Advanced interpretation systems for deeper insight into hydrocarbon prospects

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3D seismic surveying provides rich and varied information about the subsurface environment. This robust remote sensing method has enabled the oil and gas industry to map subsurface geological structures, predict lateral changes in depositional facies, and estimate lithological and pore fluid variations. Of particular interest is the mapping and identification of stratigraphic architectural elements within macro-scale depositional systems. A clear understanding of reservoir stratigraphy and facies distribution can validate (or negate) the presence of a quality reservoir at a prospective location.

The primary investigator of these data, the seismic interpreter, is tasked with extracting geologically meaningful information from seismic volumes which may cover hundreds to thousands of square kilometres. In the case of stratigraphic interpretation – a key approach in understanding depositional environments, reservoir facies distribution, and fluid migration pathways – modern 3D seismic data can provide subsurface images with a resolution approaching that of aerial photography.

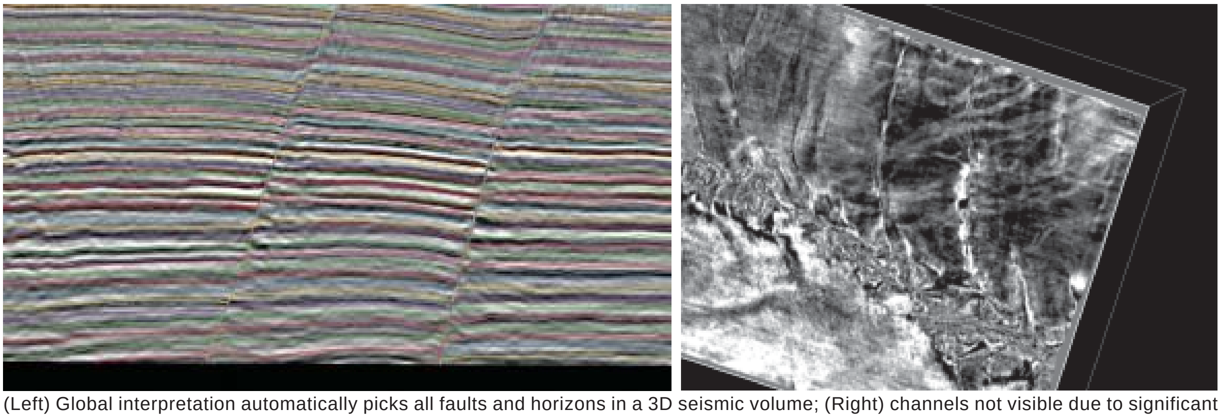
Once the seismic data have been acquired and processed, the interpreter is then faced with identifying prospective hydrocarbon reservoirs in a 3D seismic volume. Consider that a moderately sized 3D survey contains upwards of 150 billion data samples. How does an interpreter locate the few thousand samples that contain information pertaining to a hydrocarbon reservoir? Hunting for less than 0.0001% of the samples in a seismic volume amounts to searching for a needle in a very big haystack.

So how best to approach this challenge?

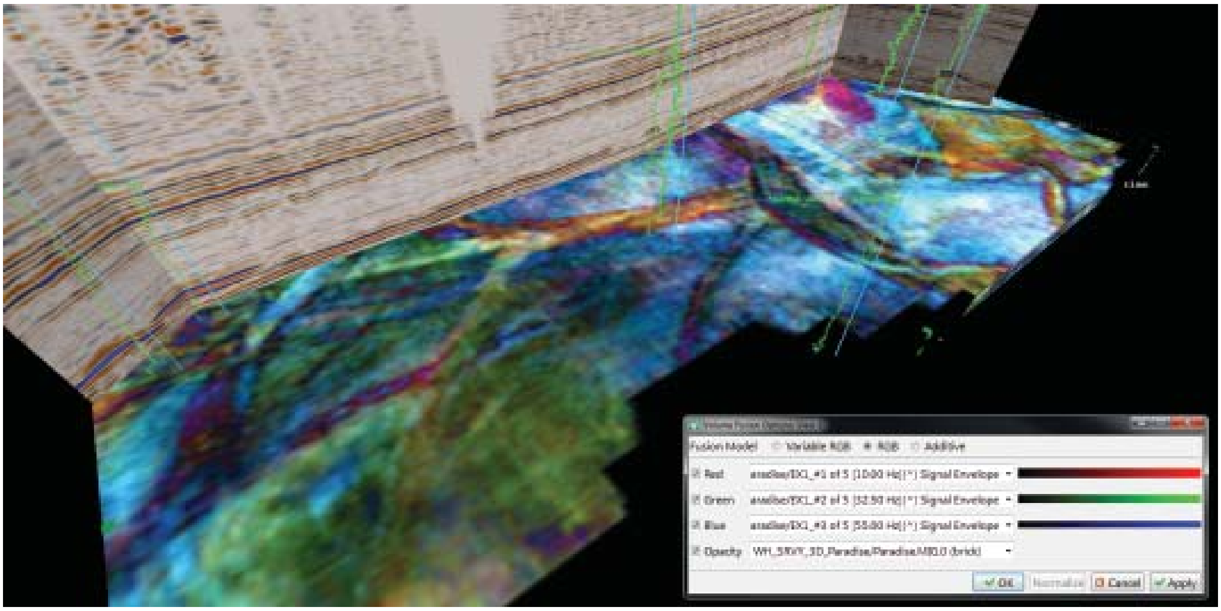
First and foremost,the interpretermust posses an in-depth knowledge of sedimentary facies models, depositional environments, sediment transportation processes, morphology of macro-scale depositional structures, and an extensive catalogue of modern analogues to draw from. Equally important is the interpreter's understanding of convolution, seismic resolution (lateral and vertical), and the effect of thin-bed-tuning on seismic amplitudes.

