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Ice coring operation at high altitudes in West Kunlun Mountains, China

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Abstract

Three ice cores, 23 m, 10 m, and 32 m long, were recovered in August, 1987 near the summit of the Chongce Ice Cap in the West Kunlun Mountains. The elevations of the drill sites were 6,327 m, 6,366 m, and 6,130 m above sea level. The drillings at the former two sites ended at a big hole in the ice sheet. The whole coring operation is described here including the preparation of drill sites and the core processing.

1. Introduction

One of the major programs in the Sino – Japanese Joint Glaciological Expedition to the West Kunlun Mountains in 1987 was the recovery of ice core at the Chongce Ice Cap and its analyses for obtaining past glaciological and climatic information in the area. Reconnaissance work carried out in 1985 (Watanabe and Zheng, 1987) suggested that the annual precipitation on the ice cap was a few to several hundred millimeters. A core of a few tens of meters would hence cover a record of several decades, during which arid areas have developed rapidly throughout the world partly because of the sharp increase in human activities.

The Chongce Ice Cap, where the drilling was carried out, is located at almost in the center of the glacial area in the West Kunlun Mountains. It extends over a distance of about 7 km in lateral extent. It has two noticeable peaks, 6,530 m and 6,374 m in altitude. The elevation of its terminus is around 5,800 m, and the southern side of the ice cap, where the major activities of the expedition were conducted, shows a rather gentle slope of about 5 to 6 degrees.

Three cores were obtained around the lower peak of the ice cap (at locations of stakes No. 12, 13 and 8 in Fig.1 in Ageta *et al.* (1989)). The lengths of the obtained cores were 23.07m, 10.58m, and 32.49m, respectively. The former two corings came across big holes in the ice sheet, and were discontinued. This report describes the logistics and the operation of the three drillings. An overall description of the expedition is given elsewhere (Zheng, Chen and Ageta, 1988).

2. Drill site set – up

The mountain slope to the ice cap is rather gentle. However, access to the glacier tongue by trucks and jeeps, was frequently prevented by muddy surface conditions presumably caused by melting permafrost, particularly during the earlier half of the field season. It was near the middle of July, 1987 that an advance base camp (ABC) was established, at an elevation of 5,805m, at the edge of the glacier tongue of the ice cap.

The drill system employed consisted of a reinforced version of the W25/ winch (Suzuki and Shimbori, 1984), and an improved S – type double – tube auger drill (Suzuki and Shimbori, 1985), and was designed to work with an 0.7 kW generator. Taking into account the high elevations of the drill sites, a 2 kW generator was used. The whole system was tested on July 20 at an elevation of 5,890 m on the glacier near ABC.

The drill sites were about 5 km from and about 500 m above ABC. Two small oversnow vehicles (similar to a Skidoo) adjusted for high altitudes were used with sledges for transporting equipment from ABC to the drill sites. They were able to carry more than 200 kg of equipments each trip. It took only about half an hour for a round trip, compared to more than half a day on foot.

The first drill site was chosen at an elevation of 6,327 m on a shoulder of the lower peak. Necessary goods were all dumped at the site on July 29 and in the following two days the working space (Fig. 1) was prepared: A pit about 1.3 m deep was excavated; snow blocks were piled up along its periphery; the space was then covered by a plastic sheet supported by several arches of bamboo stakes as shown in Fig. 2. The winch, drill and other equipment were set up inside the working space.

It was planned that a 6—man drilling and/or core processing team would stay at the drill site throughout the drilling period. However, since the oversnow vehicles worked very well, it was decided that the team went to and came back from the site every day, staying overnight at ABC. This contributed to good health for the team for the whole coring period, in spite of the tough work at high elevation. Two mountaineering tents equiped with oxygen tanks, masks, sleeping bags, cooking equipments and food for several days for the team were pitched at the site against a sudden change in weather which could prevent the team from returning to ABC. Because of continued fine weather, they were not used overnight. They were used only for short rest and lunch preparation. A similar set—up was used at the other two drill sites in the later period.

Fig. 1. Completed drill site.

