A 237-meter ice core from South Pole Station

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The Polar Ice Coring Office (PICO) used its new intermediate-depth drill system to collect a 237-meter ice core at Amundsen-Scott South Pole Station during November–December 1982. The core was collected for analysis of microparticle concentrations by the Institute of Polar Studies, Ohio State University (Mosley-Thompson, Kruss, and Bain, *Antarctic Journal,* this issue) of oxygen isotopes by the Quaternary Research Institute, University of Washington, and for carbon dioxide, beryllium-10, chlorine-36, and acidity by the Physics Institute, University of Bern, Switzerland (Stauffer and Schwander, *Antarctic Journal,* this issue). The core was split longitudinally, sampled, and packaged for retrograde to the respective investigators' laboratories in a subsurface science trench excavated adjacent to the drill platform.

The PICO intermediate drill is an electromechanical drilling system designed for continuous coring in firn and ice to a maximum depth of 600 meters in an open hole (Litwak, Kersten, and Kuivinen in press). The drill collects a 10.2-centimeter diameter core in runs of 70–150-centimeter length. A new cutting head includes three bits and core-catching dogs. The surface components are mounted on a platform and include: a Lebus winch with grooved drum containing 700 meters of seven-conductor cable, a dual tower device, a 2.5-kilowatt motor for high-speed raising and lowering of the drill, a 1.25-kilowatt motor for control of penetration and core break, and a control panel. The winch platform, the operators, and a work station are housed inside a modified Hansen WeatherPort shelter (figure 1). A 30-kilowatt, 208-volt alternating-current turbocharged diesel generator powers the winch and drill. The total weight of the drill system including winch platform, drills, generator, and shelter is 6,600 kilograms.

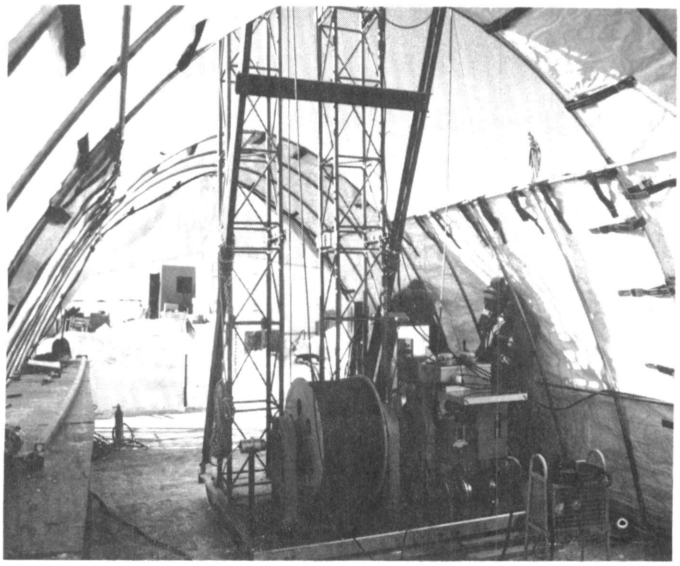

Figure 1. Winch platform including winch drum, tower assembly, and control panel inside the canvas-covered drill shelter at South Pole Station, December 1982.

The downhole portion of the drill was designed and built at PICO in 1979 and was used in conjunction with other winch systems during the 1979–1980 and 1980–1981 seasons at South Pole Station to a maximum depth of 108 meters. The winch platform was designed and assembled at PICO during 1981–1982 and was used with the downhole component of the PICO drill during 1982 at South Pole Station to a depth of 237 meters.

The 1982–1983 antarctic field season provided the first opportunity to use the complete PICO intermediate drill system in a field situation. PICO staff members B. Koci, K. Kuivinen, and J. Litwak were in Antarctica from 9 November to 20 December 1982.

Drilling took place in the center of the taxiway oval at South Pole Station. The drill platform and shelter were set up on a wooden platform after drifted snow and the past two years' accumulation were removed from its surface. A core processing and science trench (3 meters deep by 3.5 meters wide by 14 meters long) was excavated parallel to the drill shelter, roofed with timbers and plywood, and a stairway and tunnel were constructed to connect the drill platform with the science trench. Two vans were positioned adjacent to the drilling platform; one served as a workshop and break room and the other as a laboratory for the preparation and examination of ice core thin sections.

