operated in the field in Antarctica. Since this equipment requires much smaller samples, it will be possible to increase the resolution with which the yearly snow layers can be examined by a factor of at least five over that used in the study reported here. Such extremely high resolution sampling will permit the intrinsic errors to be quantified, and the capability for field operation should eliminate nearly all of the extrinsic errors.

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South Pole ice core drilling, 1981–1982

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A cooperative ice core drilling, core processing, and stratigraphic logging program was conducted at Amundsen-Scott South Pole Station during the 1981–82 season by investigators from the Polar Ice Coring Office (PICO), the national Hydrology Research Institute/Environment Canada (NHRI), and the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL). A 202.4-meter ice core was collected, logged and packaged in the field, and then shipped to the CRREL ice core storage facility, where it will be made available to National Science Foundation-sponsored glaciologists for further analysis.

The principal objective of the field program was to collect a 200-meter core from the South Pole Station in order to extend the site's ice core chronology beyond the existing 115-meter depth. This was accomplished by using the Canadian Rufli-Rand electromechanical drill, which had been used in 1980 on Mount Logan (5,300 meters elevation) to collect ice cores to a maximum depth of 103 meters (Holdsworth in press). The drill's design is based on principles established by Rufli, Stauffer, and Oeschger (1976) and by Rand (1976). The drill collects a core 96–99 millimeters (3.8–3.9 inches) in diameter in runs averaging 1 meter in length. Unique to the Canadian drill system is a geodesic dome that serves as a structural unit supporting the central fixed tower and providing shelter for the drill crew. The entire packaged drill system, including winch platform, tower, drill, and shelter, weighs 730 kilograms (1,606 pounds).

The drill shelter, a core processing laboratory van, and PICO's 6.5-kilowatt generator were set up in the center of the station's taxiway oval (figure 1). A core storage trench (3 meters deep × 3 meters wide × 6.4 meters long) was excavated adjacent to the drill site. Drilling began on 17 December with a three-member drill crew and one core processor and continued for 22 days until drilling stopped at a depth of 202.4 meters. The average working day under normal conditions was 7.5 hours.

Initial problems with the antitorque spring-skate system and cutting bits were overcome as drilling progressed. During drilling runs in the upper 60 meters of the hole, the oversized antitorque system tended to jam in the hole, thereby reducing the penetration rate and causing a "stick-slip" motion as the drill

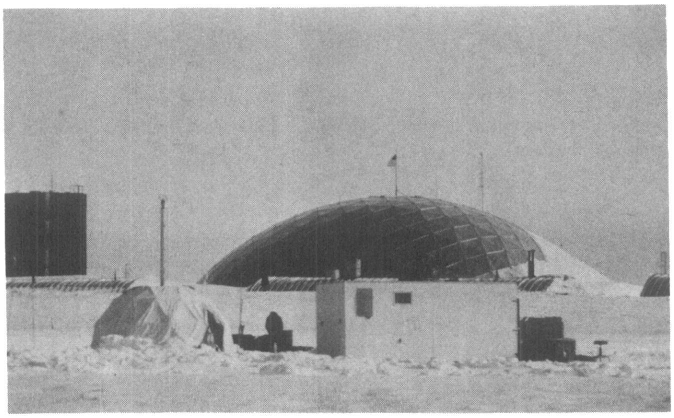

Figure 1. The drill shelter and laboratory van in the center of the taxiway oval at South Pole Station, January 1982. (Photo by B. Koci)

progressed down the hole. The cutters used were mainly those with a 15-degree clearance angle; this, coupled with reduced penetration rates, produced very fine chips. After installation of cutters that took bigger bites and addition of ice skates to the antitorque springs, drilling resumed, with the drill current increased slightly from the normal 1.0 ± 0.2 ampere to 2.0 amperes. Upon completion of one run and winching of the drill, it was apparent from cable-blistering at the sheave and tangling above the drill/cable termination that the antitorque section had failed to keep the drill from rotating downhole. As a result, approximately 62 meters of cable had to be cut off and the remaining 273 meters of cable reterminated. The antitorque system was completely reworked to eliminate jamming in the hole.

Normal drilling resumed on December 23 at a depth of 60 meters (with runs averaging 80–90 centimeters and turnaround times of 17.5 minutes) and continued to the firn/ice transition at approximately 115 meters. Below this depth, turnaround times increased to 20 minutes per run (5 minutes of actual drilling time) and core lengths were reduced to 70–80 centimeters.

At 127 meters, the cable was reterminated to correct a short circuit and the antitorque system was reworked. The increased hardness of the ice at this depth and the −51°C temperature dulled the cutter edges; the resulting fine ice chips were difficult to transport along the drill's auger flights. This made it necessary to sharpen the bits before each run. These problems contributed to gradually declining core production (5–8 meters per day) and to termination of drilling at 202.4 meters.

