ICE DRILLING AT CAPE FOLGER, ANTARCTICA

V.I. Morgan, A.P. McCray and E. Wehrle
Antarctic Division, Department of Science and Technology, Kingston, Tasmania, Australia

ABSTRACT

The use of a modified USA CRREL thermal drill is described and discussed.

INTRODUCTION

Ice drilling undertaken at Cape Folger, Antarctica, in 1981/82, is a continuation of an extensive glaciological investigation of the Law Dome ice cap, which has been studied since 1957 (Budd, 1970). The boreholes drilled in 1969 were used to study ice deformation and the core was used to study ice crystal size, crystal orientation fabrics, oxygen isotopes and ice flow properties with depth (Budd and Morgan, 1977). The latest drilling is specifically designed to clarify certain peculiarities in the ice flow which were observed previously (Russell-Head, 1979). There appear to be large irregularities in the magnitude and direction of shear strains.

The two boreholes lie along a surface flow line, one over a bedrock high point, the other over a dip in the bedrock, 300 m down glacier. Both holes extend to within a few meters of the bed, as deduced from the presence of small rock fragments contained in the lowest core retrieved from each hole.

THE DRILL UNIT

A modified USA CRREL thermal drill (Ueda and Garfield, 1969; Bird and Ballantyne, 1971) was used. The core barrel has been lengthened and the melt tank enlargened to allow a 2 m long core to be taken. The heater head assembly is that constructed by Russell-Head (1979) and uses a single element cast in a copper annulus. This has proven to be much more reliable than the previous system of cartridge heaters pressed into an aluminum head. The copper head is slightly larger than the drill barrel, to facilitate the passage of the drill in a hole which is closing.

The temperature at the head and the melt tank vacuum are both monitored. The head temperature is not critical with the copper head, since it does not melt down as easily as the aluminum one did, but it is a useful indicator of thermal contact between the head and the ice, particularly when reaming.

The melt tank vacuum reading shows up malfunctions in the water extraction system, failures of which can result in freezing in of the drill.

An hydraulic motor is used to raise and lower the drill and an hydraulic ram, which lowers the cable sheave, is used to feed the drill when coring. Better quality cores and a somewhat faster drilling rate are obtained when using this feed system.

THE DRILLING OPERATION

Due to the lack of hydrostatic balance in the hole during drilling, and the relatively high temperatures near the bottom of the hole, large closure rates of up to 1.3 mm/h were encountered. This introduced considerable difficulty during drilling, and towards the base of the holes, several reaming runs (in which the drill is operated at slow feed rate, with both heater and vacuum pump on) were necessary before taking each core. Drilling was stopped in the first hole at 301 m due to low penetration rates and the danger of losing the drill due to rapid hole closure. The radar equipment indicated an ice thickness of 303 m at this site.

In the second hole, after taking a core containing rock fragments, no progress was being made, possibly due to the existence of larger particles, so drilling was stopped at 344.5 m. The radar equipment indicated an ice thickness of 350 m at this site. However, the radar reflection will probably be from the highest layer of substantial rock fragments, so the exact bedrock depth may not have been established.

INSTRUMENTATION

The holes were logged for temperature, diameter and inclination. A platinum resistence thermometer connected to a Leeds and Northrup 8078 resistence bridge gave temperatures to $\pm$ 0.01°C. Schaevitz LSRP-5 and LSRP-30 sensors are used to measure the borehole inclination. For short period monitoring (of order 50 h) apparent tilts were erratic, possibly due to settling of the instrument in the hole. The latest boreholes have been relogged (1982/83) after periods of 0.5 a and 1 a and inclination changes of up to 12° have been measured in the lower levels (McCray, unpublished).

DISCUSSION

Eight boreholes have now been drilled approximately along a flow-line running from the dome summit to Cape Folger on the Law Dome. The holes near the edge, extend well into Pleistocene ice and the latest two penetrate practically to bedrock. Research is presently concentrated on climatic change as interpreted from the oxygen isotope data. Ice dynamics studies are in support of this research.

For the future, an improved thermal (or mechanical) drill, capable of drilling in a fluid filled hole, would allow a borehole to be drilled from the dome summit to bedrock where the ice thickness is about 1300 m. This is a particularly favorable site, as absolute dating may be obtained from the seasonal signal in the $\delta^{18}O$ variations that are locked in because of the high accumulation rate (approximately 1 m/a).

REFERENCES

Bird, I.G. and J. Ballantyne (1971) The design and application of a thermal ice drill. Technical Note No. 3, Department of Supply, Antarctic Division, Melbourne, 25 p.

Budd, W.F. (1970) The Wilkes Ice Cap Project. ISAGE Symposium Proceedings, ISAH Publication No. 86, p. 414-29.

Budd, W.F. and V.I. Morgan (1977) Isotopes, climate and ice sheet dynamics from core studies on Law Dome, Antarctica. Proceedings of a symposium on isotopes and impurities in snow and ice. ISAH Publication No. 118, p. 312-21.

McCray, A.P. (unpublished) Some aspects of ice sheet flow from studies of boreholes near Cape Folger, Antarctica. *M. Sc. Thesis, University of Melbourne, Australia.*

Russell-Head, D.S. (1979) Ice sheet flow from borehole and laboratory studies. *M. Sc. Thesis, University of Melbourne, Australia.*

Ueda, H.T. and D.E. Garfield (1969) The USA CRREL drill for thermal coring in ice. *Journal of Glaciology,* vol. 8, no. 53, p. 311-314.