GC Futuristic Efforts to Characterize Shallow Anomalies*

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Search and Discovery Article #42109 (2017)
Posted July 17, 2017

*Adapted from the Geophysical Corner column, prepared by the authors, in AAPG Explorer, July, 2017. Editor of Geophysical Corner is Satinder Chopra (schopra@arcis.com). Managing Editor of AAPG Explorer is Brian Ervin. AAPG © 2017

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General Statement

The last two Geophysical Corner articles Quantifying Shallow Seismic Anomalies, Search and Discovery Article #42101, and Characterizing Shallow Seismic Anomalies, Search and Discovery Article #42086 have focused on characterizing shallow high amplitude anomalies in the Barents Sea, first qualitatively, and then adopting an alternative workflow with different tools that lower the uncertainty in the characterization process. In this article, we discuss other efforts that are being directed at performing an integrated assessment for the prospects in the Barents Sea, and lowering exploration risk in the future.

Besides improving the quality of the existing seismic data through reprocessing (with the latest algorithms) and their integration with borehole data, the state-of-the-art acquisition of fresh data with more powerful acquisition technology are being carried out in the Barents Sea. To improve the quality of the data being used for interpretation and analysis as well as effectively de-risk the prospects ahead of drilling, the state-of-the-art technology is being used for its collection. Besides this, diverse data types, both geological and geophysical, are being brought together to come up with an integrated assessment for the prospects.

Multibeam seafloor mapping and sampling is also being done by some of the operators in that area. Plans are also under way for integrating all this data for mitigating exploration risk.

P-Cable Seismic Data

Among the more powerful 3-D marine seismic data acquisition technologies available in the industry today, the patented P-cable multistreamer seismic system holds promise in terms of resolution on the processed data that is much greater than conventional 3-D seismic data. The system consists of a seismic cable towed perpendicular to the vessel streaming direction (Figure 1), and which contains communication control units as well as the navigation hardware. For a normal configuration 8 to 24 streamers with 6.25 to 12.5 meters spacing are attached to this cable. The length of the streamers usually varies between 50-100 meters with small group intervals (3 meters), and as the source-receiver distances are short, all the near offset signals are recorded. The acquisition of seismic data with such a geometry results in high resolution, typically 1-2 meters vertical and 3-6 meters horizontal on the final processed data. The P-cable acquisition can be carried out with small vessels and lighter equipment, and is therefore cost-effective and space-efficient.

In Figure 2 we show a comparison of seismic sections passing through the Apollo well and (a) extracted from conventionally processed data at 4 ms sample interval, (b) reprocessed data at 2 ms sample interval with a proprietary attenuation correction, and (c) from P-cable seismic data volume again with proprietary attenuation correction. Of notice is the enhancement of the resolution in (b) and more so in (c), and the advantages that accrue with it in terms of interpretation.

CSEM Data

The P-cable seismic data acquisition technology discussed above is a seismic method that uses the sensitivity of the seismic wave velocity and density of the medium for generating the data. The controlled source electromagnetic (CSEM) method measures the electrical conductivity of the medium and serves as an independent source of information generating a volume of subsurface resistivity that can help locate pockets of hydrocarbon fluids. In that sense the two are disparate exploration techniques, where the processed data are interpreted separately and the results integrated. Case studies have been published where combining the information from the seismic, CSEM and well data greatly benefits in the understanding of the anomalies, despite the shortcomings in the methods or the uncertainties in the results. Alternatively, joint inversions of such data are also being carried out using different approaches.

In Figure 3 we show segments of an intersecting inline and crossline from seismic data and overlaid with the equivalent lines from the CSEM survey. Notice how the peak resistivity anomalies from the EM survey fall over the seismic amplitude anomalies, lending confidence to their interpretation as being hydrocarbon charged. The CSEM data is being extensively used by some companies for identification of play fairways for derisking their prospects.

Multibeam Sea Floor Mapping and Sampling

Natural hydrocarbon seepage on the seafloor could be due to vertical leakage of light oil or gas from charged reservoirs in the subsurface, or a result of hydrocarbons that have travelled long lateral distances through vents or via porous zones or faults and reached the seafloor. Such seepage out of the seafloor can alter the physical and biological characteristics of the water-bottom sediments. Sometimes the seepage of light hydrocarbons may not be physically detected, but as they diagenetically alter the rocks or shallow sediments through which they pass, they can be detected chemically. If such seepage is physically detected on the seafloor, it could serve as a direct hydrocarbon indicator. Biological buildups at the seafloor, and pockmarks or mud volcanoes created by the seeping oil or gas are some of the indications that can be detected on the seafloor.

