The Nansen Icebreaker

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Drilling technology for Nansen Arctic Drilling

contributed by Alister Skinner

Technological challenges continue to tease and torment scientists who wish to collect long cores from below the seafloor in the high Arctic. In good years ice-strengthened ships with suitable handling systems can extend scientific surveys far into the Arctic, collecting geophysical data with conventional equipment and collecting sediment or rock cores of limited length with remotely-operated sampling tools. Innovation, good scientific interpretation, and carefully identified sites—suitable for study with new and existing coring methods—will ensure that our geological knowledge of the Arctic continues to expand. Ultimately, however, core-length requirements dictate that drillstring operations must be considered.

Only icebreaking-hulled vessels can safely operate in permanent pack ice, reducing the number of platforms available for scientific coring in those areas. Also, conventional survey techniques begin to have serious operational problems in pack ice, especially with regard to towing instruments or running planned survey lines. Furthermore, occupying sample sites, based on interpretations of existing geophysical data, may not be possible for many years due to the prevailing ice conditions at the time a vessel is available for the work.

These restrictions are amplified when the requirement is for coring below the seafloor to a depth that can not be reached with conventional remotely-operated methods. A drillstring must then be deployed and the vessel must maintain a close tolerance position with respect to the seabed for periods of time which can be measured in days rather than the hours required for the other types of seafloor sampling.

Broadly speaking, drilling vessels available for marine science can be subdivided into three groups: site investigation drilling vessels, oilfield drilling vessels, and semi-submersible drilling rigs. For special projects—in waters up to 100-150 m deep—it may also be possible to use jack-up rigs or smaller anchored vessels and barges.

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Inside

Logistics of scientific drilling in the Arctic Ocean: Station-keeping test opens new perspectives

contributed by Yngve Kristoffersen, Anders Backman, and Gary Brass

Scientific deep-sea drilling has been carried out in every ocean basin except the Arctic Ocean where perennial sea-ice cover impedes conventional exploration. The Arctic Ocean remains unsampled for two main reasons: (1) optimum sampling sites are insufficiently documented, and (2) scientific drilling platforms are not capable of working in drifting pack ice. However, our growing awareness of the Arctic Ocean's importance in the global climate system demands an increased effort to understand its geologic evolution, particularly its Cenozoic paleoclimatic and paleoceanographic history.

The recent ARCTIC '91, an international icebreaker expedition, is a breakthrough in modern exploration of the deep Arctic Ocean. Two vessels, the Swedish icebreaker *Oden* and the German research vessel *Polarstern*, crossed the Eurasia Basin into the Makarov Basin during a 70-day cruise (Figure 1). This expedition acquired the first high-quality multichannel seismic profiles across the Lomonosov Ridge and from the North Pole to Svalbard via Morris

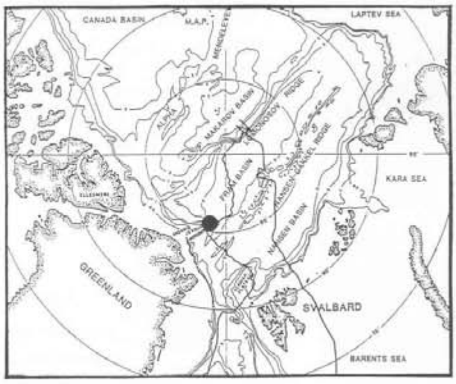

Figure 1. Track of ARCTIC '91 and location of station-keeping test (dot).

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Drilling logistics (continued from page 1)

Jessup and Yermak plateaus—1500 km of data. More than 33 sediment cores longer than 5 m were recovered; the longest was 16.9 m. Preliminary investigations suggest that this stratigraphic interval spans the last million years.

Most importantly, the seismic data across the 80 km wide Lomonosov Ridge and the marginal plateaus document the presence of a package of flat-lying, undisturbed sediments up to 450 m thick above a distinct unconformity or basement. Erosion at the plateau margins provides easy access to the deeper stratigraphic levels of this upper unit in water depths less than 1500 m.

Oden *during the 1991 station-keeping test.*

If cored continuously by scientific drilling, these sediments have great potential to significantly advance Cenozoic studies—particularly Neogene Arctic paleoceanography. This potential prompted a test, performed under the auspices of the Nansen Arctic Drilling Program, of the icebreaker *Oden's* capability to maintain station against the moving ice pack. *Oden,* which has a displacement of 13,000 tons and 24,500 Horsepower with twin screws, is the newest vessel in the Swedish icebreaker fleet which operates in the Baltic Sea.

