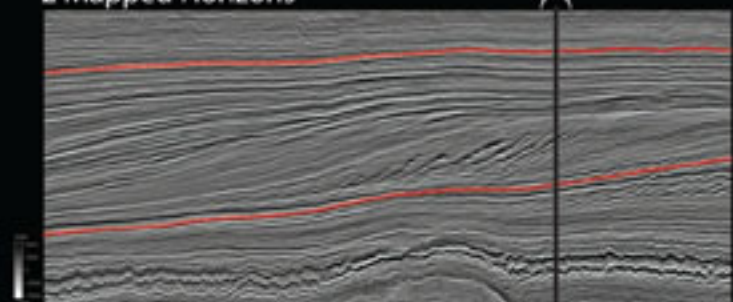
Horizon Cube Workflow

Blind Well

Blind Well

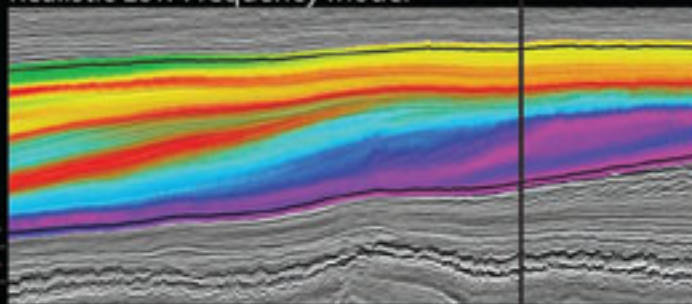
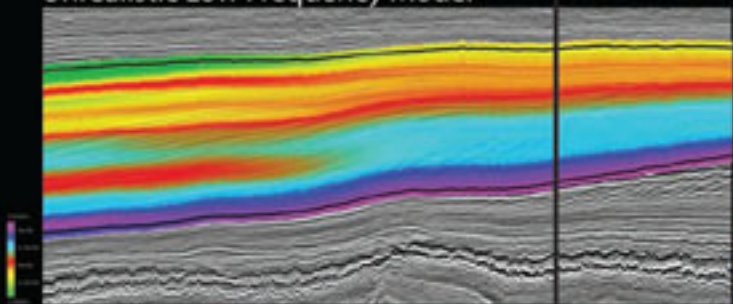
2 Mapped Horizons

Numerous auto-tracked horizons



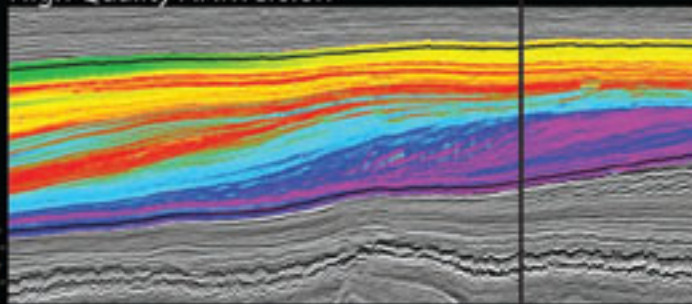
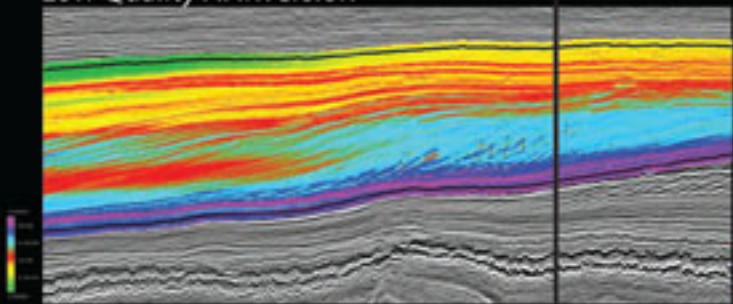
Unrealistic Low Frequency Model

Realistic Low Frequency Model



Low Quality AI Inversion

High Quality AI Inversion



Maximizing value of Geological Data

Maximizing the value of your Geological Data

Paul de Groot, President and CEO, dGB Earth Sciences

One of the single biggest challenges in seismic interpretation today is maximizing the value of geological data. While seismic interpretation technologies have improved dramatically over the last few years in their ability to predict rock types (sand, shale, carbonate, salt), rock properties (porosity) and fluid types (oil, gas, water) and develop geologically consistent 3D representations of the subsurface, too often operators remain dependent on highly generalised geological models as an input into their decision-making. There's no doubt that gigabytes of data are being generated, yet how much of this is accurate interpreted data that can play a major role in field development or prospect ranking decisions, for example? How effective is seismic interpretation today in meeting the ultimate goal of obtaining better insight into the petroleum system and reducing risk prior to drilling? In my view, it's only through improved attribute analysis, an increase in the number and density of mapped horizons, and the ability to conduct low frequency model building that more closely honours the seismic, that E&P operators can genuinely claim that they are getting the most out of their geological data. Furthermore, there is also extra pressure on seismic interpreters to deliver ever more enhanced editing and visualization features. Let's take a look at these areas in more detail.

