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Ice core drilling operations in the Northern Patagonia Icefield

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Abstract

This paper describes logistics concerning a 37.6-m deep ice core drilling operation conducted in the accumulation area of San Rafael Glacier in the Northern Patagonia Icefield in November 1985. For solving transportation problems of a drilling system and other equipments, the total weight of the drilling system was reduced to 37 kg including the weight of fuel ; the equipment except fragile ones was airdropped together with light-weight wooden sledges for the transportation of equipments over the snow field. All of them served successfully without any serious troubles. Drilling was conducted in a 3-m deep trench covered with a simple roof. Eighty-four cores with 80-mm in diameter were recovered in a good quality within a total of 23 working hours. Recovery rate of core was almost 100 %.

1. Introduction

It has been recognized that glacier drilling is one of the powerful means in glacier study. For investigating glaciological characteristics of the Northern Patagonia Icefield by means of cores, the first drilling was carried out to the depth of 37.6 m in the accumulation area of San Rafael Glacier in November 1985. The drilling site was selected at Camp 4 (1296 m a. s. l.) marked by DS in Map 2 (folded in) on a relatively flat snow field, located at about 25 km in straight distance from the glacier terminus.

This report will describe how to solve logistical problems and how to conduct drilling operations for convenience of future research work in this region. The results of core analyses are reported by Yamada (1987) in this issue.

2. Drilling operation

An electro-mechanical drill for shallow drilling, ILTS-100S, was originally designed by Y. Suzuki (Suzuki and Shimbori, 1984) and made by Institute of Low Temperature Science (ILTS). The basic data of drill system are presented in Table 1. The drill can be knocked down into two parts, a core barrel connected to a jacket packed in a FRP-barrel container and a driving unit with a reducer. In addition to the coring part, the drill system has an electric generator and a steel cable, a power cable, tools, and others. Even the heaviest barrel part including barrel container weighs only 13 kg in gross weight and is 1.8 m long. The barrel container (4.9 kg) was used as a support tower of the drill suspended with a 35-m long steel cable (diameter=3 mm). An anti-torque mechanism attached to the driving unit was composed of four guide fins with four side-cutters. Pulling and lowering of the drill was made by manpower without a winch as illustrated in Fig. 1. The light-weight generator weighing 7.0 kg was also newly designed, directly connecting a small gasoline engine (Hitachi CG 26E) to a DC-generator, 100 v/3000 r. p. m. The total fuel consumption for coring was only about 2.5 liters because the generator was run only during the time of coring without idling.

Ice coring was conducted mainly by three persons in a trench of 3-m deep., 4.5-m long, and the opening width 0.8 m and the interior width 1.8 m as illustrated in Fig. 1. The trench was covered with a simple roof

Table 1. Specifications of the drill

Type : ILTS - 100S type		Driving Unit	
Basic diameters		Input	100 V × 5.2 A DC (maximum)
Core diameter	80 mm	Reducer Type	3 stage planetary
Hole diameter	107 mm	Ratio	5×5×5 : 1
Holder Inner Diameter	82 mm	Output	300/150 W/r.p.m.
Outer Diameter	105 mm	Weight	5.0 kg
Jacket Inner Diameter	98.4 mm	Length	40 cm
Outer Diameter	101.6 mm		
Barrel Inner Diameter	85 mm	Overall weight	
Outer Diameter	87 mm	Barrel container	4.9 kg
		Barrel + Jacket	8.1 kg
Barrel		Driving unit	5.0 kg
Number of pawls	3	Generator	7.0 kg
Number of bites	3	Other equipment for drilling	9.0 kg
Bit protrusion	1.0 mm		
Standard r.p.m.	160	Total weight	34.0 kg
Calculated drilling speed	48 cm/min		
Number of augers	3		
Slope of augers	35 degree		
Length	734 mm		