CRREL's contributions to this project were providing glaciological expertise, including measurements of the basic physical and structural properties of the cores, logging, and stratigraphic analysis, and packaging of the cores at the drill site, and furnishing refrigerated facilities for processing cores for analysis by NSF-approved investigators. All cores were successfully age-dated on the basis of well-preserved annual layering, using techniques previously applied with success by Giovinetto (1960) and by Gow (1965). This depth—202.4 meters—is the deepest at which visible stratigraphy has been successfully delineated in ice cores. The core is estimated to represent a record of snow accumulation extending back approximately 2,000 years. This attention to stratigraphy is needed to ensure that sampling of the cores for geochemical, microparticle, entrapped gas, and stable isotope records will be performed on the basis of natural stratigraphic breaks. In the past, much valuable information has been lost because of the failure of most investigators to recognize the importance of stratigraphy in the selection and preparation of their samples.

While at the drill site, A. J. Gow also initiated studies of the density, bubble patterns, and crystal dimensions of the cores. Preliminary measurements of density and load are presented in figure 2. The firn/ice transition occurs at a depth of approximatey 115 meters, the deepest ever recorded in Antarctica.

Upon completion of drilling, all cores were airlifted to McMurdo Station for subsequent transshipment to CRREL, where they will be processed for analysis by approved investigators.

In addition to work with the ice core, PICO team members collected three gas samples for the Physics Insitute, University of Bern, Switzerland. The samples were collected through a Teflon tube inserted in 1980–81 in a borehole to a depth of 40 meters below the surface. The University of Bern reports that all gas samples show atmospheric composition. Collection of air samples from the firn will be repeated during the 1982–83 field season. These gas content analyses are important with respect to the interpretation of data from gas analyses performed on old ice samples (Stauffer 1981).

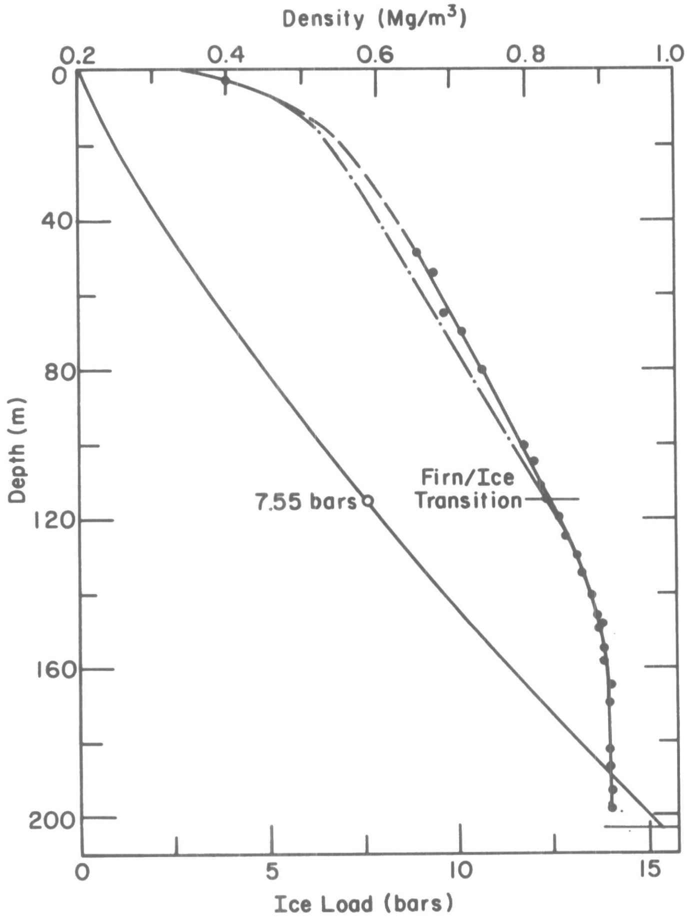

Figure 2. Density and ice-load profiles to 203 meters depth at the South Pole. Density curves obtained by Giovinetto (1960; dashed lines) and by Chiang and Langway (dashed-dotted lines) also are indicated. Density is measured in megagrams per cubic meter. (Figure by A. J. Gow)

PICO also prepared the Gearhardt-Owen logging winch (used previously in logging and sampling the Ross Ice Shelf Project access holes at J–9) for use by University of Wisconsin-Madison geophysicists in their sonic logging of the 900-meter borehole at Dome C.

The drill team consisted of G. Holdsworth, B. Koci, and K. Kuivinen; A. Gow performed the core logging and stratigraphy.

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