A DEEP HOT WATER DRILL SYSTEM WITH POTENTIAL FOR BOTTOM SAMPLING

by

B. Koci
Polar Ice Coring Office
University of Nebraska-Lincoln
940 North 17th Street
Lincoln, Nebraska 68588-0640, U.S.A.

ABSTRACT

During the 1987-88 Antarctic season, we tested a hot water drilling system capable of drilling up to 3,000 meters. By insulating a one inch diameter hose, the heat loss is reduced so water temperature at the nozzle falls off by 2°C/100 m, of water depth. In addition wires incorporated in the jacket allow measurement while drilling to assure hole straightness and large enough diameter to permit instrument raising and lowering. Heat input for this system is 0.5 W.

Some ideas will be presented on drilling sub-glacial material. Saturated till sampling requires a tool used by the well drilling industry for sampling material below the water table while rock sampling and coring frozen till utilize mining technology. The use of additives to enhance drilling rates will also be discussed.

INTRODUCTION

Experience with hot water drilling in cold ice began in 1979 at Dome C in Antarctica. Many holes to depths of 60 m were completed successfully with no problems of freezing encountered despite ambient temperatures approaching -40°C and ice temperatures of -54°C. PICO continued using a small system to drill hundreds of holes successfully.

The need for deeper drilling and recovery of bottom samples requires a high heat input and insulated hose to permit drilling beyond 1000 m. Both are necessary to prevent freeze-up within the hole and to preserve heat within the hose for drilling. An instrumented cable allows drillers to monitor progress of drilling assuring a successful hole each attempt.

This system is an expansion of drill systems currently in use allowing commonality of parts. Six to eight carwash heaters are placed in parallel producing a heat input of 0.5 MW to 0.65 MW depending on flow rates and inlet temperature.

A modified Rodriquez well is used to supply water to a triplex pump which boosts pressure to over 100 bars at 84 l/min. The water is then heated and returned to the drill. Pressures and temperatures at all above hole locations are monitored with standard gauges.

The drill hose is standard synflex 3000, 2.4 cm I.D. which has been modified by wrapping with electrical conductors, a kevlar

strength member and an outer neoprene jacket.

The outer diameter is nearly 5 cm requiring a minimum bending radius of 50 cm. This assembly can be produced in single lengths of up to 700 m which can be attached to achieve the desired length. Since the hose is buoyant (200 kg/600 m) weights must be added to the drill stem.

An electronics package (Hancock, 1988) is attached to the upper portion of the drill allowing monitoring of drill progress. Among other things hole diameter, inclination and water outlet temperatures are available to the driller. This is important when planning drilling progress to prevent freezing of the system.

A standard spraying system fulljet 15° nozzle is used to continuously mix water in front of the drill and provide maximum heat transfer coefficient with the ice surface. This type of mixing works well with the slow drilling speed we use to provide access holes.

RESULTS

During the 87-88 austral summer, this system was used successfully to drill two holes at Crary Ice Rise on the Ross Ice Shelf. (Bindschadler, 1988) The deepest of these holes was 480+ m with an additional penetration of 15 m of bottom sediment.

Since heat loss of the hose was limited to 2°C/100 m of hose immersed, extrapolation suggests holes up to 3000 m of depth can be drilled. In addition the large cross sectional area of the hose keeps pressure loss within the hose to 1/4 bar/100 m at a flow rate of 80 l/min.

Placement of thermistors in the hose was done using a Cortland Cable hi-wire cable strengthened with kevlar. This cable is compliant and can survive 30 % stretch suggesting its use in active ice. Thermistors and junctions all survived the freezing process and were giving reasonable data at season end.

SYSTEM SIZE AND FUEL CONSUMPTION

This system is large and bulky despite being able to be separated in smaller pieces the single largest piece is the hose reel and hose which weights 1700 kg and occupies an entire U.S. Air Force pallet. In addition, a 16 kW pump and 10 kW generator are required. Both weigh 200 kg.

Heaters each weigh 125 kg and burn 10 l/hr of diesel or Jet A-1 fuel. This translates to a consumption of 2 l/m diesel plus 8 l/hr of gasoline.

CONCLUSION

This system was designed for use in deep ice or to provide access holes through ice for scientific experiments. In the future bottom sampling can be carried out using either a sampler designed for collecting material in saturated till or for coring rock through use of a packer, screwjack, hydraulic motor and rock coring barrel. We plan to begin testing this system in shallow areas for shallow cores soon and will borrow much of the technology from the mining industry. This should provide access to the other 98 % of the Antarctic geology.

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REFERENCES

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