Tools such as multibeam sonar and piston coring are being used these days to cost-effectively and efficiently evaluate the hydrocarbon prospectivity of the offshore areas. Multibeam sonars transmit sound waves at frequencies less than 100 Hertz and record the reflected waves off the water-bottom. These returning sound waves would exhibit a monotonous seafloor signature and thus is used for bathymetric image reconstruction. However, the sound waves are backscattered off the pockmarks or buildups on the seafloor which will alter the intensity of the returning sound waves. This data after processing allows the identification of anomalous features that could be related to seepage of hydrocarbons. The resolution of the reconstructed images is good, being from 10-100 meters laterally, and less than 5 meters vertically.

Similarly, seafloor geochemical cores can be collected using a grid spacing pattern over the area of interest, and analyzed. Depending on the water depth and type of corer used for the purpose, core samples up to 30 meters or more may be retrieved.

Conclusion

The presence of near-surface migrated hydrocarbons can provide strong evidence on whether an active petroleum system is present, as well as critical information on source, maturity and migration pathways. Such work is being carried out in the Barents Sea, and integration of more such data with other types of data will help with exploration work in the area.

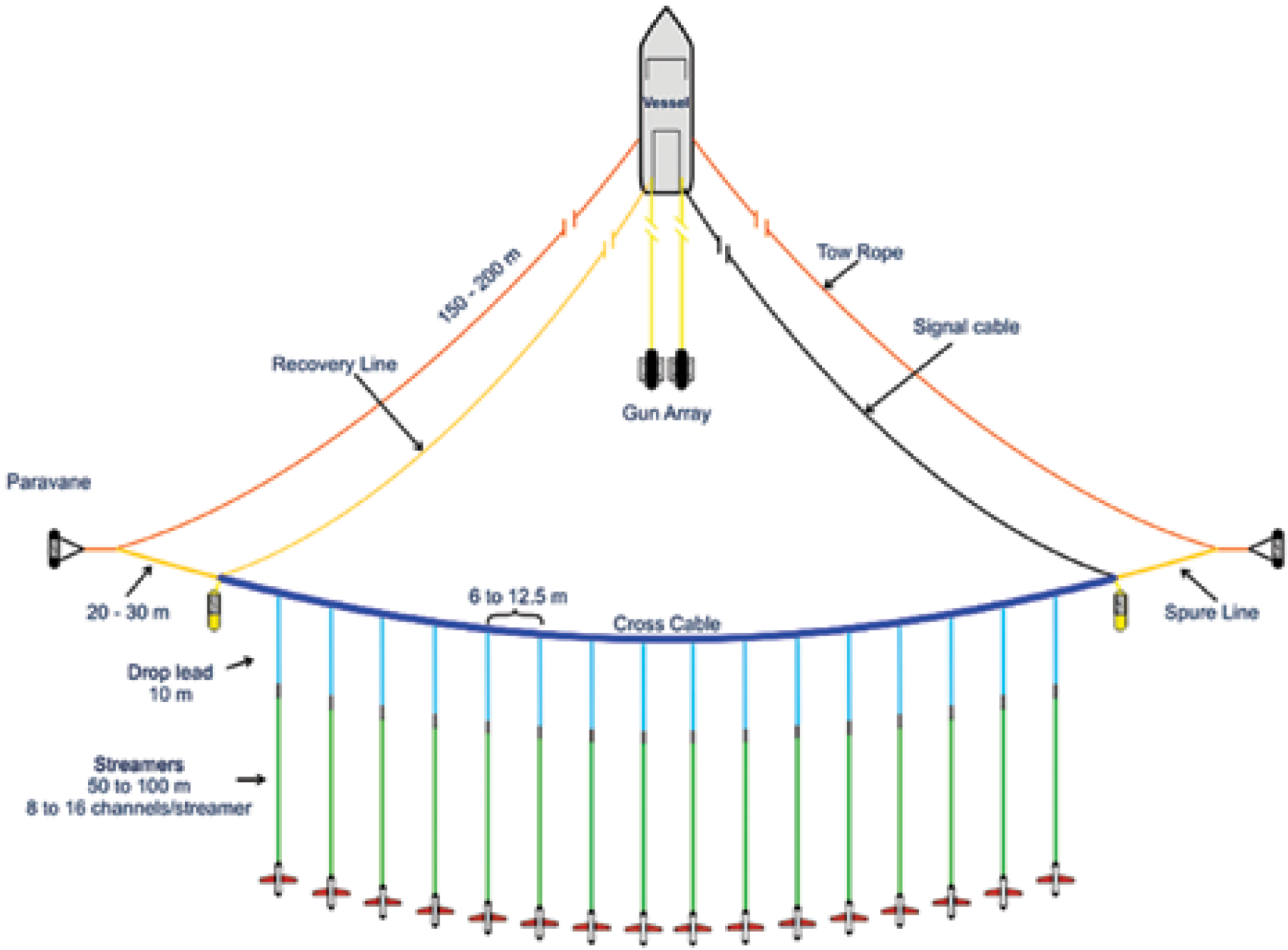

Figure 1. A typical configuration of a P-cable acquisition layout. Image courtesy of P-cable 3D Seismic AS.