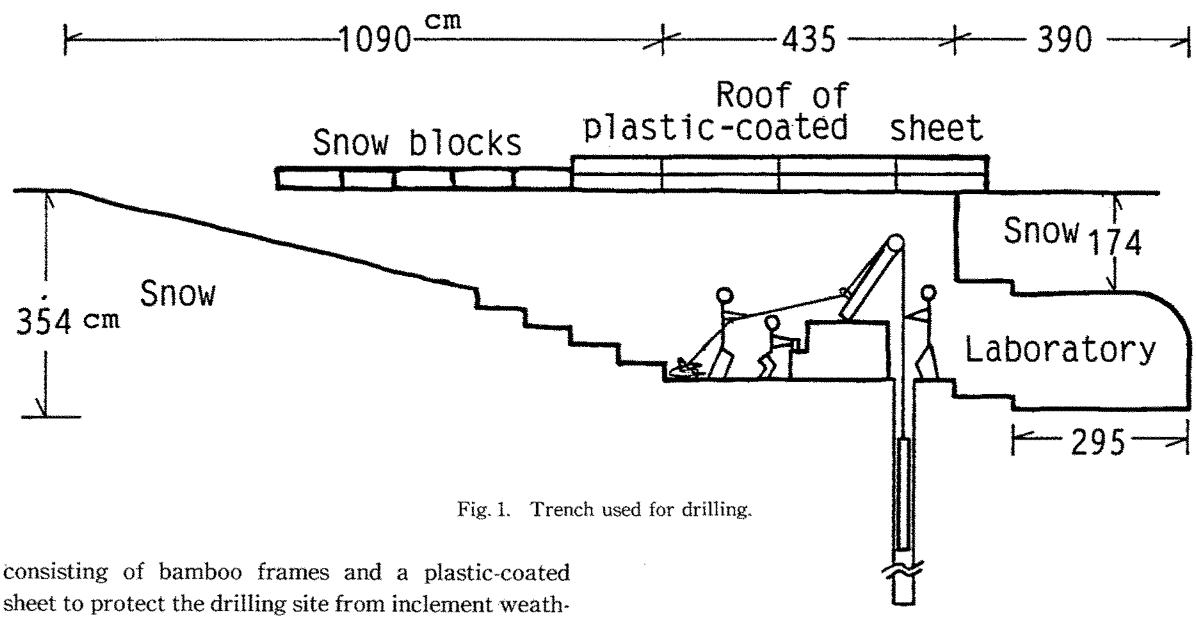

Fig. 1. Trench used for drilling.

consisting of bamboo frames and a plastic-coated sheet to protect the drilling site from inclement weather conditions in this region. A snow cave which was excavated adjacent to the trench was used as a laboratory for core analysis and chemical sampling.

The drill system is capable of recovering a core 80 mm in diameter and boring a hole 107 mm in diameter at the speed of 48 cm per minute, and the average core piece length was about 400 mm when using a 734-mm long core barrel. In addition to the main drilling, another drilling was made from surface to the depth of about 8 m for taking fresh cores near surface layers. Operational progress in coring is shown in Fig. 2.

The attained maximum depth of 37.6 m in the present drilling was due to the logistical limitation of our transportation capability. The operation started on 22 November 1985 after one-week preparation for logistic setting ; a total of 84 cores were recovered in a good quality without serious troubles within 23 total working hours by 26 November. Recovery rate of core was almost 100 %. An en-glacial unconfined aquifer was found at a depth between 25 m and 27 m. Below this depth the bore hole was filled with water.

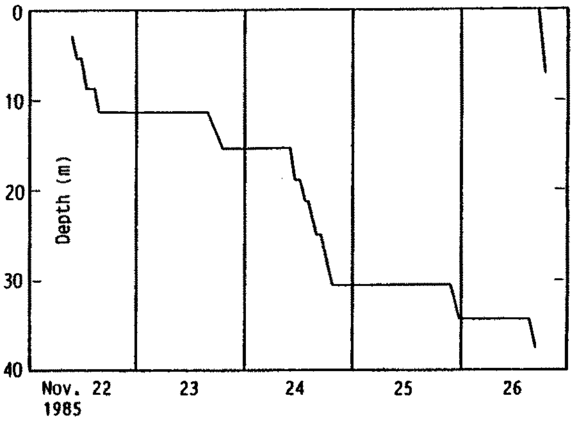

Fig. 2. Operational progress in coring.