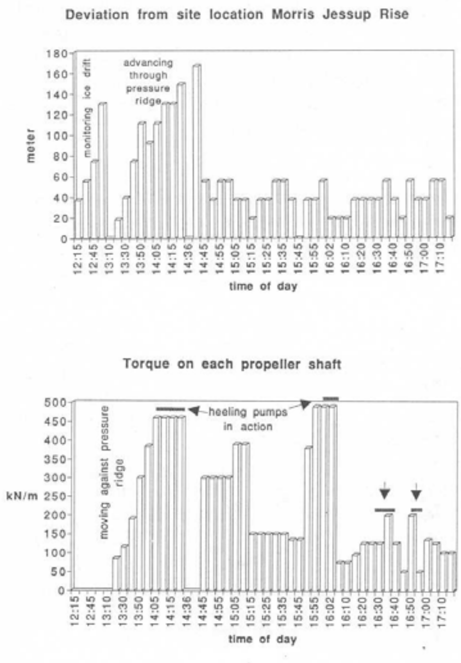

Figure 2. Results of Oden*'s station-keeping test.*

The first test was carried out on Morris Jessup Rise on 16 September 1991 in 8-9/10 pack-ice cover which drifted southeast at a speed of 0.1 knots increasing to 0.3 knots at the end of the experiment. The water depth was 1100 m. Position was monitored by a Magnavox 4400 GPS receiver. After an hour of monitoring the pack-ice drift, the vessel was positioned against a 1.4 x 2 km floe of 2.5 m average thickness with a pressure ridge of 2-3 m sail height, about 30 m from the edge. Initially, the vessel receded 170 m in spite of 75% full forward thrust and heeling pumps in operation (Figure 2). After a short backup (30 m), *Oden* hit the 11.5 m thick and 20 m wide ridge at 2 knots and broke through.

During the next 2.5 hours, as the floe passed over the designated site location, *Oden* had no problem maintaining station to within 40-60 m as determined by the GPS navigation system. The test was terminated at 1715 hours as the floe had passed the site and the ice load became substantially lighter. The heeling pumps provided up to 7 degrees list from port to starboard in 15 seconds. The ship motion broke the ice and the vessel was able to advance in 2.5 m thick ice at reduced forward thrust at sufficient speed to maintain station.

The ice conditions encountered during August and September in the Eurasia Basin and over the potential sampling localities at the Lomonosov Ridge, Morris Jessup, and Yermak plateaus were characterized by small floe sizes, generally less than 1 km, separated by substantial open water in some areas. The size of yearly variations is not known, but 1991 was probably a light ice year. Under such conditions, it is clearly feasible for medium-sized icebreakers like *Oden* to maintain station for periods of several days.

Contrary to previous beliefs, this test proved that an icebreaker can maintain its position in moving pack ice. Therefore, tantalizing possibilities exist for future scientific drilling in the Arctic Ocean since extremely important polar paleoenvironmental objectives can be achieved in an initial phase requiring less than 500 m of penetration in water depths less than 1500 m. Potential drilling vessels would need to keep station for 2-4 days and handle a cruise of 2 months duration. In further planning of the drilling operation, an operational plan should be considered which includes a either drill ship or a drilling barge with two escort vessels.

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Arctic research opportunity

Planning is now underway for an international, interdisciplinary, multi-ship Arctic expedition with a target date of 15 July to 30 September 1995. The expedition's main goal is to better understand the evolution and present state of the Arctic system. Emphasis is on the questions of how the Arctic will be influenced by global change and how a changing Arctic will impact the global climate system. Focus will be on the deep basins of the central Arctic including the Eurasian and Canadian basins and their link to the continental margins and shelf seas. Point of contact is Dr. Peter Schlosser, Lamont-Doherty Geological Observatory, Columbia University, Palisades, New York, 10964, USA. Fax: +1 (914) 365-3183.

Chukchi Investigations

contributed by Arthur Grantz, United States Geological Survey

A USGS geophysical/geological field program to investigate the Chukchi Continental Borderland was successfully completed in 1992. Studies were conducted from the US Coast Guard cutter *Polar Star* from 20 August to 25 September 1992, and the program was led by Art Grantz (Chief Scientist) with Steven D. May, Patrick E. Hart, and R. L. Phillips.

The near-term goal of the project is to acquire sufficient information about the geology and structure of the ridges and basins of the borderland to determine their plate tectonic origin. The long-term goal is to use these data to develop a rigorous model for the tectonic history and reconstruction of the entire Arctic Ocean region, which can not be accomplished in the absence of firm data on the geologic character of the Chukchi Borderland.

During this cruise, the geologic characteristics of parts of Northwind Ridge, Northwind Basin, and Chukchi Spur were investigated. Piston cores were used as long dart cores to obtain bedrock samples from sites on Northwind Ridge where the overburden of Quaternary deposits was known or inferred to be thin.

Geologic structure was studied with a two-channel seismic reflection system with a six-airgun, 900 cubic inch source array that generated a signal every 12 seconds. About 450 km of seismic reflection data were recorded. The airgun source array signal was also received by sonobuoys deployed astern to generate seismic refraction/wide-angle reflection profiles from which deep sediment layer velocities can be calculated. Deeper structure was examined by a marine gravity meter, which operated during most of the deployment, and by a total-field magnetic intensity survey across Northwind Basin. Shallow structure and thickness of Quaternary deposits were determined by use of the ship's 3.5 kHz high-resolution shallow seismic profiler.

The field program produced several findings of general interest. The Northwind Ridge consists of continental crust that has been thrust relatively eastward over oceanic crust in the westernmost Canada Basin of the Arctic Ocean. Northwind Basin consists of continental crust that has been thinned by east-west basin-and-range style crustal extension. The extension was sufficiently intense to produce the Northwind Basin by listric faulting and block rotation, but it was not large enough to produce new oceanic crust beneath the basin. The Chukchi Spur is also a continental fragment which, like Northwind Ridge, was only mildly affected by east-west extension. Work done from *Polar Star* in 1988 indicates that this extension is of Tertiary age. These findings suggest that the Chukchi Borderland was part of the continental margin of the East Siberian Sea in early Tertiary time.

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