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Recent Soviet activities on ice core drilling and core investigations in Arctic region

Victor S. ZAGORODNOV
Institute of Geography, USSR Academy of Sciences, Moscow, 109017, Staromonetny per., 29 USSR

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Abstract

This article provides a discription of the equipment of the thermal drill for liquid-filled hole for investigation of both temperate and cold glaciers in Arctic region. Some results of deep thermal drilling done at some glaciers in Svalbard are described. Ice core analysis is also mentioned. From May to June 1980 the 368 m deep ice core samples were obtained in the central part of the Amundsenissen in Svalbard. This glacier contained abandant water in ice. In Svalbard archipelago both temperate and cold glaciers exist, showing negative temperature gradient. Temperate glaciers were found in Polar Ural mountains. Cold conditions and negative temperature gradient were discovered for glaciers in Franz Josef Land and Severnaya Zemlya.

1. Introduction

Investigations of glaciers in the Arctic region have been carried out in these ten years by expeditions of Institute of Geography, the USSR Academy of Sciences. Most of knowledge about climate and glacier conditions in Svalbard and in the Soviet Arctic region was obtained during IGY (1957–1959) (Kotlykov, 1985).

The first Soviet glaciological research work in Svalbard dates back to 1965–67 (Kotlykov, 1985) and in 1974 the second stage of investigations has started for more detailed study of mass balance, hydrology, fluctuations of glaciers, composition, thermal regime, evolution of glaciers in the archipelago during Pleistocene and Holocene with broad application of such modern geophysical and geochemical methods as radio-echo sounding and thermal drilling.

The Arctic and Antarctic Research Institute has also started glaciological investigations in Severnaya Zemlya in 1975. Table 1 and Fig. 1 show the outline of recent ice core drilling carried out by Soviet glaciological expeditions.

Table 1. Soviet Ice Core Drilling Activities in Arctic Region.

AREA	YEAR	TOTAL DEPTH OF HOLE, m	
		with core	without core
Svalbard	1975-1985	1586	950
Franz Josef Land	1957-1959	196	
Severnaya Zemlya	1975-1987	2500	500
Polar Ural	1973-1974	110	900

2. Electrothermal drills

Glaciers in Arctic region, except the central part of Greenland Ice Sheet and the upper part of some polar type glaciers, melting occurs in summer. Many glaciers, particularly existing in Iceland, also in south and west coast of Svalbard are temperate type and contain much of water in glacier body. Drilling system and ice core investigations for such glaciers lead to need special technique to dig a hole and unique analysis to study ice cores.

Arctic and Antarctic Research Institute, Leningrad has been developing technology and equipment for drilling at temperate and polar type glaciers under contract with the Institute of Geography, the USSR Academy of Sciences (Korotkevich and Kudriashov, 1974; Morev, 1972). These equipments were tested at temperate glaciers in Polar Ural in 1974, Pamir in 1972 and in Spitsbergen as well as at the Ross Ice Shelf and some other places in Antarctica (Zotikov, 1979).

Electrothermal "hot-point" drill system is shown in Fig. 2a. It consists of electric heater, pipe and