Since the drill was not waterproof, much time had to be spent for drawing up water from the bore hole. This was the main trouble during the drilling, because weather conditions were unusually favorable during the operation. The present drill proved its capability in spite of minor shortcomings.

3. Transportation

The manpower transportation of drilling system and other equipment to the drilling site arises problems. A total weight of the drilling system and accompanying research and logistical equipments for the drilling operation was estimated as approximately 300 kg because five persons must spend at drilling site during 15 days for drilling and core analysis. To solve the logistical problems, at first, a light-weight drilling system was newly designed, only 37 kg in gross weight with fuel ; secondly, airdrop was planned for direct supply of equipment near Camp 2 (1000 m a. s. l.) in the snow field ; finally, three simple wooden sledges were prepared for the transportation of equipments deposited at Camp 2 to drilling site at Camp 4.

Camp 2 was established on the foot of a nunatak which served as a good target for airdropping. The vast snow field extends from Camp 2 to the center of the Northern Patagonia Icefield, gradually increasing the altitude where it is easy to use manhauling sledges.

Fragile equipments including the drill and research instruments had to be carried by men from Base House near glacier terminus to Camp 2.

3. 1. Airdrop operation

An airdrop operation with a Cessna airplane was conducted in cooperation with a ground party for ensuring security and quick collection of equipment scattered on the snow field, otherwise they would be covered and hidden by newly fallen snow. It was planned that a 4-man ground party awaited good weather for airdropping during one week at Camp 2, which was the supply limit within our logistical capability. Weather conditions are essentially important to airdropping. Fortunately, two airdrop operations were conducted under favorable conditions of relatively fine visibility, with neither precipitation nor strong wind. The airplane was departed from Coihaique Airport and stopped at Lagoon San Rafael Airport near our Base House where all cargoes were loaded. The airplane flew over 20 km to Camp 2 within 15-20 minutes ; the relatively short flight time minimized a risk caused by an abrupt weather change. The airplane was capable of carrying about 140 kg of cargo each flight. The first operation consisting of three flights was completed within three hours on 25 October, followed by a one flight operation on 16 November 1985. A total of 470-kg cargoes, including 170 kg of the equipment for drilling operation, food, camping equipment, poles and decomposed sledges, were airdropped. At each trial of round-flights over a target marked on the snow surface, three or four boxes were dropped from 50 m above the snow surface. Since communication failed between the airplane and the ground party, boxes were scattered along the flight course in the extent of 200 m in width and 1.5-2 km in length. The snow cover absorbed landing shock of boxes fairly well, but a half amount of kerosene was lost because some bottles were broken. A half of the plastic carton boxes ($60\times45\times30$ cm or $30\times45\times30$ cm) had cracks but the contents did not burst out from them except two heavy food boxes. The skis as well as wooden and metal poles were sticked into snow without any damage. Consequently, almost all the airdropped equipment was successfully recovered at Camp 2.

Damage should be reduced from our experience if the contents of the box are light enough in weight comparing with the strength of the box and are packed with enough space. Light weight and loose packing can decrease the acceleration of the contents at the moment of landing, even without shock absorbing materials in the box. In fact, a fairly heavy food box over 20 kg and the bottles fully filled with kerosene were near breaking. Light boxes with enough space inside and half-filled kerosene bottles were intact.

3. 2. Sledge

The widely dispersed boxes were collected by three wooden sledges which were also airdropped and assembled within one hour and a half after recovery. The wooden sledge costs very little because used skis are substitute for runners and it weighs only 10 kg. One person can handle the sledge weighing from 60 to 70 kg at the speed of 1 to 3 km per hour depending on snow conditions. A line drawing of the sledge is illustrated in Fig. 3. The sledge disjointed several times, but it was easily repaired with cord within a few hours. The sledges were used without serious troubles for around 15 days and cover a total distance of over 100 km during 3 months-stay on the snow field in the center of the Northern Patagonia Icefield.

