ION’s ArcticSPAN program is taking an unprecedented first look at new exploration frontiers. They have acquired approximately 16,000 km of 2D data in eastern Beaufort Sea from 2006 to 2008. The surveys are designed for deep imaging using 18 second records and 9,000 meter cables. The seismic lines are located in a geologically-oriented grid driving new ideas about total basin potential and crustal evolution.

See full story starting on page 39.
The Canadian portion of the Beaufort Sea has been the site of intense interest and bidding in recent licensing rounds. Regional reconnaissance 2D seismic programs designed to image down to the base of the Earth's crust are redefining frontier basin evaluation.

In June of 2008, BP Exploration Company spent a record $1.18 billion for a 202,380 hectare parcel in the Canadian Beaufort Sea north of Tuktoyaktuk, North West Territories. This surpassed the previous record of $585 million Imperial Oil and ExxonMobil Canada paid in 2007 for a 205,000 hectare exploration lease in the same area. Last year, BP was awarded three leases covering 611,000 hectares. Two other leases were awarded in the same sale: a 41,000 hectare parcel was won by MGM Energy, ConocoPhillips Canada, and Phillips Petroleum Canada, while ConocoPhillips Canada won a 196,000 hectare lease.

The area is not new to leasing and exploration. Over 50 oil and gas discoveries have been made in the shallow waters of the Beaufort/Mackenzie delta area during the 1970s and 1980s with all of these still waiting development and transportation to markets. Devon Energy drilled the first well in 15 years north of Canada's mainland. Their Paktoa well was drilled over the 2005 and 2006 drilling seasons 180 km north of Inuvik, North-west Territories. In 2007, they announced it to be a major oil discovery with recoverable reserves estimated at 240MMbo.

Government estimates have the area containing a significant percentage of Canada's conventional oil and gas. The Geological Survey of Canada estimated the mean undiscovered resource at 2.75MMb (16.8Bbo) inclusive of deep water (to 2,500 m) while the U.S. Geological Survey put a mean of 1.5MMb (10.5Bbo) in the basins in water depths less than 1,800 m.

**Program Design**

New tools and new approaches in geoscience are needed to help oil and gas companies meet reserves and production targets. One such approach developed by ION Geophysical's GX Technology group (GXT) has been to acquire geologically inspired and constrained programs known as SPANs. "SPANs are basin-wide, ultra-deep, 2D seismic data sets that are acquired and interpreted using the most advanced geologically informed and geophysical technology available," says Joe Gagliardi, ION's SPAN Program Director. "SPANs are custom designed to provide critical insight into the geologic evolution, deep basin architecture, deposition, and structural history of a petroleum system. The resulting data provides oil and gas companies with new information, insights, and prospect generation opportunities for under-explored or unexplored frontier basins.

ION currently has 10 SPANs available and is in the detailed planning stage for additional programs worldwide."

The line shown on this issue's seismic foldout (pages 36-38) was part of one of the three season programs from 2006 to 2008 and demonstrates the potential of ION's ArcticSPAN surveys located on the Free Air Gravity Map (gravity data from the Arctic Gravity Project of Kenyon and Forsberg, 2001). The COB line is coincident with other interpretations with the Kuskokwim Delta seaward block the boundary.

**ArcticSPAN Data**

ION ArcticSPAN. More Insight. Less risk.

**There is more beneath the surface that others can't see. But you can.**

**ArcticSPAN**

Basin-scale, Ultra-deep Data Program

Data Available for Upcoming Lease Sales

- ChukchiSPAN (U.S.)
- BeaufortSPAN (East Canada)
- Final-ever look at the deep water in the Beaufort-Mackenzie basin
- Final-ever look at the Banks Island western margin
- BeaufortSPAN Airborne Magnetic Survey
- Flex Wave Study

**See the big picture and make visionary decisions before the next licensing round.**

ION's ArcticSPAN program is designed to provide unique insights that are unlocking new prospect opportunities. Take a new look at the Arctic's exploration potential.

ION ArcticSPAN. More Insight. Less risk.

**Basis in SPANS**

Imaged by GXT
2008 to gather 2D long-offset, reconnaissance seismic data in the Canadian Beaufort Sea. More than 16,000 km of data was collected in a geologically driven (oriented) grid along the continental margin, from the U.S. border traversing the Mackenzie Delta shelf and slope northeast to the Amundsen Gulf and Banks Island. Depending on ice conditions, the lines extend as far as possible offshore and into deep (over 2,000 m) water.

“The Arctic SPAN program is typical of our other Basin SPAN programs,” says Joe. “We designed this program to image down to the base of the crust with a 9 km long cable, 18 second recording and final depth processing (prestack depth migration) to 40 km. The seismic data are interpreted together with simultaneously collected gravity-magnetic data to regionally map the crustal continent-ocean boundary (COB) and the top of the MOHO discontinuity. The seismic data is tied to existing well data to identify the major stratigraphic sequences. This Beaufort survey was specifically designed to image the entire crust and basin architecture along with excellent seismic resolution within exploration depths (8 km).”