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Let's take a look at these areas in more detail.

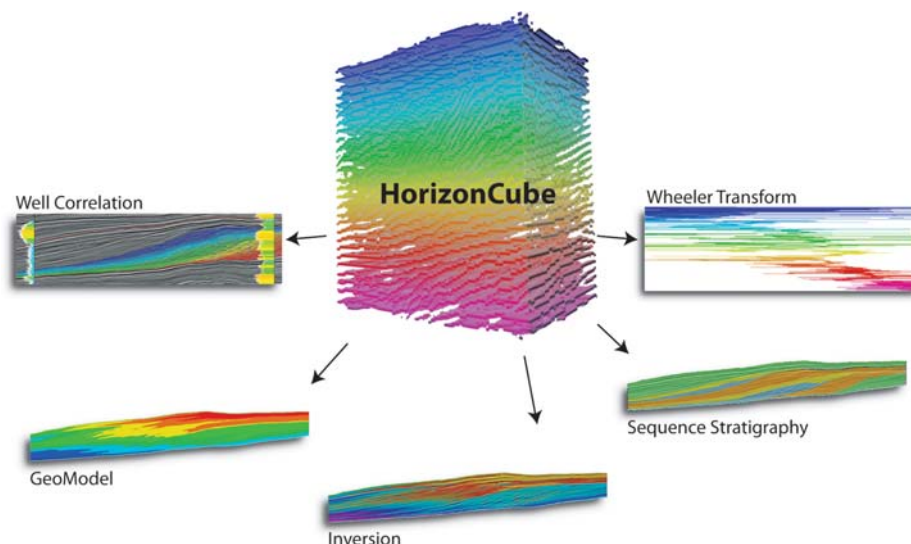
Advances in Attribute Analysis

Attributes today are an integral part of the seismic interpretation process, revealing otherwise hidden geological information and allowing relevant information to be extracted for integration purposes. They play an important role at every stage of the E&P cycle from horizon tracking through to supporting advanced 4D interpretation. Recent developments include 3D attribute extraction, cross plotting, multi-attribute analysis, and enhanced visualization.

As attribute analysis has advanced, however, so has the need for software that supports multi-volume and interactive analysis and that comes with new interpretation capabilities.

This is what we are achieving with our software OpendTect, the only available open source seismic interpretation platform used in the oil & gas industry today. With a powerful attribute engine that supports sophisticated multi-volume, interactive analysis, users can target and calculate attributes on the fly, test attribute parameters (frequency, time gate or step out) within a highly visual environment, and create their own attributes to find the optimal settings for their data.

In addition, we have also developed a number of commercial plugins for OpendTect. For example, we have improved multi-trace attributes by extracting attribute inputs along reflectors. In this way, the interpreter can calculate unique attributes, such as dip &



azimuth, volume-curvature, and variance of the dip. Our neural network plugin also combines multiple attributes into meta-attributes which are used for pattern recognition and inversion along well tracks.

The result is highly detailed and sophisticated attribute analysis.

Increasing the Number and Density of Horizons

One of the reasons for the generalized geological models we spoke about earlier in the article is the limited number of key horizons that are mapped as part of conventional interpretation workflows.

An improvement in interpretation can be achieved, however, by greatly increasing the number of mapped horizons. This can increase the potential of high resolution seismic in reservoir characterization, leading to improved

quantitative rock property estimation, an enhanced definition of stratigraphic traps, and more accurate, robust geological models.

That is the reasoning behind our new HorizonCube plugin, part of our latest version of OpendTect (OpendTect 4.2), which, through a series of semi-automated techniques, can greatly increase the number of mapped horizons. *Figure 1* outlines the process behind the HorizonCube and the areas it has an impact on.

