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A 905-meter deep core drilling at dome C (East Antarctica) and related surface programs

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Following reconnaissance work during the 1974-75 field season (Lorius, 1975) and the development of a 1,000-meter deep thermal drill in our laboratory, it was proposed to use this equipment at dome C ($74^{\circ}39'S, 124^{\circ}10'E$, elevation 3,200 meters). The accumulation rate for the last 20 years (4 centimeters of ice per year) obtained from radioactive fallout layers indicated that it could be possible to reach the coldest part of the Wisconsin ice age, the ice layers down to that depth being free of perturbations connected with ice dynamics. The hope of getting a good climatic record was also supported by the present linear relationship between the surface mean annual temperature and the stable isotopic composition (δD and $\delta^{18}O$ per mill) observed from the coast near Dumont d'Urville up to the plateau near dome C (Lorius and Merlivat, 1977). Although isotopic variations connected with past changes in ice thickness are probably small in central parts of East Antarctica, we also planned to use the total gas content to separate purely climatic events (Raynaud and Lorius, 1973).

Time permitting, we also intended to sample for depicting changes in the chemistry of the atmosphere from the study of the snow, both at South Pole and dome C sites. Previous work (Boutron *et al.*, in press) indicated that heavy metals (lead, cadmium, copper, etc.) are highly enriched when compared with elements from crustal (aluminum) or oceanic (sodium) origins. For these pollutants a small but significant increase

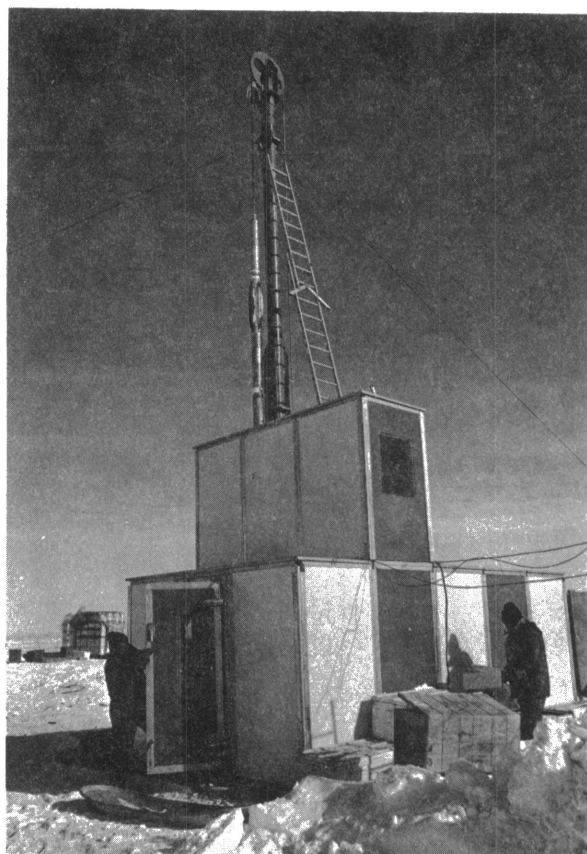


Figure 1. Drilling shelter and electromechanical corer, Dome C, 1977-78 field season.

was also observed during the past 25 years. Sulfates also showed marked changes, some of these being connected with volcanic events such as Mount Agung in 1963 (Delmas and Boutron, in press). To determine the relative contributions of natural phenomena and industrial activities, it was thought necessary to dig clean snow pits for sampling a longer time period because of the risk of contamination with coring devices was high.

The overall project was delayed by LC-130 Hercules airplane crashes. Successful recovery operations were completed during the 1976-77 season (Bellafronto, 1977). Finally, as part of the International Antarctic Glaciological Project (Radok, 1977), a 905-meter deep core was recovered at dome C during the 1977-78 field season. The team was composed of M. Briat, T. Cappellet, D. Donnou, P. Duval, M. Dumerchat, G. Lorius, F. Pinglot, C. Rado, G. Ricou, N. Rousset, S. Thomere, J. P. Valentin, and G. Yvon. The first of the 14 flights required to support this operation (35 tons of equipment, 7 tons of ice samples, and fuel) was made on 18 November 1977; the last was made with the closing of the camp on 31 January 1978. With the assistance of U.S. Navy personnel, the camp and runways facilities set up during the previous seasons for the recovery of crashed LC-130s were reactivated first.