To leverage this geoscience background, the choice of interpretation system used to investigate seismic volumes is also critical. Due to the sheer size of these datasets, interpreters performing stratigraphic investigations requirean interpretation system designed to support seismic stratigraphic analysis.

The single most critical step in stratigraphic interpretation is the ability to generate high-quality horizons free from picking artifacts. Manually picked surfaces often bear a distinctive "striping" pattern based on the orientation of the section where the picks were made. If these "striped" horizons are subsequently used for investigations on stratigraphic intervals, the striping will be manifested in the output amplitude or facies maps. This can



(Left) Global interpretation automatically picks all faults and horizons in a 3D seismic volume; (Right) channels not visible due to significant faulting can be readily identified when detailed structure and stratigraphy is used to view seismic amplitudes along paleo-depositional layers. Data courtesy of Clyde Petroleum.



Spectrally decomposed seismic data (Gabor-Morlet decomposition) rendered using an RGB volume fusion technique to enhance the visibility of fluvial stratigraphic features of the Mannville Group, Western Canadian Sedimentary Basin.

be problematic and can often mask subtle geological features such as current ripples, dunes, or low-throw faults. To avoid this artifact, modern waveform-based horizon auto pickers must be used whenever possible to create a smooth surface that honours the seismic events.

Typically the "interesting" geology lies hidden in weak, discontinuous seismic reflections. When viewed in a vertical cross section, the subtle meaning of these amplitudes can easily be overlooked. A skilled interpreter can often identify these areas as features warranting further investigation. When viewed along a stratigraphic slice instead of a vertical section, the lateral variation in amplitude patterns can be enlightening. Spatially varying facies, erosional processes, and sediment remobilization features can all readily beextracted from otherwise unremarkable seismic events.

The latest developments in 2D/3D interpretation and visualization systems include significant expansion of their stratigraphic interpretation capabilities. This includes support for rapid stratigraphic prospecting in the same visualization canvas used for multi-survey regional structural interpretation. New workflows enable geoscientists to perform single-horizon and multi-horizon volume flattening (i.e. vertical shifting) and horizon parallel and multi-horizon proportional slicing through seismic data volumes. In conjunction with automated horizon tracking tools, interpreters can rapidly and interactively slice seismic data volumes along interpolated stratigraphic layers with sub-sample precision. This approach allows for rapid investigation and prospecting of seismic data volumes while maintaining the larger regional perspective of the complete depositional system.

Global interpretation workflows are now available that automatically track all faults and horizons in a 3D seismic volume. This extremely detailed structural and stratigraphic information can then be utilized to restore seismic volumes to an un-deformed state. By visualizing the un-deformed seismic volumes along stratigraphic layers, the interpreter can slice up and down in depositional space, achieving high-quality stratigraphic seismic images throughout the entire 3D volume, even in areas close to faults where standard horizon slicing workflows are prone to artifacts.

Complementary to these surface-based stratigraphic analysis approaches, advanced voxel rendering technologies are also a standard component of the3D visualization canvas. Through the use of graphics processing units (GPUs), where hundreds of processing cores are deployed to carry out seismic volume rendering, this visualization process removes rendering artifacts to reveal details of the geology and accelerate refresh speed. By deploying this technology in the same application used for multi-survey interpretation, geoscientists can carry out detailed volume rendering of stratigraphic features without disrupting their thought process.

Using detailed horizon and fault picks as a reference, stratigraphic intervals can be isolated and sculpted from the complete seismic volume. Variable opacity rendering of these sculpted intervals and techniques such as volume lighting (i.e. casting shadows on transparent seismic volumes) and optical stacking can be used to identify subtle stratigraphic features that otherwise would not be visible in a single amplitude slice.

To coax further subtle stratigraphic details from the interval under investigation, interpreters may generate many seismic attribute volumes. These volumes can easily exceed the available workstation memory and limit the ability to perform multi-attribute interpretation. To address this limitation, new technologies that have recently reached the market enable roaming through seismic volumes directly from disk. By automatically adjusting display resolution, reading data using multiple processing threads, and leveraging a new sparse brick seismic file format, these powerful technologies enable geoscientists to simultaneously co-render, blend, slice, and interpret many seismic attribute volumes, even on workstations with limited system memory. dewjournal.com

about the author

Wes Hamlyn is the Product Manager for Paradigm's seismic interpretation suite. After completing a B.Sc. (Hons) in Earth Sciences from Memorial University, Canada, he joined Paradigm as a geoscientist in 2003. Wes has worked in Paradigm's Calgary and Kuala Lumpur offices and has engaged with clients throughout North America and Asia Pacific advising on best-practices for interpretation and reservoir characterization using Paradigm technologies.