HorizonCube consists of a dense set of correlated 3D stratigraphic surfaces that are assigned a relative geological age with a corresponding colour. Our second generation 3D auto-tracker algorithm tracks the dip/azimuth field to generate horizons that are typically separated by one sample at the starting position. Optionally, the user can smooth the dip-field and thus reduce the impact of random noise.

An advantage of dip-steered auto-tracking is that dip fields are more continuous than amplitude fields. This is as opposed to conventional auto-trackers that pick amplitudes and which lead to a set of patchy horizons rather than a set of continuous, chronologically consistent horizons.

With HorizonCube, users can interactively reconstruct the depositional history in geological time

using the HorizonCube slider, flatten seismic data in the Wheeler domain, and make full system tracts interpretations with automatic stratigraphic surface identification and base-level reconstruction.

Well correlation can also be enhanced with the seismic interpreter able to view in detail how events are correlated between the wells and how rock properties vary laterally.

The example in *figure 2* demonstrates the power of high density horizon tracking for chronostratigraphic

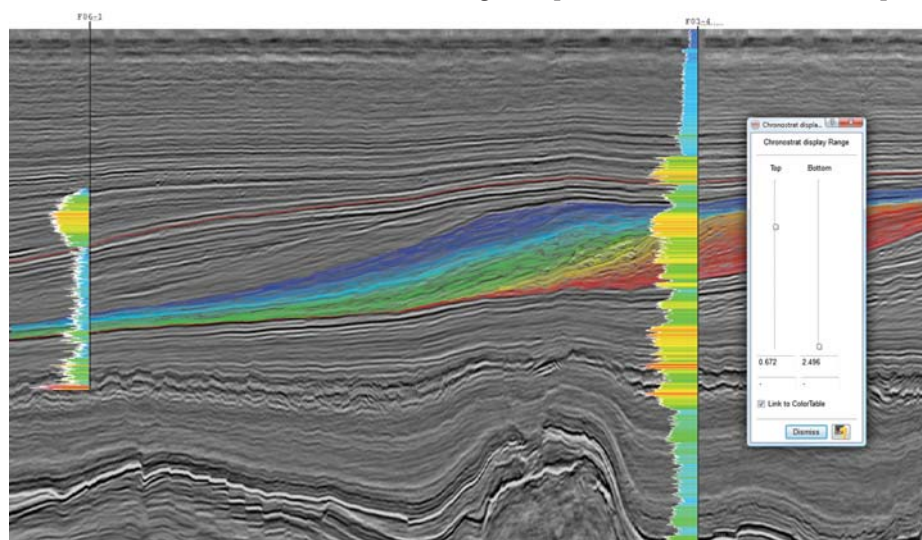
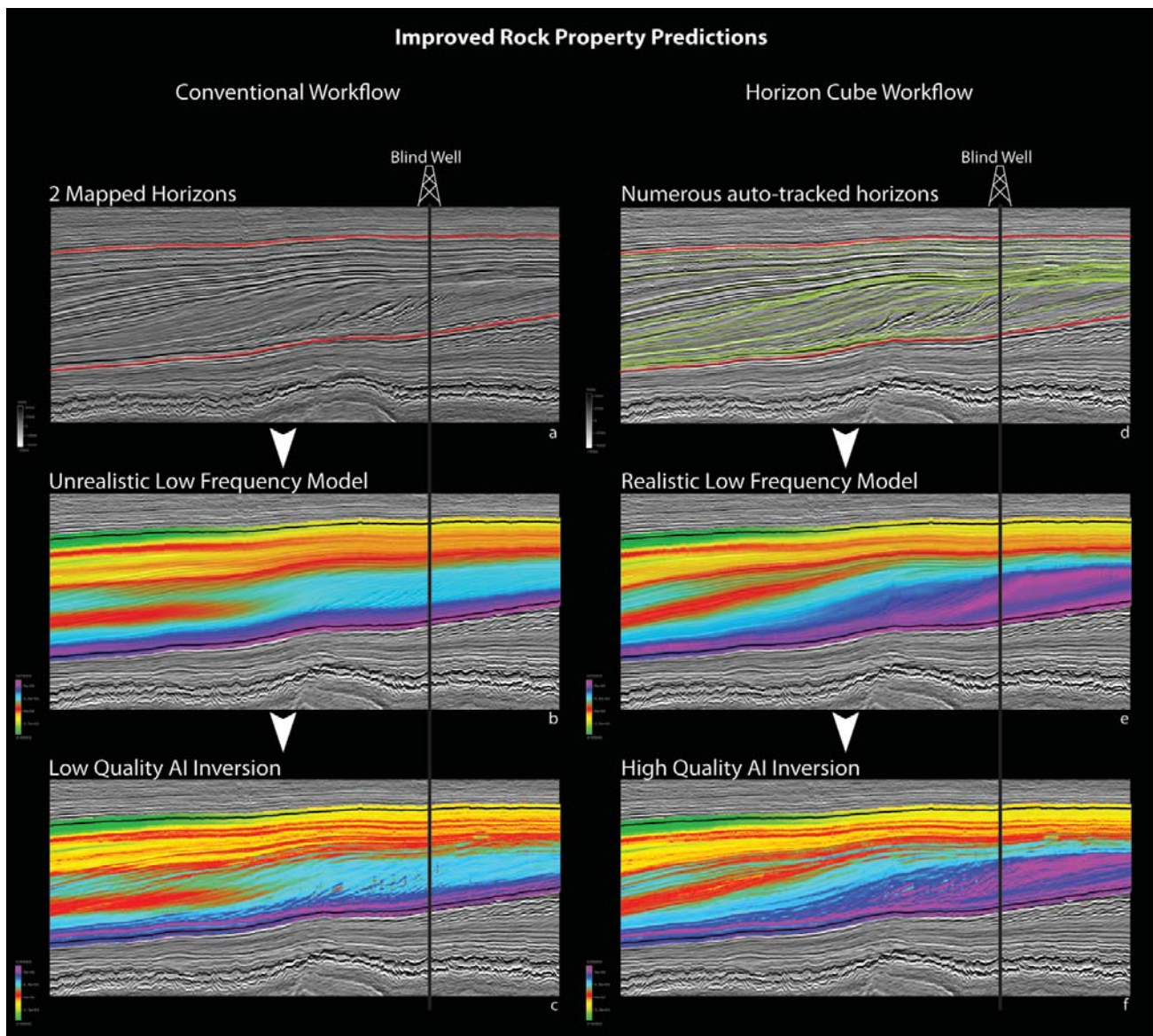


