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THERMAL DEEP DRILLING IN CENTRAL GREENLAND

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Cold Regions Research and Engineering Laboratory
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13. ABSTRACT

Drilling into ice represents essentially a different problem than geologic boring. From an engineering standpoint, the main problems involve the viscous deformation of the ice and the refreezing of the melted water, from which drilling rods or cables become jammed unless preventive measures are undertaken. In the deep ice drillings, one is interested primarily in the temperature profile. The author developed a thermal deep-drilling probe with which the deepest ice layer on earth (over 4000 cm) can be pierced. Within the scope of the IGGE, two such probes were put into operation for drilling at the Jarl-Joset Expeditionary Station in summer, 1968. Apart from the heating element difficulty with the premature ending of the run, the operation proceeded according to plan and the measurement yield was copious.

14. KEY WORDS

Deep drilling	Melt water
Freeze-thaw cycle	Refreezing
Heating	Temperature profile
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THERMAL DEEP DRILLING IN CENTRAL GREENLAND

Umeschau (Review), No 16, 1960
pp 515-516

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For measuring the temperature profile of thick ice layers, a probe has been developed which melts its way into the ice. Two probes of this type (Figs. 2 and 3) were utilized in Central Greenland and new experiences were gained thereby. The evaluative studies have now been partly completed.

Drilling into ice represents essentially a different problem than geologic boring. From an engineering standpoint, the main problems involve the viscous deformation of the ice and the refreezing of the melted water, from which drilling rods or cables become jammed unless preventive measures are undertaken. In the deep ice drillings, one is interested primarily in the temperature profile. However, one can also measure this with a lost probe, which in addition can serve other purposes, such as measurements of pressure, seismic, radar and ice motion parameters. These considerations have led the author to the development of a thermal deep-drilling probe (see Umschau for 1966, No. 11, p 360) with which the deepest ice layer on Earth--over 4,000 m-- can be pierced.

By means of electrical heating, the probe melts its way through the ice without any mechanical drilling motions. The pair of wires for transmitting the heat output and the measurement data is built into the probe and winds from here outward into the ice, where it freezes in. Within the scope of the IGGE (International Glaciological Greenland Expedition--Denmark, Germany, France, Austria and Switzerland), in summer of 1968, two such probes were put into operation for deep drilling at the Jarl-Joset Expeditionary Station (Fig. 1).

These probes were powered by two 5 kw gas generators which had already been installed in 1967. More than 20 tons of gasoline had been dropped from low-flying aircraft in 1967 without the use of parachutes. The remaining material was hauled in together with the personnel in 1968: by airplane over the western glacier and fault zone, and over the main route across the ice cap by full-track vehicles ("weasels") including camping and sledding equipment.

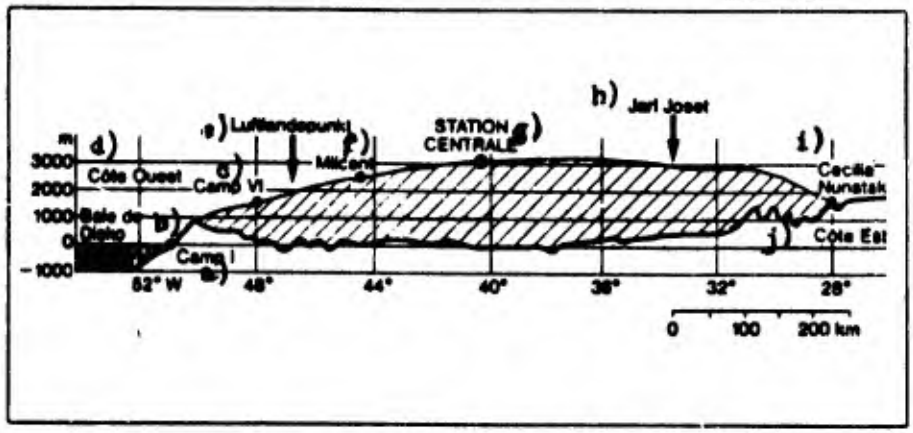

Fig. 1. Section Through Ice Shield Along the IGGE Route: from Baie de Disko Toward Kaiser-Franz-Josef-Fjord (According to E.P.F., Report No. 16) Key: a), b), c) read as they are; d) West Coast; e) air landing point; f) read as is; g) Central Station; h) read as is; i) as is; and j) East Coast.

At this time, we had temperatures (second half of April) to below -40°C. One could seldom travel at more than 8 km/hr. We reached Jarl-Joset on 21 May 1968. Probe I was started from a 4.5 m deep shaft (Fig. 3), and probe II was started from "Dumont Tunnel" leading to 40 m under the surface. At the heating cartridges serving for propulsion at the lower end, in both probes disturbances developed relatively quickly, later causing a short-circuit. Accordingly probe I reached only 220 m depth; after a planned delay at 600 m, probe II reached 1,000 m. Apart from the heating element difficulty with the premature ending of the run, the operation proceeded according to plan. The measurement yield (temperature values plus numerous operational data for the probes) was copious (see the Table). Additional drillings based on this novel principle are planned.

Table. Some Data and Results Obtained from Thermal Deep Drilling

Jarl-Joset:	330°30'W, 71°21'N; altitude 2865 m
	Ice thickness about 2500 m; average firn temperature -28.5°C
Probe dimensions:	diameter 11 cm; length 260 cm; wire length 2 X 3100 m
Course of probe :	Up to 50 m/day at 4 kw total outper per probe; vertical state (Checked by inclinometer) good
Depth measurement :	With the 100 Hz harmonic measurement of coil inductance.
Pressure Measurement:	Wire strain gauges: 600 m: 1, 1.5, 4 and 20 hrs after heating connection: 100 or 140 100 or 50 atm
Temperature:	-29.°C at 220 m;-29.3°C at 600 m; and -30°C at 1,000 m.

Fig. 2. The "Annemirl" Is Ready for Operation. The bottom part (with copper jacket) contains a heating element and measuring instruments; the long epoxy tube contains the winding reel and the oil tank.

The drilling was conducted jointly with Pater H. Jännichen and E. Gmeineder, with assistance from a French field engineer. All the participants are thanked sincerely, and also the DFG, the Swiss National Foundation and the French Polar Expedition.

A detailed report will be published in Meddelelser om Grönland.

Fig. 3. Lowering the Probe in the 4.5 m Shaft; Thereupon. Oil Was Poured in, Filling the Cavity in and Above the Winding Reels.