Improving Structural Imaging

Reprocessing of several seismic data sets acquired offshore Norway in the 1980's have demonstrated significant improvements in both resolution and structural imaging. The improvements were gained mainly through more accurate velocity modelling and effective multiple attenuation.

Svein-Erik Sjulsen and Chris Stevens, GGS Spectrum

A huge area in the Norwegian Sea – offshore the spectacular Lofoten islands situated due north of the Arctic Circle (between 67° and 70°N) – remains largely unexplored for political reasons. While the oil industry believes that the sedimentary basins of Mesozoic and Cenozoic age may prove to contain several billion barrels of oil equivalents, environmental groups have been able to delay all attempts to get on with licensing and exploration, as this is an important spawning area for cod.

The Norwegian Petroleum Directorate (NPD) acquired seismic data in the areas in the period from 1986 to 1989. A total of 8800 kilometres were collected in 6 surveys. Seismic service companies have also collected multiclient seismic data. NPD will acquire additional seismic during 2007.

Two licenses were awarded in 1995, but only one exploration well reaching the Upper Cretaceous has been drilled to date.

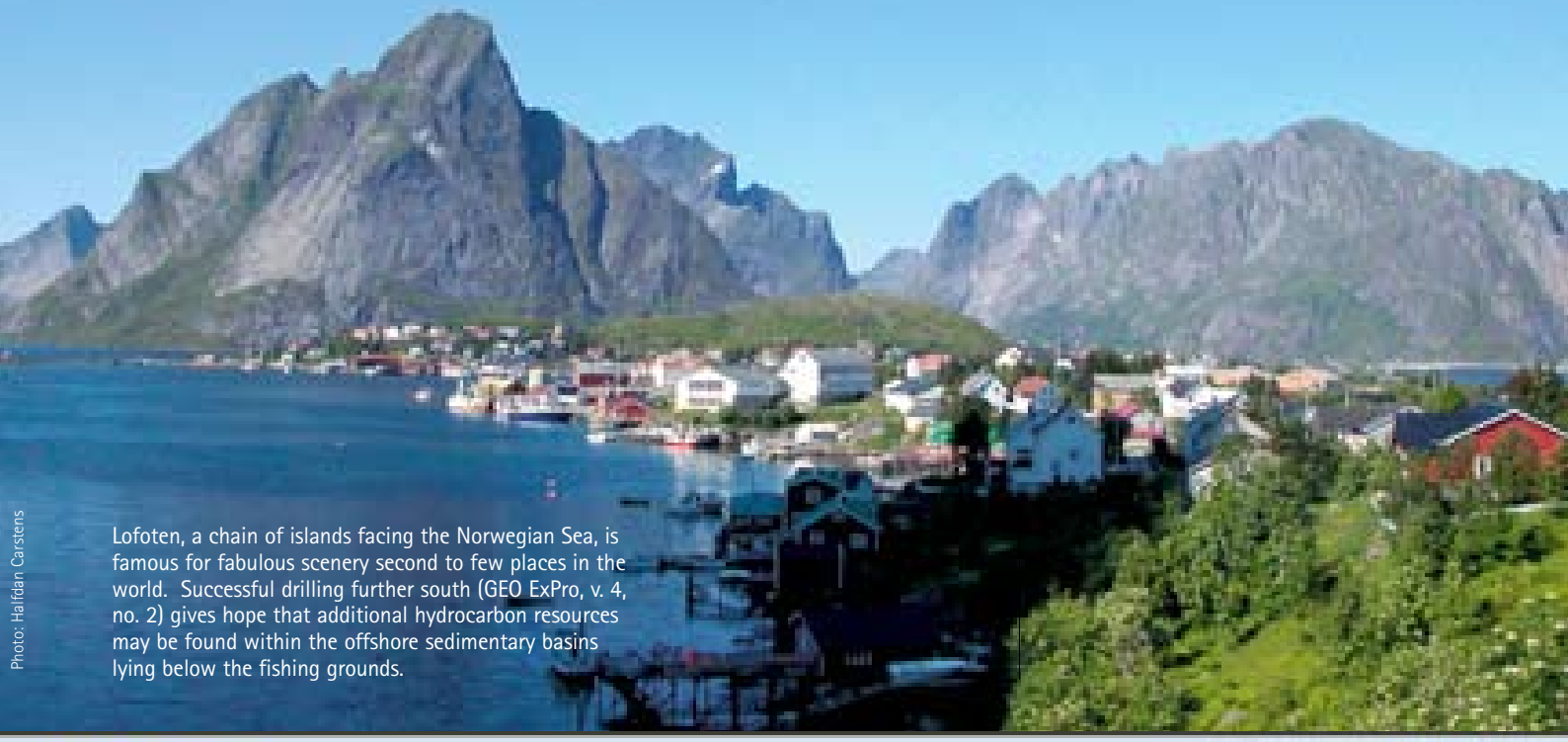
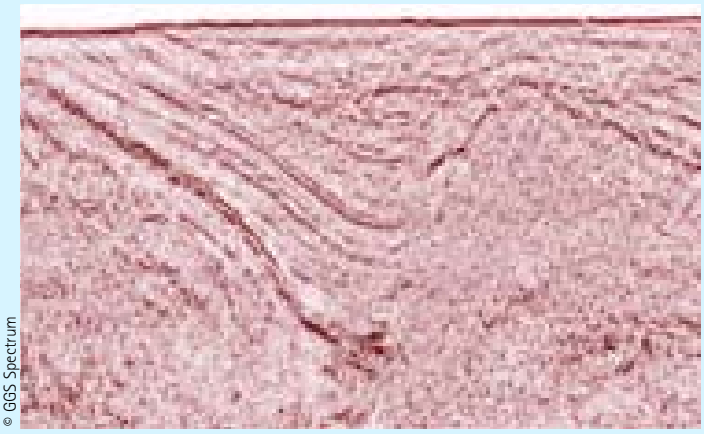
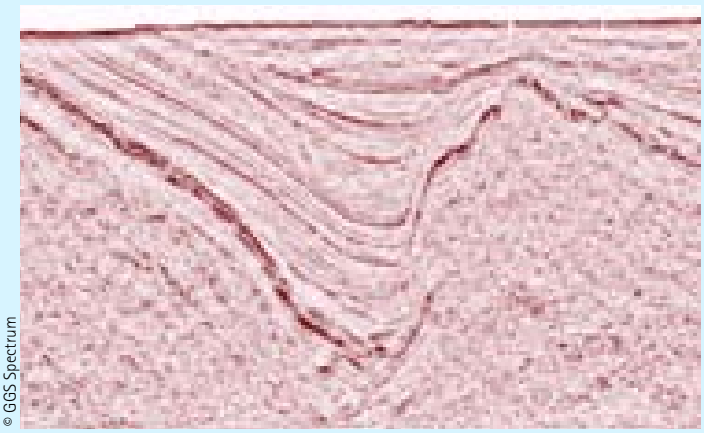


