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TECHNICAL NOTE

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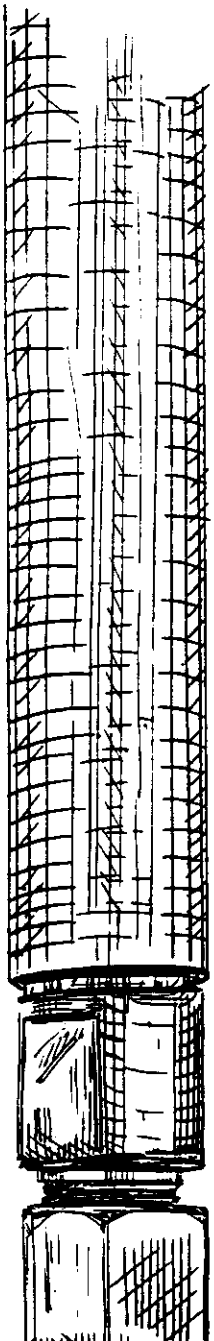

Review of Methods for Cutting Ice Cores

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Sampling of an ice core for chemical and physical analysis involves making many cuts of varying shapes. The volume of ice lost in the cutting process becomes significant, especially in areas of particular interest. New processes such as laser and liquid jet cutting are worthy of investigation because of the narrow kerf, lack of mechanical shock, and omni-directional cutting ability.

Currently, band saws are used to section cores while plastic hole saws are required for "clean" sampling. Both introduce mechanical vibration and stress perpendicular to the direction of cut. Contamination from lubricants and wheel materials must also be considered. Thickness of cut ranges from 0.8 to 1.5 mm.

The use of lasers is being reinvestigated by Zeller and Dreschoff[1] (pers. comm., 1991). This process was investigated by Thompson[2] (pers. comm., 1983) and Koci (unpublished data, 1984) with poor results. Previous investigations used a pulsed laser which may have contributed to the core shattering. Present investigations involving the use of a continuous 10W CO_2 laser are promising. A piece of ice core from 150-m depth at GISP2 was used after it was cooled to -40°C. Since this cutting method is thermal, high specific energy requirements result in slow cutting speeds unless the kerf is narrow (<0.2 mm). Further tests using a 25W CO_2 laser are recommended.

A third option, using high pressure liquid to cut core, was investigated at Flow International, Seattle, using core from 150-m depth.

Water or another liquid is run through an intensifier where the pressure is increased to between 200 and 360 MPa. High pressure liquid is directed through a small nozzle (0.1 mm or larger) where the flow is accelerated to 1000 m/sec. Mass flow through the nozzle is 0.3 (1/min). Flow continues through material being cut without adhering to the surface.

Two series of tests were run to determine feasibility of cutting an ice core using a high pressure liquid jet. The first test involved making longitudinal cuts, cylindrical sampling from the core center, and observations on making thin cuts. The second set of experiments examined temperature rise in the core as a result of the cutting process.

Cutting an ice core at -15°C was successful. The jet easily cut 15 cm of ice with clean edges. Surface finish and the ability to make thin cuts without fracturing the ice core were demonstrated (Figures 1 and 2).

A core at -40°C was instrumented with a 3-point calibrated thermistor placed 3 mm from the cut. Temperature rise within the core was less than predicted (Jois *et al.*, 1990)[3]. The core was subjected to thermal shock from high humidity and a room temperature of 23°C. Some surficial cracking of the core occurred which was not a direct result of the cutting action. There was no evidence of thermally-induced cracking which might be expected from the interaction of warm water with the ice. High jet velocity and low mass flow limit water contact with the ice, hence heat transfer is kept to a minimum. Under lab or field conditions, mineral oil is recommended to prevent freezing and possible contamination of the sample.

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High pressure liquid jets appear to be an appropriate method for sectioning ice core under laboratory or field conditions. The narrow kerf and omni-directional cutting ability reduces stress on the core. The cutting process can be pre-programmed to provide accurately-sliced samples free of contamination quickly and efficiently. A lack of apparent thermal shock is evident even when water is used as the cutting medium.

Although liquid jet cutting methods appear to be feasible, the anticipated cost (~$100,000), power consumption (25 kW) and weight/cube of the equipment is high. Laser shaping devices for ice cores, if ultimately proven to be useful, may provide a programmable means for cutting and shaping of ice cores with minimum impact on the ice.

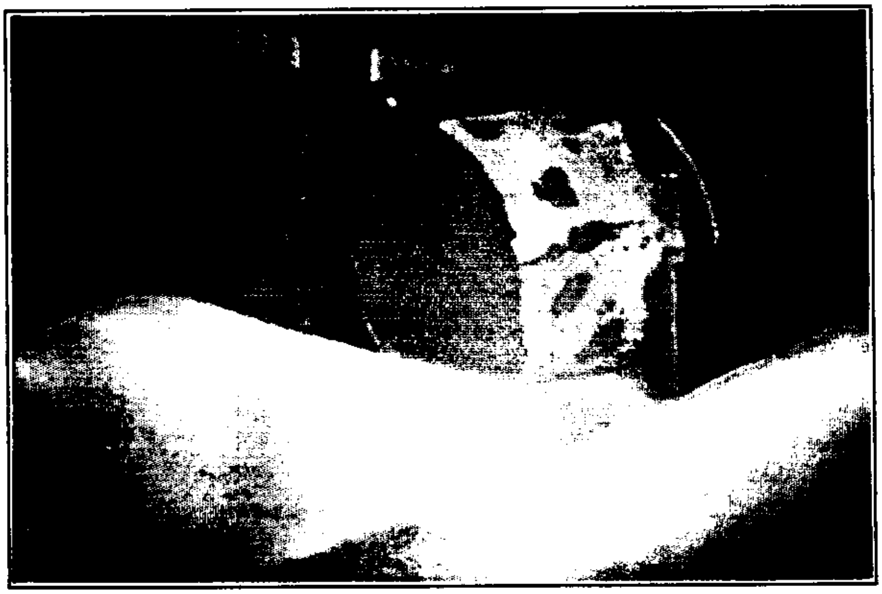

Figure 1. Longitudinal cut.

Figure 2. Demonstrating ability to cut thin slices.

[1]E. Zeller and G. Dreschoff, University of Kansas, Lawrence.
[2]L. Thompson, The Ohio State University, Columbus.
[3]Jois, S., D. Das and B. Koci, 1990. Temperature rise in ice coring during water jet cutting process, PICO Technical Report 90-3, University of Alaska Fairbanks, Fairbanks, AK.