A wealth of information about the past climate of the Earth lies buried in the rocks beneath the Arctic Ocean. But drilling in the high Arctic poses unique technical challenges, as **Andy Kingdon**, **Dan Evans** and **Alister Skinner** explain.

On top of the world

The Integrated Ocean Drilling Program (IODP) began operations in 2004. Its second operation, Expedition 302, the Arctic Coring Operation (ACEX), was the first ever mission-specific platform drilling for IODP. It took place in sea ice within 240 kilometres of the North Pole, where drilling penetrated to a maximum depth of 429 metres below the seabed and a total of 330 metres of core were recovered. Prior to this, the longest core recovered from the Arctic Ocean floor was about 16 metres.

The ACEX operation was undertaken during August and September 2004 for IODP, by the ECORD Science Operator (ESO). ESO is a consortium co-ordinated by the BGS and includes the University of Bremen and the European Petrophysics Consortium (EPC, the universities of Leicester, Montpelier, Aachen and Amsterdam).

Mission-specific platform operations differ from conventional scientific drilling as they may make use of vessels that are not primarily drillships. In the case of ACEX, the operation involved three icebreakers: the Swedish registered *Vidar Viking* as the coring vessel and two protecting vessels, the *Sovetskiy Soyuz* and the *Oden*. The two protecting vessels were essential while drilling because the ice was constantly moving, and if not broken up into manageable pieces, would push the *Vidar Viking* off station.

The *Vidar Viking* came on contract at Aberdeen as a bare-decked vessel and was transformed in six days into a drilling platform, complete with the 34-metre high R100 rig installed by Seacore, the drilling contractors. A 100-tonne additional section or stern notch (essential when in ice) and a helideck were added in Sweden before proceeding to Tromsø in northern Norway, inside the Arctic Circle. Here it rendezvoused with the Swedish icebreaker *Oden* before departing north on 8 August. It was joined two days later by the *Sovetskiy Soyuz* at the ice margin, on a date planned nearly a year before, when none of the ships were even under contract.

The powerful *Sovetskiy Soyuz* was an essential component in the success of the expedition. During transits it led the convoy, finding the best paths through the ice so that the *Oden* and the *Vidar Viking* could follow at a good pace. During drilling the *Sovetskiy Soyuz* acted as 'destroyer', scouting ahead of the other ships and breaking larger floes and ice ridges into smaller pieces that could then be broken further by the *Oden* (the 'protector'), allowing the *Vidar Viking* to hold station.

The *Oden*, contracted through the Swedish Polar Research Secretariat, acted

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Transferring personnel between vessels during the Arctic Coring Expedition.

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The destroyer Sovetskiy Soyuz *breaking ice during ACEX.*

as the expedition command centre for ice and fleet management. It was also the base for the small number of scientists who could be accommodated on the offshore part of the expedition. Three scientists were flown by helicopter to the *Vidar Viking* for each shift, but the micropalaeontologists who formed the bulk of the scientific staff had their laboratory on the *Oden* and received regular core-catcher samples.

A key aspect of the success of ACEX was the ice-management programme, including the exemplary co-ordination of the activities of the whole fleet by the experienced Fleet Master, Captain Anders Backman. The *Oden* and the *Sovetskiy Soyuz* broke all but the strongest multi-year ice and allowed the *Vidar Viking* to drill for extended periods. Arno Keinonen, the leader of the ice-management team observed that, 'this work is much more difficult than normal ice breaking, for icebreakers usually avoid the most difficult ice in order to make passage, but in protecting the *Vidar Viking* they have to deliberately break the heavy ice. Taking an icebreaker to the North Pole is easy compared with the task that has been accomplished with ACEX.'

The BGS's contribution was at the fulcrum of all ACEX activities, including overseeing the drilling operations undertaken by Seacore on the *Vidar Viking*. Also on the drillship were ESO colleagues from University of Bremen who were curating and handling the core, while the University of Leicester (for EPC) were responsible for petrophysics including the borehole logging operation that was conducted by Schlumberger. On the *Oden* the scientific operations were co-ordinated by BGS personnel with colleagues from the universities of Bremen and Stockholm. Meanwhile, both at sea and on land, a high-profile media campaign undertaken by the BGS, the University of Bremen and the Swedish Polar Research Secretariat achieved impressive media coverage in some 21 languages and 31 countries.

" taking an icebreaker to the North Pole is easy compared with the task that has been accomplished with ACEX "

Another unique feature of this operation was that the majority of the research was not undertaken during drilling but later, at the IODP University of Bremen Core Repository during November 2004. A larger group of scientists than could be accommodated on the ships were able to undertake detailed examination of the core at this stage. The oldest cores are of Late Cretaceous age. The unconformably overlying younger sediments have already yielded significant results, showing that the sea temperatures of the Arctic Ocean were almost subtropical at the end of the Paleocene. This event is being closely studied as an analogue of a greenhouse climate.

ACEX has been a very real adventure that has broken new technical and scientific barriers in both Arctic exploration and international ocean drilling and will spawn a large number of significant scientific publications. Having demonstrated the ability of a well-chosen fleet with experienced personnel to drill in the Arctic ice, we hope that further drilling campaigns will follow in the region.

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The first samples of sediment from beneath the Arctic sea floor.

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Installing GPS beacons to monitor the ice trajectory.