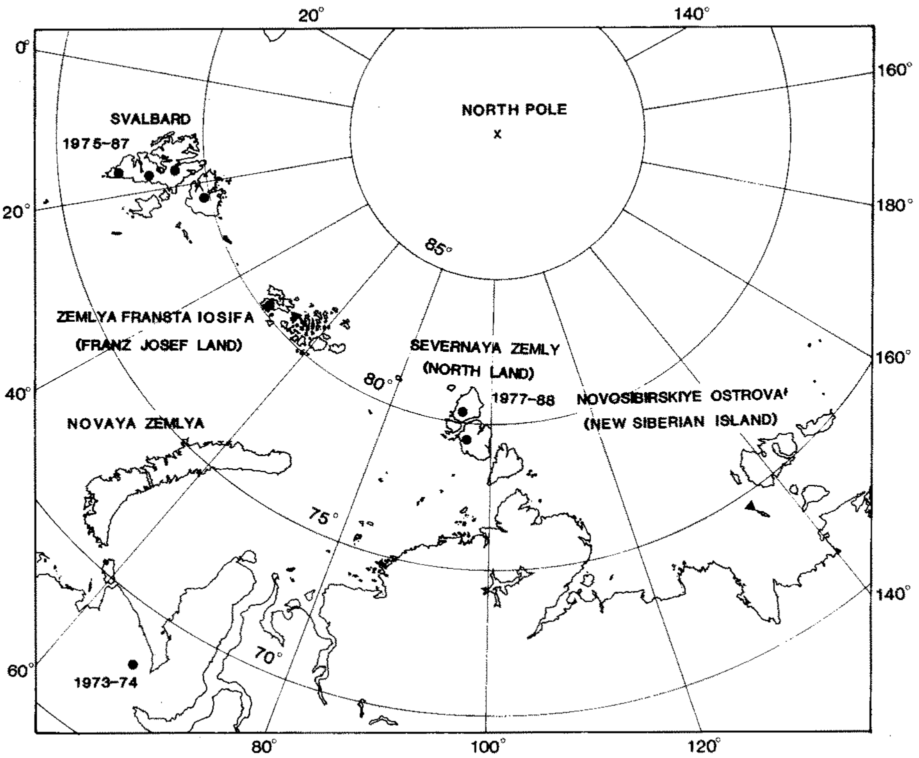

Fig. 1. Location of ice core drilling sites done (solid circle) and planned (solid triangle) in the Arctic by the Soviet glaciological expedition.

plag. Input voltage for electric heater is 220–320 volts, and the velocity of drilling in pure ice reaches 12–18 meter per hour. The dimensions are 40 mm in diameter, 1.5 meter in length, and 30 kg in weight. This drill has reached 586 m in deepest borehole in Amundsenissen, Svalbard in 1980 (Kotlyakov, 1985).

Electrothermal drill for liquid filled holes is presented in the Fig. 2b. It consists of core barrel, piston, core catchers and ring heater. Alcohol-water mixed anti-freeze is stored in the inner pipe of core barrel and is pushed out through holes of the piston by upward movement of the piston during ice core drilling. Anti-freeze then goes to the bottom of the hole and mixes with melted water.

Diameter of the borehole is 110–120 mm and diameter and the length of the core are 75–82 mm and 1.5–3 m, respectively. The drilling speed reaches 5 m per hour. During the first 24 continuous working hours, drilling speed reaches to the depth of 100–110 m and 45 to 50 m per day at the depth of 500 m.

We had not happened to meet any technical problems and could obtain the core samples with good quality for temperate glaciers and for cold glaciers with uniform temperature distribution in the Arctic. On the other hand, we have great difficulties during the drilling at cold glaciers with negative temperature gradient. In such conditions segregation of ice would occur during drilling. To prevent this phenomenon, we extract the melted water from the borehole when the negative temperature gradient takes place. In order to settle this problem, new antifreeze of alcohol-glycerine-mixture is designed to use in the borehole in the future.

We have used this thermal drill under the temperature condition from 0° to −32°C. New thermal drill for exploration under the temperatures up to −60°C has experienced in Antarctica. More than 6000 m in total length of ice cores have been recoverd using the present thermal drilling equipment in both Arctic and Antarctic regions. Maximum depths of boreholes in Antarctic and Arctic regions were attained 870 m and 561 m, respectively.

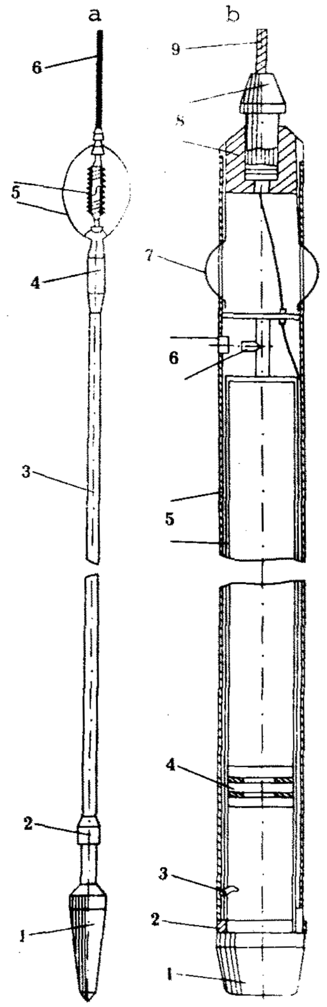

Fig. 2. Electrothermal drilling system. a : hot-point type drill : 1—conical electrical heater, 2, 4—connector, 3—tube, 5—spring centering device, 6—cable wire ; b : thermal drill for liquid-filled holes : 1—electrically heated ring, 2—flange, 3—core catchers, 4—piston, 5—stainless steel outer and inner pipes, 6—pipe for filling inner pipe with antifreeze, 7—leaf spring, 8—drill head, 9—cable wire.