3. Time sequence of coring operation

A snap shot of the operation is given in Fig. 3. Figure 4 shows the drill record at the first drill site. A core about 0.5 m long was obtained in each run. When the drilling was continued too long, increased cutting began to disturb the smooth rotation as well as the vertical movement of the drill. Hence, each run should be ended before such disturbance occurred. Otherwise, the drill could be stuck at the bottom of the hole. Such an accident took place, on August 5, but various efforts enabled us to recover the drill fortunately in a few hours.

The rate of failure in retrieving core samples increased in the later half of the drilling period (Fig.

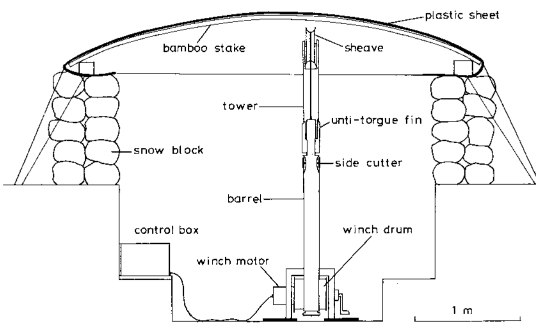

Fig. 2. Schematic view of the drill site.

Fig. 3. Drilling operation. Inner and outer tubes as well as Archimedean pump are under cleaning.

4). This was mainly due to alternative presence of snow and ice layers, to which the adjustment of the core catcher was rather difficult. A relatively long core recovery followed a couple of failures of core recovery, owing to additional drillings of the order of 10 cm in each trial.

At a depth just below 17 m, the drill encountered a cavity of the order of 10 cm. The obtained core was with big hoar crystals of 4 to 5 cm in diameter at its bottom. Careful drilling was required to go through the cavity since the length of the anti-torque fin of the drill was only 20 cm. Below the hole, there was found a fracture zone, and the dip of stratification increased suddenly up to 70 degrees.

At a depth of about 22.5 m, a core with hoar crystals at its bottom edge was again obtained, which indicated the existence of another cavity. Subsequent drilling produced a core with semicylindrical cross section, suggesting that the cavity would be a vertical crevasse. Its depth was found to be more than 0.8 m, that is, much greater than the length of the anti-torque fin. Hence, it was decided to end the drilling.

The second drill site was chosen almost at the summit of the lower peak of the ice cap at an elevation of 6,366 m. Drilling record at this site is shown in Fig. 5. A couple of failures in core recovery seen in the figure are probably due to inappropriate adjustment of the core catcher. A two-day break of the operation, August 12 and 13 was for rest at Base Camp at 5,260 m.

The last core on 15th of August at a depth of 10.5 m had many hoar crystals at the bottom, showing that the drill encountered a cavity. The cavity seemed to be thicker than 1.4 m, and further drilling was given up.

The third drill site was at an elevation of 6,130 m, approximately 2 km downstream from the first drill site. Though in the mid-stream of the ice cap, the site was rather flat. Figure 6 shows the drilling record at this site.

One of the troubles at the site was an encounter with a very fragile zone about 0.7 m thick at a depth of around 10 m. The anti-torque fin was replaced with the alternative one 70 cm long to increase the torque against the rotation of the drill. This worked successfully, and the drill was able to pass through the zone, although the size of the fin and the zone thickness were almost equivalent.

Another trouble encountered in the later half of the period was that the movement of cuttings along the Archimedean pump became unsmooth. This could perhaps be caused by increase of surface roughness of the inner tube. As a result, cuttings were piled up and compacted at the lower part of the pump, preventing fresh cuttings from moving into the pump any more

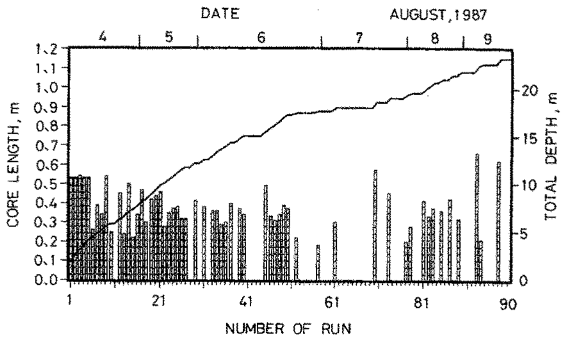

Fig. 4. Drill records at the first drill site (6,327 m). Vertical bar indicates the core length at each run, and a solid line shows the total depth achieved.

