Efficient Interpretation

Pioneering science, aided by modern software, removes some of the guesswork

The concept of applying the principles of seismology using reflected seismic waves to ascertain properties of the Earth’s sub-surface occurred to Canadian inventor Reginald Fessenden almost 100 years ago. It was prompted by work he had done on the propagation of acoustic waves in water for measurement of water depths and detecting icebergs after the sinking of the Titanic by an iceberg in 1912. He applied for a patent on a seismic exploration method in 1914, which was issued in 1917.

In the same period, however, American and German researchers developed methods using refracted, not reflected, seismic waves for prospecting and, in the 1920s, successfully applied a refraction method to locate a series of shallow salt domes near the Gulf Coast. Commercial use of the reflection method didn’t begin until 1927, but it soon displaced refraction in popularity for most applications, despite its greater cost.

Although seismic work, no doubt, helped boost U.S. oil production in the 1920s, much of the approximately 2.7 million barrels per day that the country was producing by 1930 owed their successful exploration and development to neither method.

Today, on the other hand, drilling an exploratory well without first shooting seismic and using software tools for calculations, analysis and interpretation would be unthinkable.

Referring to SeisEarth, a software product from Paradigm that enables interpretation of large volumes of seismic data, Victor Vega, an exploration adviser with Custer Resources, says, “It makes sense to use this software for any well, whether exploration or development. It’s not just the geology interpretation that it helps with, but it also reduces the financial risk. So, use it for a $250,000 well as you would for a deep-water one that could cost $150 million.”

Unlike SeisEarth, which can provide three-dimensional visual interpretations of geologic data, much as a CAT scan provides 3D visualization of a patient’s internal organs, earlier software was limited to interpretation in two dimensions, “even though the data was in 3D. Everything you could see was in 2D, but you had to think in 3D. You would have to go line by line and, essentially, you would have to do the correlations. You yourself
would have to build a 3D model consisting of structures and the stratigraphy in which there is rock that potentially contains the hydrocarbons. SeisEarth combines all the data — well data, 2D and 3D — to help you build the model, so you can see the mass of what you’re looking at,” says Vega.

He says some majors have recently switched to Paradigm after a key client worked with the company to improve the SeisEarth software.

SeisEarth provides three windows — 3DCanvas, as well as and 3D seismic surveys plus geologic information via the wells and sampling.”

Pronk says the program can cover large geologic areas in a single project, integrating all of the available information. “You can work from a regional scale down to a prospect scale. It is not limited to a single domain, both time and depth are supported. What appears as a hill in time, based on raw seismic data, could in fact be flat, based on depth.” The end goal, she says, is an efficient interpretation workflow that also increases accuracy.

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traditional 2D section and base map views. Using a computer with plenty of 3D graphics capacity, large volumes of 2D and 3D seismic, well and interpretation data can be loaded into central RAM (random access memory) and shared by the applications. This enables true volume-based interpretation of multiple 2D and 3D seismic surveys and volume-based interpretation of well data. With volumes of seismic and well data loaded into RAM, Paradigm products like 3D Propagator, 2D Propagator and FaultTrak, powerful auto-picking tools, which are integrated within SeisEarth, become interactive tools in the hands of interpreters.

SeisEarth includes tools to assist in the computation of fault and horizon intersections and provides direct access to surface modeling. “Other 3D programs are solely designed for visualization of a single 3D seismic survey,” says Andrea Pronk, an interpretation and visualization adviser at Paradigm’s Calgary office. “With SeisEarth, the program integrates multiple 2D

In seismic interpretation, each sound wave change indicates a subsurface change — from sand to shale, or shale to fluid, for example — and an event or change marks a horizon, a new stratum. Viewed in 3DCanvas, the horizon appears as a subsurface landscape, as if somehow seen from a plane, instead of the abstract matrix of dots and lines of 2D seismic images.

An amplitude map shows all the changes within the larger change that is called the horizon. “In the old days, if you saw an amplitude anomaly, you’d drill, but not today,” says Pronk. The information was often far from complete: the anomaly might or might not indicate a channel. “But with 3D, you can know for sure whether or not you’re looking at a channel. You can understand the geologic setting. The software incorporates advanced interpretation tools which utilize techniques such as waveform correlations, enabled by one of SeisEarth’s tools, in this case one called Propagator. It’s a waveform-based auto picker that analyzes trace shapes instead of amplitude, giving you a quick, accurate horizon pick from a single, interpreted point.”

In other regions of the world the complexity of interpretation is also increasing,” says Pronk. When it comes to making accurate interpretations of subsurface data, there’s no such thing as too much information. VoxelGeo is another tool in Paradigm’s arsenal for seismic interpretation. “Similar to 3DCanvas, VoxelGeo is used for 3D interpretation, but provides more advanced tools for stratigraphic interpretation, and can be particularly useful to look at geomorphology. It allows you to apply opacity, that is, make part of the data transparent, or completely invisible, so as to isolate specific features like channels or a submarine fan complex. Using multiple volumes simultaneously [amplitude mixed with other volumes such as AVO or other seismic attributes], VoxelGeo also allows for detecting geo-bodies within the data to automatically identify those portions of the volume that meet a specific set of criteria,” says John Tyrrell, a technical adviser at Paradigm.

In the last two decades, especially, oil and gas exploration has begun to benefit from the blending of sedimentology, stratigraphy and depositional systems analysis in the development of a modern approach to sequence stratigraphy. “It [sequence stratigraphy] involves the recognition that there is cyclicity in the formations, and that those that are cyclic are more predictable,” says Henry Posamentier, senior consultant geologist at Chevron Energy and 2010 recipient of the William Smith Medal. It is a medal of the London-based Geological Society, awarded for outstanding research in applied or economic geology.

In recent years, Posamentier, who had a pivotal role in the development of modern sequence stratigraphy, has both pioneered and helped popularize the discipline of seismic geomorphology. According to its abstract, a short paper that he will read at the Geological Society’s award ceremony in June, will state that, “Integrated seismic stratigraphic and seismic geomorphologic analyses are used to effectively predict lithology ahead of the drill bit, recognize and anticipate stratigraphic architecture, and recognize stratigraphic compartments that influence how hydrocarbons are trapped.”

Modern software, provided it is fast as well as functional, has an important role in seismic interpretation, says Posamentier. “SeisEarth, 3DCanvas and VoxelGeo allow you to explore, and dive into the stratigraphy of the subsurface as it is manifested by the seismic data. It helps you identify paleo-landscapes. Each of them has the capacity to provide spectacular images — and that improves the precision of the interpretation.”

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