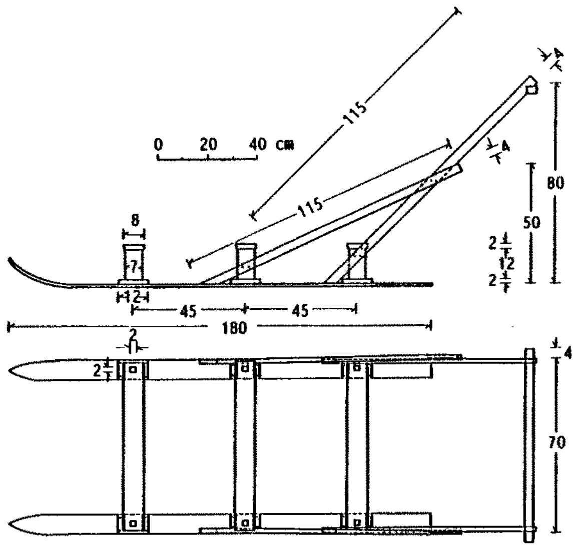

Fig. 3. A line drawing of sledge.

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Resumen

Logística de la operación de perforación efectuada en el campo de hielo, Hielo Patagónico Norte (HPN)

En este paper se describe la logística de la perforación desarrollada a fines de Noviembre de 1985 en el área de acumulación del Glaciar San Rafael. El sitio elegido (DS) se ubicó en el campo de hielo relativamente plano, a una altura de 1.296 m. s. n. m., a unos 25 km en línea recta del frente del glaciar.

El problema logístico más grave residió en el transporte de material, de un total de 300 kg. Se empleó un sistema de perforación liviano del tipo electro-mecánico, con un peso bruto total de sólo 37 kg incluyendo combustible. Bajo condiciones de visibilidad relativamente clara sin precipitación y con fuertes vientos se efectuó dos lanzamientos de carga (sin elementos frágiles) desde una avioneta monomotor Cessna sobre el campo de hielo a cota 1.000 m cerca del Campamento 2 (Ver Mapa 2 anexo en esta publicación), lugar que constituyó el límite superior de provisión de materiales dentro de nuestra capacidad logística. Debido a la buena capacidad para absorber golpes de la cubierta de nieve (2 m de espesor), los materiales lanzados no sufrieron ningún daño serio. Se usó tres trineos simples de madera de sólo 10 kg c/u para trasladar los materiales desde el campamento 2 hasta DS. Esto se realizó sin problemas mayores durante los tres meses de la operación, siendo fácilmente transportados 60-70 kg de carga por una sola persona ya sea empujando o tirando del trineo con una velocidad entre 1-3 km por hora. En la Fig. 1 se muestra el diseño del trineo para operaciones futuras.

La operación de perforación se realizó básicamente con tres operadores dentro de un campamento establecido en un pozo de 3 m de profundidad con

techo simple (ver Fig. 2). Debido al riguroso clima, dicho campamento fuė diseñando para operar incluso durante las condiciones meteorológicas más adversas. Tal como se presenta en la Tabla 1, nuestro sistema de perforación podía lograr una perforación de 107 mm y extracción de un testigo de 80 mm de diámetro con una velocidad de 48 cm por minuto. El progreso operacional del sondaje se muestra en la Fig. 3. Se obtuvo un total de 84 testigos hasta una profundidad de 37,6 m durante un total de 23 horas de trabajo. El único problema se suscitó debido a la presencia de un acuífero englacial entre los 25 y los 27 m de profundidad. El agua llenaba la perforación y se debió emplear mucho tiempo en evacuarla debido a que la máquina de perforación no era del tipo impermeable.