The drilling started on 4 December 1977; working in two shifts around the clock, it took 72 hours to reach the 141-meter depth with a newly developed electromechanical corer. (See figure 1.) A thermal system (Gillet *et al.*, 1976) was then

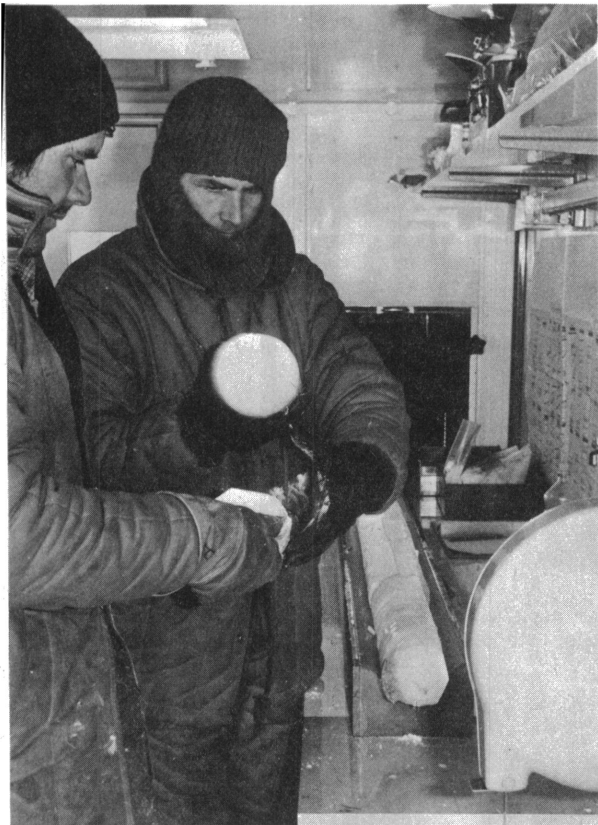


Figure 2. Processing ice cores in the cold laboratory, Dome C, 1977-78 field season.

used. The drilling was stopped after 42 days at a depth of 905 meters, the mean rate of progress being of the order of 1 meter per hour. This figure includes the time required to overcome technical problems which occurred mainly at 620 meters, at which depth almost no progress was made during 5 days. Although our cable was a little longer, we were unable to core deeper than 905 meters, probably because of the rate of closure of the dry hole. Tests with fluid were made for future developments. Recovery of the core, which is 100 millimeters in diameter, went well, but all the samples obtained with the thermal equipment show cracks.

Several operations were carried out along with the drilling (figure 2): logging and sampling for further laboratory studies (including in the United States), total gas content determinations (down to 170 meters), crystal size measurements, tests for mechanical properties of the ice, and filtration of the collected meltwater. *In situ* measurements consisted of diameter and temperature profiles.

Although it was not possible to wait for equilibrium, the latter shows a minimum in the first 100 meters, the temperature being of the order of -47°C near the bottom of the hole. The mean crystal size values show distinct features that appear to be connected with climatic changes depicted from

the first stable isotope analyses. The δD and $\delta^{18}\text{O}$ per mill values are rather constant in the first 400 meters, which probably cover the Holocene period (about 10,000 years). The transition to a colder climate then takes place, and approximately the last 350 meters of the core consist of precipitations deposited during the last glacial period (Wisconsin).

A surface program was also carried out. It included meteorological observations and atmospheric sulfur dioxide (SO_2) sampling. The former dome C site (a few kilometers away) was reoccupied for snow surface and accumulation studies. The 5-meter-deep pit dug 3 years ago was extended down to 8 meters for stratigraphy and snow sampling. Shallow coring and temperature measurements were also performed.

The dome C team spent some time at South Pole for acclimatization. This allowed the start of digging a 10-meter-deep snow pit which, along with the one at dome C, was covered at the end of the season for further use. Stratigraphic studies and detailed sampling were performed by J. R. Petit and M. Pourchet; after completion of the program the latter joined the dome C team on 29 December 1977.

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