Redefining Broadband

Marine isometric seismic technology provides new interpretational insights from effective spatial sampling.

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The seismic industry has tended to use the term “broad-band” to refer to temporal bandwidth and vertical resolution. A narrower wavelet gives sharper resolution, while a reduction in side-lobe energy leads to a more direct view of the geology. This improves interpreters’ ability to see complex detail in the subsurface and assess risk; however, interpreters also must take care that the frequency content observed in the data is real.

Frequencies spectra contain both signal and noise, and it is often difficult for geophysicists to measure a reliable signal-to-noise ratio on the final migrated section. Methods used to achieve seismic noise become the basis of methods to suppress the noise, and, as a result, the residual noise becomes closer to resembling signal. Interpreters also are learning that much of the noise comes from issues related to spatial sampling limitations of acquisition geometries. For example, shallow overburden noise may alias to appear at different spatial frequencies. Adequate spatial sampling is required to avoid such aliasing, so survey design is influenced as much by noise characterization as by signal requirements.

The Earth presents complex 3-D geology, so interpreters must consider what happens to the signal in such environments. Complexity in the seismic wavefield results from large-scale macrostructures as well as distortions caused by smaller geologic features located closer to the sources and receivers. Interpretations, based on simplistic 1-D geologic models predicting emergent waves propagating vertically, no longer apply.

Interpreters must, therefore, expand the definition of broadband to encompass resolution in all directions, including spatial as well as temporal. This places new demands on the methods required to sample and reconstruct the seismic wavefield and a greater emphasis on controlling both amplitude and phase across the full bandwidth.

The term broadband should include spatial bandwidth, increasing the range of wave numbers in all directions—X, Y, and Z—over which useful information content contributes to the image volume. Achieving adequate sampling to avoid spatial aliasing of the recorded seismic wavefield means that the data can provide high-resolution images of geological features irrespective of their orientation in the earth.

The IsoMerix marine isometric seismic technology not only broadens the temporal bandwidth of towed-streamer seismic data though 3-D deghosting but also allows generation of datasets on a fine, evenly sampled grid. This provides a spatially de-aliased broadband product in all three dimensions: in-line, cross-line and depth. This fine-scale resolution of the wavefield in all directions can translate directly to fine-scale resolution of the geology in all directions, enabling a more accurate representation of the subsurface.

The 4,780-sq-km East Loppa survey, part of a major Barents Sea Schlumberger multiclient program, provides many examples of the benefits of acquiring a high-quality broadband IsoMerix dataset. The Western Barents Sea is well known as a structurally complex region where several tectonic events have resulted in the development of a number of fault complexes. This new dataset is providing fresh insights into the geology of the area and its associated hydrocarbon prospectivity.

The survey area contains two main fault systems associated with the Asterias fault complex and a remote part of the Hoop fault complex. A strike-slip fault system angled at about 45 degrees to each other. The high spatial resolution of the seismic image has made it possible to auto-track the entire fault system independent of fault orientation. Some of the faults seem to control shallow hydrocarbon reservoirs in the Upper Triassic stratigraphic interval, and their mapping is crucial for shallow target exploration.

A complex Upper Triassic channel system is another important geological feature of the Loppa high area. High-quality seismic data demonstrate the Snadd Formation channel system associated with floodplain development in the Upper Triassic. Seismic attributes such as variance can highlight the fluvial depositional system. The data reveal a variety of small-scale fluvial geomorphological features, including point-bar systems, clustered channel fill complexes and ribbon channel sandstone bodies. For more information about 3-D broadband data acquisition and multiclient data from the Barents Sea, visit Schlumberger at booth 940.