Figure 2 - A random line through two wells showing gamma-ray logs and densely tracked chronostratigraphic horizons. The color-coding indicates relative geologic age. The chronostrat slider on the right is used to interactively correlate chronostratigraphic sequences of interest.



correlation and rock property prediction. To facilitate correlation, a random line through the wells is created from the 3D volume, and a dense set of horizons is autotracked. All tracked events are assigned a relative geological age displayed with a corresponding color with an interactive slider used to add or remove these chronostratigraphic events.

This enables the interpreter to reveal the spatial evolution of the sedimentary succession by visually moving forwards and backwards in geological time. The process highlights in detail how events are correlated between the wells and aids in the understanding of how rock properties vary laterally. For example, the sandy shelf-edge facies observed in the right well correlates with a shaly, toe-of-slope facies in the well on the left.

Improved Low Frequency Model Building

While originally designed for the sequence stratigraphy domain, HorizonCube today has applications across the entire interpretation workflow – particularly in the ability to generate more accurate and detailed low frequency models than was previously the case.

The greater the number of horizons, the greater accuracy in the Acoustic Impedance (AI) and Elastic Impedance (EI) inversion results and the generation of a high resolution model which more faithfully honours the seismic. The result is a model that is the cornerstone of the seismic interpretation process with better seismic predictions and more accurate input into reservoir management decision-making.

Figure 3 is an illustration of an AI inversion experiment with two different low frequency model

inputs. The simple model uses only top and bottom horizons to guide the well interpolations (a). The detailed model uses 19 additional horizons (d). The simple low-frequency model (b) does not fully honour the seismic while the detailed model does. The inverted results which are driven by the input models reflect these differences (c & f).

As one can see, the difference in detail between the conventional workflow and HorizonCube is significant.

Other Features of OpendTect 4.2

HorizonCube is just one - albeit an important element - of OpendTect 4.2. Other improved visualization and editing features are also key to maximizing the value of the geological data.

For example, the new version of the software comes with significant new cross plotting features, including the ability to predict rock properties by cross plotting colour-coded well logs and attributes; a colour density plot workflow which predicts the relationships between the seismic volumes and well properties; and the creation of Probability Density Functions (PDFs) in the cross plot domain which can then be applied to create rock property probability volumes. All these features provide important tools to seismic interpreters in their quest for maximum value.