Drilling started at a depth of 108 meters in a hole drilled by PICO in 1980–1981 (Kuivinen 1981). A direct-current drill motor was used throughout the drilling operation. Bits with a 78° cutting angle were used first at 108 meters. These produced very fine chips which packed around the core inside the inner barrel and caused the core to be twisted off at the base before completing a run. Attempts were made to remedy the problem by reducing the clearance between the core and inner barrel wall, increasing the cutting angle of the bits to 55°, and sharpening the cutters, but the problem persisted.

Cutters with a 78° angle from horizontal and no adjustments for penetration eventually produced good core in 70-centimeter runs with penetration rates of 0.5 centimeters per second to a depth of 215 meters. Thereafter, core quality deteriorated, with frequent cracks and wafering occurring and with the length of runs reduced to 30 centimeters or less. Unsuccessful attempts were made to drill using a new head and bit configuration designed and built at the University of Bern. Problems encountered with this head were (1) penetration was limited to 10 centimeters per run due to chips packing behind the cutters and (2) packing around the core dogs resulted in failure to catch the core. Drilling was finally stopped at a depth of 237 meters.

In summary, the new winch and drill system worked well; we experienced no mechanical failures and only one electrical problem with the load-cell readout which was later bypassed. The tower system took 6 workhours to assemble, yet was erected easily, and provided a stable tower throughout the 1-month drilling season. The drill shelter with its 6-section canvas cover and Velcro tie-down straps was easily erected in 8 workhours and provided a satisfactory windbreak throughout the field season. The drill head and bit designs will be revised to include self-stabilizing bits which should result in improved core quality, penetration rate, and run length in the system's next field application.

Figure 2. Solar-powered drill at South Pole Station 1982.

PICO lightweight coring augers (Koci in press) were used by other investigators at the South Pole, on Mount Erebus, and in the Allan Hills region to collect more than 100 meters of firn and ice core for later analysis.

Tests of a solar-powered version of the auger were conducted at South Pole Station (figure 2). Solar panel performance was 20 percent above the rated power output, exceeding results from Greenland during July 1982, due to the lower ambient temperatures and higher altitude at the Pole. We found that 300 watts of power from the solar panels was sufficient to produce penetration rates of the same order as with the electromechanical drills.

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Core processing and analyses of ice cores drilled at the South Pole

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Analyses of ice cores provide unique information on the history of the Earth and the planetary system. This information helps in the understanding of climatic mechanisms. Our laboratory had the opportunity to take part in a joint core drilling and core analysis project at the South Pole. Our main scientific goals in this project were:

- To reconstruct the history of the atmospheric carbon dioxide (CO_2) concentration by analyzing air extracted from ice samples from different depths and, therefore, different ages.
- To reconstruct the history of solar activity by measuring the beryllium-10 and chlorine-36 concentration in ice samples. Both isotopes are produced by cosmic radiation in the atmosphere.
- To measure the acidity of ice cores as a function of depth, which gives, for example, information concerning the volcanic activity in the past.

Ice cores from the South Pole are especially well suited for the CO_2 analyses. Because of the low temperature there is no danger of any interaction of CO_2 with the liquid phase. Three members of our laboratory (W. Bernhard, J. Schwander, and B. Stauffer) were in Antarctica from 9 November to 27 December 1982 to collaborate in the processing of ice cores at the South Pole. During the season, ice cores of a total length of 103 meters drilled in 1980–1981 and 120 meters (from a depth of 106 to 227 meters below surface) drilled in 1982–1983 were processed. The drilling site was 250 meters from South Pole Station.

To set up a processing line, a trench 3 meters deep, 3.5 meters wide, and 14 meters long was excavated next to the drilling site. The core processing procedure is shown schematically in figure 1. The visual stratigraphy (breaks, meltlayers, varying optical transparency) were recorded on graph paper and also with a video camera on tape. The video recordings are very useful later to select samples for special analyses. Breaks and melt layers are visible in the video recordings and, with improved illumination and recording techniques, it should be possible in the future to see finer details as well.

The acidity measurements can be performed in the field, and they were therefore included in the core processing. To perform these measurements, two electrodes were moved with a constant velocity over the flat and clean surface of the ice core. For a voltage of 1,000 volts between the electrodes, the current through the ice was about 2 to 4 microamperes (μA), depending on the acidity in the ice (Hammer 1980). The acidity in the ice shows the following characteristic features: