



→ Charged to innovate. Driven to solve.™

CHALLENGING ENVIRONMENTS

Arctic Exploration

At ION, we are driven to develop and apply innovative technologies that help oil companies and seismic contractors solve their toughest imaging and operational challenges. When operators needed information to make exploration decisions in the icy waters of the Arctic, where no modern seismic data existed, they turned to ION. ION responded to the challenge by creating and employing new technologies that enabled data acquisition under the ice supported by special data processing techniques that attenuated the ice noise. As a result, the operators were able to acquire data further north than ever before while dramatically extending the traditional data acquisition season.

CHALLENGING ENVIRONMENTS:

Arctic Exploration

Challenge: Limited availability of high-quality seismic data to guide exploration decisions.

Approach: Develop proprietary technology to enable acquisition of seismic data under ice and processing techniques to attenuate ice noise.

Result: Data acquired and processed. Dramatic extension of the acquisition season.

As a result, operators were able to acquire data further north and dramatically extend the traditional data acquisition season.

FACED WITH LIMITED SEISMIC DATA TO GUIDE EXPLORATION DECISIONS

With an estimated 30% of the world's undiscovered hydrocarbon resources, the Arctic has reemerged as an area of increased exploration interest. Despite its tremendous potential, the Arctic poses extreme challenges to all E&P activities, including seismic acquisition and data processing. Harsh conditions offer a narrow weather window for seismic operations, wreak havoc with in-water acquisition equipment, and introduce unwanted noise into acquired seismic datasets. Combined, these factors have limited both the quantity and the quality of available seismic information in the Arctic. Without access to this critical subsurface data, E&P operators are "flying blind" when making assessments about what acreage to lease and, eventually, to drill.

ENABLING ACQUISITION AND PROCESSING OF SEISMIC DATA WITH PROPRIETARY TECHNOLOGY

As Greenland emerged as the next exploration frontier in the Arctic, E&P operators turned to ION to design a regional program for Greenland's highly prospective northeast coast, building on ION's ArcticSPAN data library. Reaching into its geophysical toolkit, ION adapted some of its



core technologies and designed a program to safely and efficiently acquire and image seismic data under the icy waters of offshore NE Greenland. These acquisition technologies cleared paths through the ice for the seismic acquisition vessels, steered the streamer cables within fairways of planned ice cover (vetted to be within system tolerances), and enabled acquisition despite the challenges of operating in extremely cold waters and near the northern magnetic pole. The data was then processed by ION's GX Technology (GXT) group using special techniques to record, and remove, ice-induced noise, backscatter, and multiples.

DRAMATICALLY EXTENDING THE ACQUISITION WINDOW

To deliver greater insights into offshore Greenland's northeast coast, ION custom-designed a multi-client regional program. The acquisition goals for the first season were set just above 4,000 km. However, by the end of the first summer of acquisition, over 5,280 km of high-quality regional data had been recorded. These operations took place in a challenging ice season that

prevented other seismic service providers from ever leaving port or, if they did, from achieving anything close to the acquisition targets agreed upon with their E&P underwriters.

Adapted to the Arctic, ION's marine acquisition technologies were clear drivers behind this productivity advantage. ION's intelligent streamer steering system, guided by Orca software and implemented in-water by DigiBIRD and DigiFIN, allowed the vessel operator to tow the streamer cables within the planned fairway of ice-covered water and, when necessary, to steer around or beneath large floe deep-keeled ice bodies close to the vessel. Furthermore, these systems allowed the vessel operator to keep the streamer cables in the water despite storm-induced wind gusts in excess of 100 knots. Even under harsh Arctic conditions, technical downtime was less than 2%.

The complexity of acquiring data in icy conditions required innovative processing tools and techniques. Overcoming the ice-related noise and multiples problems for 2D Arctic data is often more challenging than for a typical 3D program. GXT designed and pioneered processing techniques, including a cascaded processing flow approach, to attenuate noise from various sources, including the ice.

In addition, GXT geophysicists fine-tuned proprietary de-multiple techniques that allowed them to remove the backscatter or "ice multiples" that occur when the source energy reverberates off the underside of pack or floating ice near the surface, further enhancing the quality of the signal and the resulting images.

As a result of ION's drive and determination, the data obtained provides a better understanding of the opening history of the North Atlantic and reconstruction of Greenland with its conjugate Mid-Norway and Barents Sea margins. Furthermore, the improved structural development of the region can be used to develop palaeogeographic interpretations that better predict source and reservoir deposits.

The data have also resulted in the identification of play types, and numerous structural leads have been mapped. New interpretations suggest that rich oil-prone Jurassic source rocks are present over much of the area. These observations, together with comparisons with the conjugate Mid-Norway margin, suggest that the area has excellent hydrocarbon potential.

Building on its success in the Arctic, ION is now pursuing additional in-ice Arctic programs focused on the U.S. and Canadian Beaufort Seas as well as Greenland.

ION'S ARCTIC TOOLKIT

SURVEY PLANNING AND PROGRAM MANAGEMENT

- Feasibility studies
- Survey design, planning, permitting, and Arctic community relations
- Acquisition project management

ACQUISITION TECHNOLOGIES

- DigiSTREAMER™ solid towed streamer acquisition system
- Orca® command and control
- DigiFIN® and DigiBIRD® positioning systems
- DigiSHOT® digital source control

DATA PROCESSING AND IMAGING

- Proprietary techniques for multiples suppression and noise removal
- Pre-stack Depth Migration (PreSDM)
- Interpretation

ARCTICSPAN™ DATA LIBRARY (U.S. CHUKCHI SEA, CANADIAN BEAUFORT SEA, AND NORTHEAST GREENLAND)

ABOUT ARCTICSPAN

Since 2006, ION has acquired nearly 40,000 km of depth-imaged seismic data in the U.S. Chukchi and Canadian Beaufort seas, and offshore Greenland. Like all of our BasinSPANS, these programs are custom designed in a collaborative relationship with government agencies, regional experts, and E&P companies with experience in the area. Collectively known as ArcticSPAN, these geologically inspired, basin-scale programs help oil & gas operators better understand the petroleum systems of these regions and more effectively determine hydrocarbon potential.

ARCTIC SEISMIC DATA PROGRAMS

- BeaufortSPAN – MacKenzie Delta, Beaufort Passive, and the Banks Island Basin (~23,000 km)
- BeaufortSPAN East Potential Fields Program – Bailey Point in the south to west of Prince Patrick Island (airborne magnetic survey – ~225,000 km²)
- ChukchiSPAN – Chukchi and North Chukchi Sea Basins (~3,000 km)
- Northeast GreenlandSPAN – South Danmarkshavn Basin, Thetis Basin, and the Northeast Greenland Volcanic Province (~12,000 km)



ABOUT ION

ION Geophysical Corporation is a leading provider of geophysical technology, services, and solutions for the global oil & gas industry. ION's offerings are designed to allow E&P operators to obtain higher resolution images of the subsurface to reduce the risk of exploration and reservoir development, and to enable seismic contractors to acquire geophysical data safely and efficiently.

To learn more about how ION helps oil & gas companies and seismic contractors solve their toughest imaging and operational challenges, visit us at iongeo.com.

ION Geophysical Corporation
2105 CityWest Blvd., Suite 400
Houston, TX 77042
Phone +1 281 933 3339
Fax +1 281 879 3626
iongeo.com