OpendTect 4.2 also comes with improved visualization and editing capabilities with an enhanced 2D Viewer with added tree, horizon and fault tracking capabilities. This allows for smooth 3D auto-tracking within fault-blocks and 3D horizon tracking that can be bound to fault compartments. Interactive fault construction can also take place using fault sticksets, a set of sticks for fault interpretation. Gridding can also take place within OpendTect 4.2 using Generic Mapping Tools (GMT).

The Move Away from Mouse Clicks

As you can see, seismic data interpretation today is carried out with highly specialized software. It also takes

place on high-end and modern seismic interpretation workstations - high-end PC's or Linux-based computers with multiple CPU's, huge and fast disk storage, lots of RAM and two or more, large high-definition monitors.

Despite these advances, however, a large part of seismic interpretation work today still consists of the manual picking, drawing, mapping and editing of automated results, depending on the data quality and geologic setting. In short, seismic interpretation software is still driven by mouse-clicks.

It's with this in mind that we at dGB Earth Sciences have teamed up with Japanese company Wacom, the world's leading manufacturer of pen tablets, interactive pen displays, and digital interface solutions, where OpendTect and our software workflows will support their products.

We believe that this development will usher in a new era for seismic interpreters where they can draw horizons, faults and objects within a highly user-friendly and graphics-focused environment.

For example Wacom's Cintiq 21UX interactive pen display, which is traditionally used in the digital photography, graphic design, illustration and fashion design industries, will help seismic interpreters use optimal hand-eye coordination and the pen to interact directly with the tablet in their editing and visualization processes.

Benefits include natural, intuitive working with optimal hand-eye coordination, a completely flat display surface for natural arm movements, touch strips for scrolling and zooming located on the backside for easy adjustment and reach, and a 21.3" TFT display with high resolution.

It is developments, such as these, that play a crucial role in maximizing geological data.

The Importance of Integration and the Peer Review Process

Finally, there are the important issues of integration and peer review and the roles they play in maximizing

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geological data.

Seismic interpretation today has applications across the entire reservoir management workflow. An accurate workflow and integration with other data sources ensures that best practices are disseminated, provides a sound basis for uncertainty assessments and asset integrity management decisions, and ensures that the value of geological data is maximized.

In summary, there needs to be a seamless workflow between seismic acquisition and interpretation, the building of reservoir modeling, and reservoir simulation and history matching that can help determine the key characteristics of the reservoirs.

With this in mind, it has been particularly important to dGB that our seismic interpretation has an integrated workflow which covers not only geology and geophysics applications, but that can be fed into future reservoir models and reservoir management decision-making.

To this end, OpendTect comes with the ability to post data in Google Earth and translate GUI text using Google Translate – an important tool in OpendTect's applicability across the world.

Furthermore, the fact that our OpendTect software is open source ensures that it is easy to integrate with other applications as well as being subject to continuous peer review.

Since Sept 1st 2009, OpendTect has been downloaded over 36,000 times direct from our web site. We have also dispensed over 1,000 free licenses to 200 universities worldwide - a truly global list which includes 58 universities in Europe, 12 in the Middle East, 27 in Africa, 28 in Asia, 10 in the Asia Pacific region, and 43 in the Americas.

One of the most recent donations was to the University of Pittsburgh's Bradford's Petroleum Technology program, where students will use the software to interpret seismic data on oil and gas reserves in Pennsylvania – in particular the Marcellus Shale. The Shale contains largely untapped natural gas reserves and is of special interest to operators, particularly due to its proximity to the high energy demand markets of the Eastern United States.

In all these cases, the universities have benefitted

from having access to industry leading seismic interpretation tools and we have benefitted from a continuous feedback process as we look to maximize the value of geological data.

Some oilfield services companies have also taken the open source code of OpendTect and developed their own commercial plugins – something we actively encourage.

For example, UK-based seismic geophysics specialists, ARKCLS have developed a seismic spectral blueing and seismic coloured inversion plugins for our software as well as a workstation access plugin which supports direct import and export from Landmark's SeisWorks/OpenWorks and Schlumberger's GeoFrame-IESX data stores.

This is an example of how through integration with other software packages and workflows and through a constant feedback process, we can continue to ensure that seismic interpretation meets the needs of today's operators.

Rising to the Challenge

Where are the targets that I need to drill? Will I find oil, gas or water? How can we avoid drilling hazards and how many hydrocarbons are trapped and are they sufficient to make the field economic? These are just some of the questions operators need answers to as they seek to maximize the value of their interpretation data.

Recent developments demonstrate that we are rising to the challenge! 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.