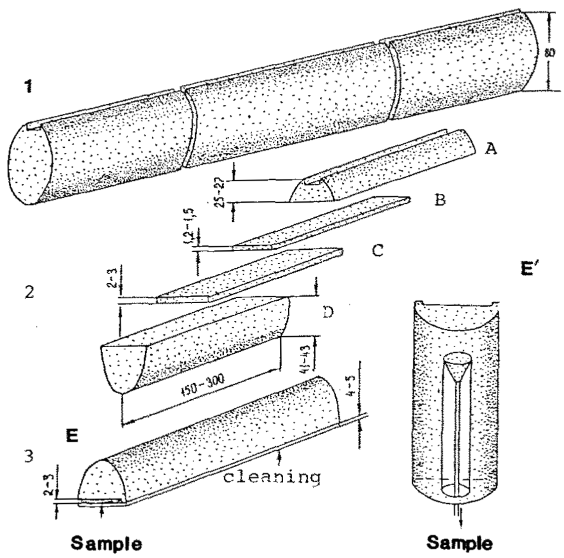

Fig. 3. Succession and types of ice studies.
1—stratigraphic studies : description, photographing, continuous measurements of optic density, electric conductivity and shear strength,
2—stuctural studies : A—sample for density, isotope and chemical composition and microparticles concentration and for spores and pollen ; B—sample for photographs of crystal structure and air bubbles ; C—sample for pholographs of air bubbles ; D—residual core after samples A, B and C were cut out by electrothermal cutter.
3—isotope-geochemical studies : E—selection of samples without ice melting by mechanical sampler ; E'—melting of the core centre by hydrothermal sampler (remainder is used for ice density measurements and measurements of gas pressure in it). All the dimensions are given in mm.

3. Ice core investigations

The drilling and in-situ ice core analysis were carried out by a team consists of 5 to 8 members.

Figure 3 shows the consistency of operations of ice core investigation. The description and photographing of an ice core are made just after its extraction from the drill. For stratigraphic observation of the core is lighted from both sides and is photographed from the above. Then electric conductivity and optical density are measured continuously along the core. Operations mentioned above are performed on a special mount.

Then core is cut into 10—30 cm in length. Core cross section is made by a band saw.

With a help of an electrothermal cutter (Fig. 4), these core pieces are cut into two plates (each thickness 1—1.5 mm and 3—3.5 mm) and two segments. These plates are photographed on a phototable in polorized and reflected light in micro-and macro scale. The thickness of plate are measured on this table. The variation of thickness is no more than 0.1 mm from one speciment to other.

With the ice core plate, measurements of concentration and dimension of air-bubbles and form and

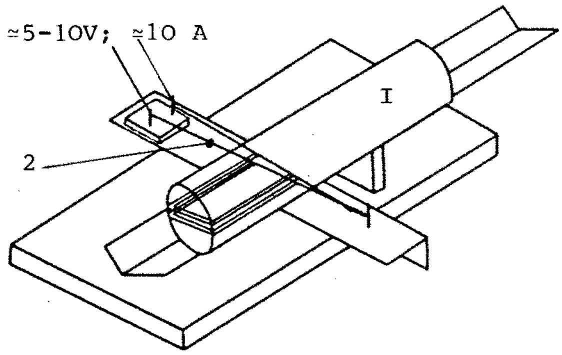

Fig. 4. Electrothermal cutter. 1—ice core; 2—Nichrome wire.

dimension of ice crystals are carried out. One of the segments is used for measurement of the density by hydrostatic method. The larger segment (shown as E in Fig. 3) is used for chemical and isotope analyses.

We apply two types of extractors. The one is a cutter-plane with two blades made of stainless steel. The wide first blade erodes the ice surface. The second narrow blade, following the wide one, cut out the sample. The second type of extractors is designed for melting the core heart. This operation is performed by the device having funnel shaped heater, in which hot water circulated. The working surface of the extractor is coated with the polyethylene.

All equipments used for core investigations were disigned and fabricated by the Institute of Geography, USSR Academy of Sciences and were tested at Austfonna in Svalbard and at ice cap called Academy of Sciences in Severnaya Zemlya (Fig. 1).

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References

Korotkevich Ye. S. and Kudriashov B. B. (1974): Ice sheat drilling by Soviet Antarctic expeditions. Ice core drilling (J.F. Splettoesser, ed.). University of Nebraska, Licoln, 28—30 August, 1974, 63—70.

Kotlykov V.M. (ed.) (1985): Glaciology of Spitsbergen Results of Researches on the International Geophysical projects, Moscow, "Nauka", 200 p., (in Russian).

Morev V.A. (1972): A device for electrothermal core drilling. Bulletin og Inventoins and Discoveries, 27, License 350945, (in Russian).

Zotikov I.A. (1979): Antifreeze-thermodrilling for core through the central part of Ross Ice Shelf (J—9 Camp), Antarctica. CRREL Report 79—24.