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DEVELOPMENT OF A LIGHTWEIGHT HOT WATER DRILL AND BOREHOLE IN-SITU OBSERVATION SYSTEM

Drilling hot-water holes in glaciers and deploying various sensors into the holes for observation represents a direct approach to acquire internal parameters of glaciers. Since the 1960s, a large number of observations on internal ice temperature, subglacial water pressure, ice flow velocity, and borehole photography have been carried out globally for polar ice sheets and mountain glaciers, generating abundant data that have significantly advanced the understanding of the mechanisms underlying glacier changes. In China, however, the observational data on internal glacier parameters are relatively scarce, primarily due to the lack of efficient drilling methods and in-site observation instruments. To achieve rapid ice drilling and in-site multi-parameter detection in glaciers, a lightweight hot water drill and two sets of wired multi-parameter in-situ observation systems was developed by Jilin University.

The maximum drilling depth of hot water drill is 200 m, with a borehole diameter of not less than 100 mm, and the maximum mass of a single component does not exceed 60 kg. Using this hot water drilli, a drilling footage of 122 m was completed at an altitude of 4531.5 m on Glacier No. 12 in Laohugou, Qilian Mountains, China. During drilling, the maximum penetration rate reached 37.5 m/h, and the average penetration rate was 17.5 m/h, with the borehole diameter exceeding 105 mm.

The in-situ observation systems for ice boreholes integrated with temperature, water pressure, and attitude sensors can realize multi-point observation at varying depths within the borehole via cable cascading. The temperature detection range is from - 30 ℃ to 0 ℃, with an accuracy of ±0.5% FS. The water pressure detection range is from 0 to 3 MPa, with an accuracy of ±0.3% FS. The accuracy of the X and Y axes of the attitude sensor is 0.2°, and that of the Z axis is 1°. During the 41st Chinese Antarctic Research Expedition (2024/2025), this system was employed to monitor the internal ice parameters of the existing JLU-2 borehole located 30 km away from Zhongshan Station. The sensors were deployed to a depth of 430 m, with a module interval of 25 m. Preliminary analysis of the data reveals that the lowest temperature in the JLU-2 borehole occurs at a depth of 180 m, reaching - 20 ℃. Below 180 m, the ice temperature gradually increases, reaching - 12.5 ℃ at a depth of 430 m. The temperature gradient in the ice below 180 m is 0.03 ℃/m. The ice flow velocity calculated from the sensor indicates that the maximum difference between inglacial and surface flow velocity can reach 8.47 m/year.

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