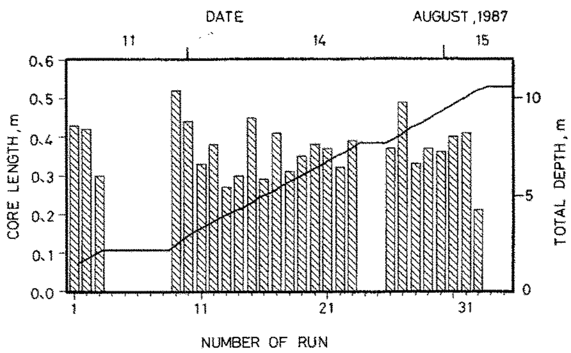

Fig. 5. Drill records at the second drill site (6,366 m). Vertical bar indicates the core length at each run, and a solid line shows the total depth achieved.

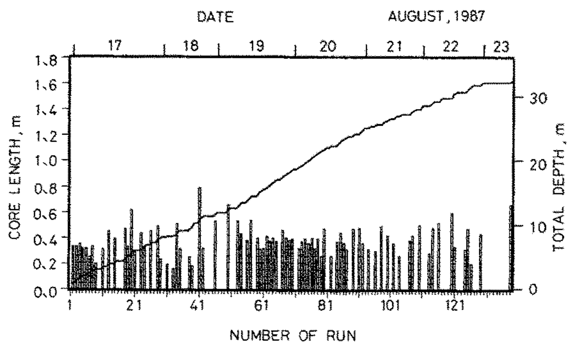

Fig. 6. Drill records at the third drill site (6,130 m). Vertical bar indicates the core length at each run, and a solid line shows the total depth achieved.

even after a very short drilling, say about 10 cm. At such a situation, the core cachers did also not work. Hence, several runs were necessary to have a core 30 to 50 cm long. This was the main reason for the decrease in coring speed in the latter half of the period. The drilling ended at the final depth of 32.49 m on August 23, the end of the period allocated for the operation.

4. Brief description of core processing

After the length measurement, the obtained core samples were packed with plastic bags and buried in the surface snow layer adjacent to the drilling sites. They were picked up and brought to ABC near the end of the field season. Most of the core processing was carried out at ABC during nighttime when the temperature was below 0°C.

Each core sample was cut vertically into half. One half was packed in a plastic bag and stored in a freezer, which was later shipped to Lanzhou. The other half was first used to stratigraphic observation (Fig. 7) and electric conductivity measurement (Hammer, 1980). Then it was cut horizontally at about every 5 cm into pieces. Each piece was put into a plastic bag, after its surface was shaved with a stainless steel knife. Each piece was washed twice with its melt water at the surface. It was then melted completely, and bottled. The bottled samples were shipped to Japan for chemical analyses. Some results of preliminary analyses of the samples are reported in this issue.

5. General remarks

The whole operation was nothing but a challenge to the high elevation. Although drill test/training had been carried out in advance in Japan as well as near ABC, and a manual for the drilling had been prepared, careless mistakes were made several times during the operation. They were considered due to incomplete acclimatization of the team members to the altitude. Reliable performance of the oversnow vehicles was an outstanding support to the operation (Fig. 8). Without it the members should have kept staying at the drill site, so that their health conditions would have been much worth and the operation would not have been that successful.

Fig. 7. Core processing. Stratigraphy is under examination using a half cut core with a light table.

Fig. 8. Oversnow vehicles actively engaged in the coring operation. The shot is at the highest peak of the ice cap.

The generator worked satisfactorily at the high altitude since the rated power was three times as large as the required power of the system. Also the vehicles were able to carry this heavy generator (50 kg) without any difficulty. In case such a vehicle was unavailable we might have used solar batteries instead (Koci, 1985).

The drill system needs further improvement: a variety of core catchers now have to be prepared to accomodate various types of snow and ice. A general type which works even for alternating layers of snow and ice is preferable if possible. Also the Archimedean pump must be improved to work for any type of snow or ice.

The importance of core analyses has greatly increased lately, and the requirements for snow/ice cores have become demanding. They have to be collected not only from polar regions but also other possible sites throughout the world. We would then face much more variety of snow and ice to drill. It is hoped that the development/improvement of core drills will progress rapidly in the near future.

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