A KEY LINE
“The 547 km-long Line 5600 is the most seaward strike line in the Beaufort survey and the most dramatic, revealing the variable basin architecture in three distinct crustal domains,” says Dr. Menno Dinkelman, ION’s chief geologist. “The southwest end traverses the Beaufort fold and thrust belt of the highly prospective offshore Mackenzie Delta. The fold belt has a very deep (15 km) detachment zone overlying oceanic crust, including the inferred southward extension of the buried mid-ocean ridge beneath the deformation front. The central portion of the line is in deep water (>1,000 m) with flat lying sediments on oceanic crust. The eastern part of the line crosses the Continent-Ocean Boundary (COB) of the passive margin along the Banks Island shelf. This line also ties the entire 15+ km-thick Canada Basin Megasequence of Late Jurassic to Recent age from the area with well control in the south to the frontier exploration territory to the north at offshore Banks Island that has thus far not been penetrated by wells.”

PASSIVE MARGIN
The central portion of Line 5600 shows the most important stratigraphic sequences designated by age. The Plio-Pleistocene sequence (0–5.3 Ma) is more than 3 km thick. Many intra-sequence unconformities, erosional, and truncation features are seen in the Miocene (23.0 Ma) and younger sediments seaward of the shelf edge onto the continental slope. The Valanginian (136.4 Ma) breakup unconformity syn-rift blocks, and the top of faulted, tilted blocks of oceanic crust are clearly shown.

The opening history of the Canadian Basin has been debated for years. “Although many questions remain and need to be more fully investigated, as it stands now the SPAN data appear to support a rotational opening of the basin and an extension of the ‘paleo-spread center’ to near the mouth of the Mackenzie River,” says Dr. Dinkelman. “We also have identified a passive margin boundary that extends along the Tuk Peninsula and Banks Island. The continuation into the Alaska Beaufort Sea is masked by the thickness of the Mackenzie Delta sediments. Our interpretation would suggest that a significant part of the delta is underlain by oceanic crust which appears to be more expansive than previously mapped.”

B. Line 3700 showing the compressional features in the Eocene to Miocene Beaufort Foldbelt. The detachment surface is located near the 136.4 Valanginian breakup horizon and the “outer high” caused by the Late Tertiary inversion is clearly shown.
BEAUFORT FOLDBELT
The structural style changes on the south-
eastern portion of Line 5600. Gravity sliding
and Brooks Range compression in north-
eastern Alaska have created folds and thrusts
in the highly prospective offshore Beaufort
Foldbelt. The master detachment level lies
at approximately 15 km depths along the
southern and western parts of the area. The
well developed growth synclines between the
green and pink reflectors (Late Eocene, 41-
34 Ma) indicate the age of the main folding
event. A younger, late-Tertiary compressional
event caused the structural inversion, folded
the detachment surface, and created a large
structure at the shelf edge which extends into
deeper waters.
“This inversion structure is located where
we have postulated the presence of a now
inactive spreading center under the delta sedi-
ments,” says Dr. Dinkelman

PROSPECTIVE EASTERN
SECTION
The eastern end of the line overlies con-
tinental crust. At the continental margin,
high angle, basin-bounding faults separate
the Paleozoic sequences mapped on the
Canadian Arctic Islands from the oceanic
crust and rift-sediments. This transition at
the COB is interpreted as a major crustal fault.
“The Meso-Cenozoic stratigraphy is well
imaged and attains a thickness in excess of 12
km,” says Dr. Dinkelman. “This is considerably
thicker than previously thought would be the
case with this offshore area being more than
300 km from the Mackenzie River sediment
source. In addition, in the deeper waters
offshore the southeastern edge of Banks
Island, a major rollover feature is imaged in
Late Cretaceous and younger sedimentary
sequences along one of the major down-to-
the-basin dipping faults seaward of the COB.
The full extent of this feature has not yet been
mapped but suggests hydrocarbon trapping
possibilities along this boundary. The rollover
is almost 30 km wide and has nearly 800 m of
structural relief.”

Landward, the Paleozoic section is dis-
rupted by down-to-the-basin faults. Depth
to the MOHO is almost 30 km beneath the
highly-reflective, lower continental crust near
the termination of Line 5600.
“Whether dealing with exploration fron-
tiers in the Arctic margins or synthesizing
regional tectonics in established petrolifer-
ous provinces such as the Mackenzie Delta,
these state-of-the-art deep seismic surveys
provide thought provoking illumination of
basin scale tectonics and crustal architec-
ture,” Dr. Dinkelman concludes. “We have a
firm foundation for basin analysis and assess-
ment.”

C. The east end of Line 5600 showing a very thick Late Cretaceous and younger sedimentary section at a considerable distance from the Mackenzie
Delta area. A very large rollover into a fault is clearly imaged on the line.