Accepted Manuscript

Electric thermal drills for open-hole coring in ice

Pavel Talalay, Bowen Liu, Yang Yang, Xiaopeng Fan, Jialin Hong, Da Gong, Mikhail Sysoev, Xiao Li, Yazhou Li

PII: S1873-9652(18)30021-5

DOI: 10.1016/j.polar.2018.05.007

Reference: POLAR 394

To appear in: *Polar Science*

Received Date: 7 February 2018

Revised Date: 29 April 2018

Accepted Date: 9 May 2018

Please cite this article as: Talalay, P., Liu, B., Yang, Y., Fan, X., Hong, J., Gong, D., Sysoev, M., Li, X., Li, Y., Electric thermal drills for open-hole coring in ice, *Polar Science* (2018), doi: 10.1016/j.polar.2018.05.007.

Electric thermal drills for open-hole coring in ice

Pavel Talalay, Bowen Liu, Yang Yang*, Xiaopeng Fan, Jialin Hong, Da Gong, Mikhail Sysoev, Xiao Li, Yazhou Li

Polar Research Center, Jilin University, No. 938 Ximinzhu Str., Changchun City 130021, China

*Correspondence author. E-mail address: **Yang Yang** (yangyang2014@jlu.edu.cn)

Abstract

Electric thermal drills are more advantageous than electromechanical drills in temperate, near-temperate, and polythermal glaciers because they can avoid problems arising from refreezing of wet chips, which causes drills to become stuck in the borehole. When the refreezing rate of meltwater in borehole is expected to be too high and there is no considerable englacial water flow, thermal drills with meltwater removal system are optional for open-hole shallow (200–300 m) ice coring. To reach a sufficiently high rate of penetration of approximately 6–7 m h^{-1}, the power density of thermal head should be maintained in the range of 100–110 W cm^{-2}, which can be provided by tubular elements cast integrally with an aluminum or copper annulus. To remove meltwater via air reverse circulation, thermal drills can be equipped with a small blower. The safest and most even mode of water removal is lifting in the form of water film on the wall of air sucking tubes. The maximum water removal rate using a single water-lifting pipe via air reverse circulation created by a blower with a sucking power of 110 airwatts was ~0.35 L min^{-1}. Assuming a penetration rate of 6–7 m h^{-1} and the outer and inner diameters of 135 and 110 mm, respectively, of the drill head, the meltwater should be removed at a rate not less than 0.8–1.0 L min^{-1}. In this case, at least three water-lifting pipes should be used in the drill.

Key words: Thermal drill; thermal coring head; meltwater remova

1. Introduction

Ice-core electric thermal drills were designed for continuous or discrete sampling of glaciers, ice sheets, and sea and lake ice covers. The core is produced by a heated annular coring head, which melts the ice around the core. The first thermal corer was developed in the Meteorological and Geophysical Institute of University of Vienna, Austria at the beginning of the 1950s (Schwarzacher and Untersteiner, 1953) to obtain ice samples from the surface of glaciers. This was a portable rim-heated device enabling the extraction of cores 80 mm in diameter and up to 20 cm in length.

Between the 1960s and 1980s, thermal ice-core drills were extensively developed (e.g., Ueda and Garfield, 1969; Morev et al., 1984; Kudryashov, 1989); however, they are infrequently used nowadays. The main limitations of these type of drills are their relatively high power requirements and low penetration rates. Another limitation of electric thermal drills is the intrusion of components that cannot be molten, such as dust or rock particles, present in ice. In