Photo: Halfdan Carstens

Lofoten, a chain of islands facing the Norwegian Sea, is famous for fabulous scenery second to few places in the world. Successful drilling further south (GEO ExPro, v. 4, no. 2) gives hope that additional hydrocarbon resources may be found within the offshore sedimentary basins lying below the fishing grounds.



Seismic line example from the original processing.



The same line after re-processing.

Good reservoir zones were recorded in Paleocene sandstones, but they proved to be water bearing. In the Upper Cretaceous carbonate cemented sandstone stringers with low saturation of hydrocarbons were penetrated.

The seismic being more than 20 years old, there was a significant potential for better quality data. The key objectives were to improve the basin imaging, delineate fault planes and remove multiple energy.

The original processing on the different surveys was typical of the large-scale regional processing flows of the time. The geological variations meant that the region is a mix of good and poor data quality (poor data where the basement reaches the seafloor). Limitations in the seismic data processing techniques when the data was originally processed meant that the data was contaminated with multiples even in the good quality basin zones. This in turn limited the accuracy of the original velocity models that were generated.

Reprocessing trials on three sample lines concentrated on a variety of demultiple techniques both pre and post stack. The pre stack techniques required several passes and different algorithms, and when used in combination enabled sufficient primary signal to be imaged on the Kirchhoff pre-stack time migration gathers. This enabled much more accurate velocity picking than had previously been achieved.

Post stack residual demultiple techniques were employed to optimize the final stack data.

Following on from the obvious success of the Nordland reprocessing there was sufficient industry interest to reprocess the entire five datasets. During the reprocessing project, our team continually monitored and evaluated the processing flow. We were also extremely grateful for the suggested processing flow refinements suggested by some of the local Norwegian oil companies.

Testing showed that an additional pass of taup deconvolution and muting in the receiver domain improved results especially in the very shallow water areas where refracted energy obscured the reflections. Then the targeted post-stack demultiple was applied on offset planes before migration. Further improvements were obtained by applying radon demultiple on the migrated gathers. At this stage of processing the velocity field was accurately known and the moveout of the multiples was mostly hyperbolic so that the radon process was more effective than before migration.

The combined effects of Kirchhoff pre-stack time migration and several passes of assorted demultiple techniques have produced a significant improvement to the various NPD Nordland seismic surveys.

The results of the reproces sing of these vintage datasets can thus now be used by the interested oil companies to locate prospective structures for more detailed geological studies.