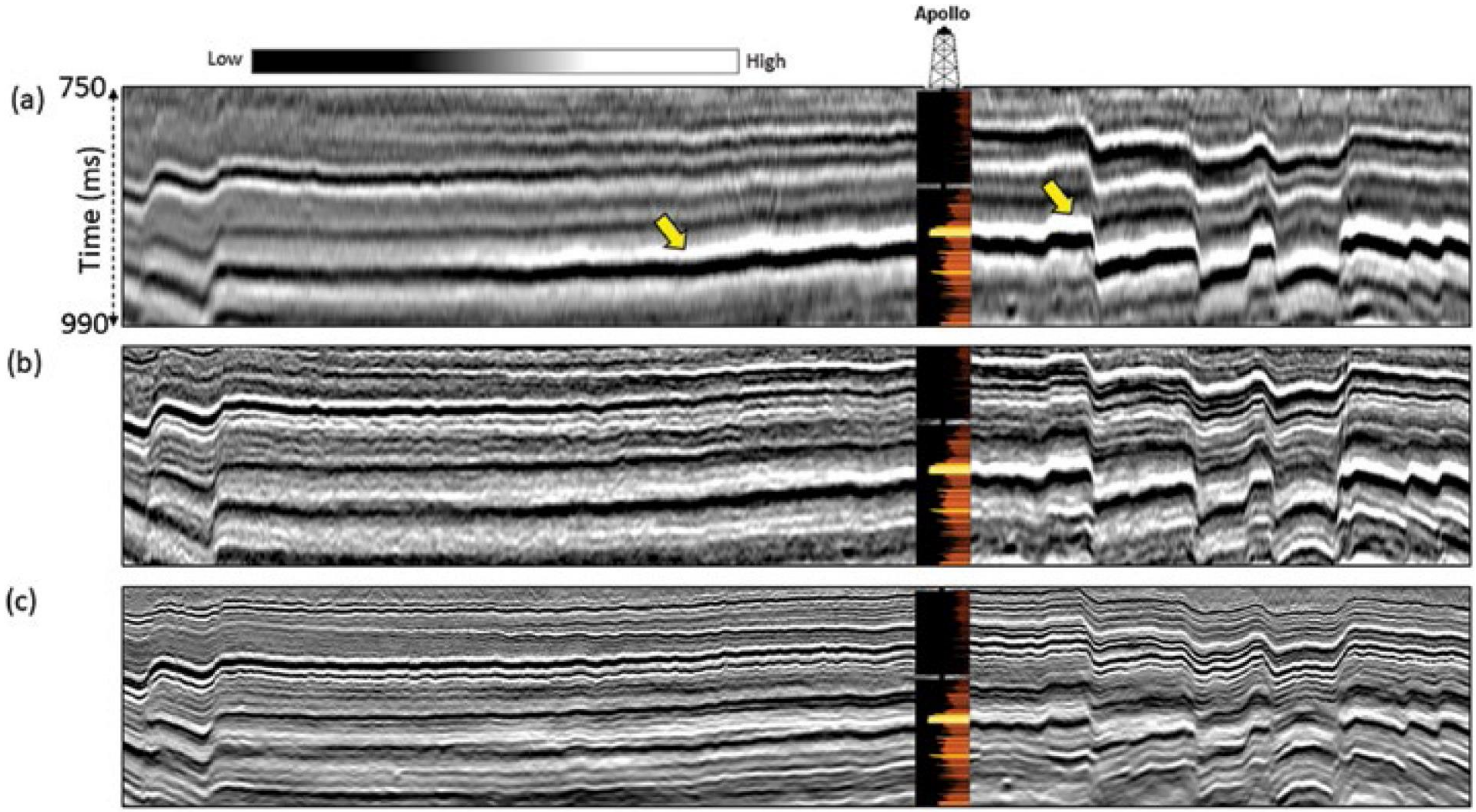

Figure 2. Segments of an inline (23 km in length) passing through the Apollo well from the (a) conventionally processed seismic data volume at 4 ms sample interval (SI), (b) reprocessed seismic volume at 2ms SI and with a proprietary attenuation correction process applied, and (c) P-cable seismic volume processed at 1ms SI and with the proprietary attenuation correction process applied as in (b). The yellow blob in the well represents the Stø Formation. Notice the enhanced resolution of the data in (b), and even higher resolution is seen in (c). The bright amplitude on the closure as indicated with the yellow arrows is seen on the conventional section shown in (a), but disappears in (b) and (c). Perhaps it's appearance in (a) is due to the tuning effect.

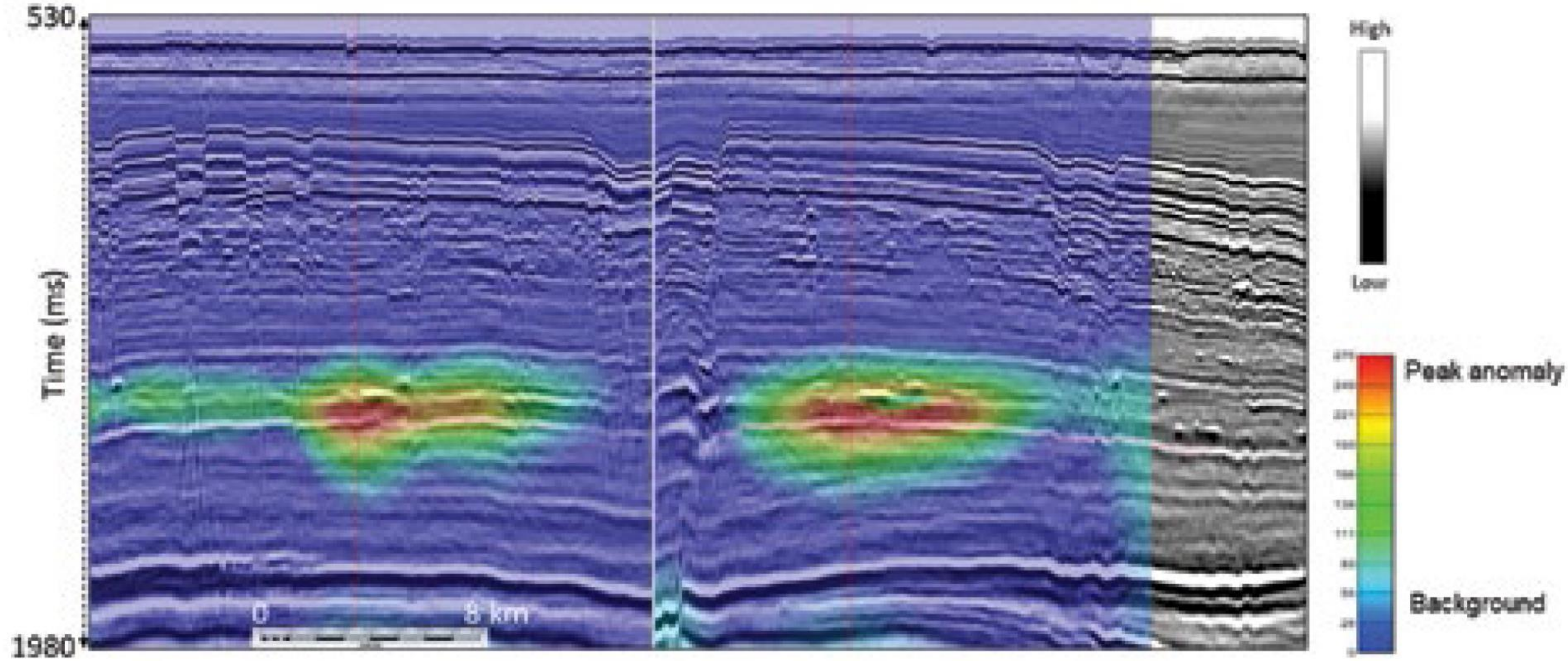

Figure 3. Segments of intersecting inline (left) and crossline (right) from the reprocessed seismic data volume with a proprietary attenuation correction. Overlaid on the seismic lines are the equivalent lines from the EM survey. Notice the peak resistivity anomalies from the EM survey fall over the seismic amplitude anomalies, lending confidence to their interpretation as being hydrocarbon charged. The scale bar displayed to the lower left shows a length of 8 km.