A Shallow Wet Drill for Improved Core Quality in Blue Ice Areas

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SHALLOW

- In Blue Ice Areas, high wind speeds cause ice to be transported and sublimated away faster than it can accumulate, resulting in a net mass loss from the ice surface.
- These areas typically form in proximity to topographic features, which push older layers of the ice sheet upwards (Fig. 1).
- As such, very old ice can be found at shallow depths in Blue Ice Areas.

DEPTH REQUIREMENT: 400 METERS

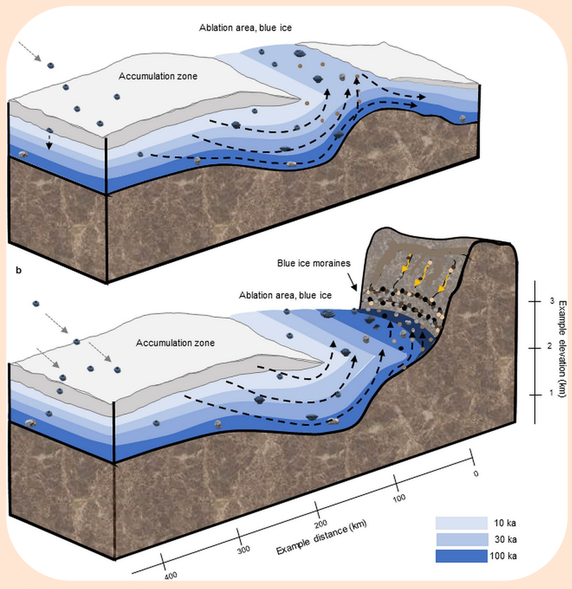


Figure 1. Sketch representing the formation and composition of Blue Ice Areas. [1]

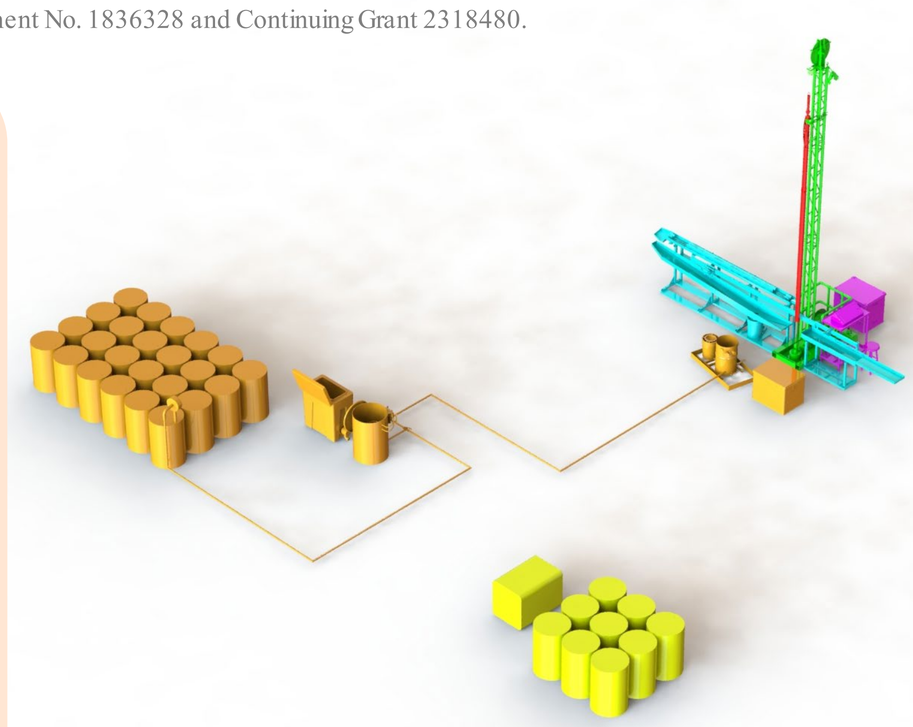


Figure 2. Image of the Shallow Wet Drill with subsystems grouped by color: Winch and tower (green), sonde (red), core processing (blue), controls (pink), fluid handling (orange), generators and fuel (yellow), tent (not shown).

WET

- IDP has struggled to produce high quality core samples from Allan Hills over 7 seasons using 3 different dry electromechanical drills (Eclipse Drill, Blue Ice Drill, & Foro 400 Drill).
- Core quality degrades at depths as shallow as 50 meters, with samples cracked, broken, or fully disintegrated when brought to the surface (Fig. 3).
- IDP speculates that drilling in a fluid-filled borehole (or "wet drilling") will help improve core quality by:
  - Dampening shock loads that propagate to the core.
  - Increasing borehole pressure to more closely match the overburden pressure within the ice sheet.

BOREHOLE TO BE FILLED WITH ESTISOL 140

Figure 3. Examples of poor-quality samples from Allan Hills from the Foro 400 Drill (left) and Blue Ice Drill (right).

DRILL

Figure 4. Conceptual image of the Shallow Wet Drill sonde showing the anti-torque section (red), motor section (green), and 1m barrel set (purple).

BARREL SET FOR 1m CORE

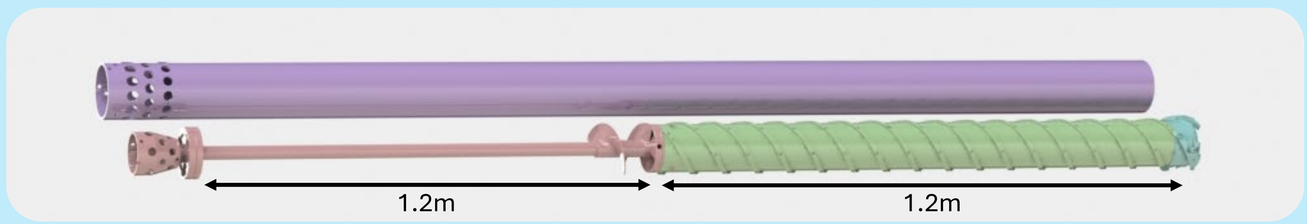


Figure 5. Conceptual image of the newly fabricated barrel set with outer barrel (purple), hollow shaft assembly (red), core barrel (green), and cutter head (blue). Dimensions shown indicate the length of the chip chamber (left) and the longest core that could fit inside this drill (right).

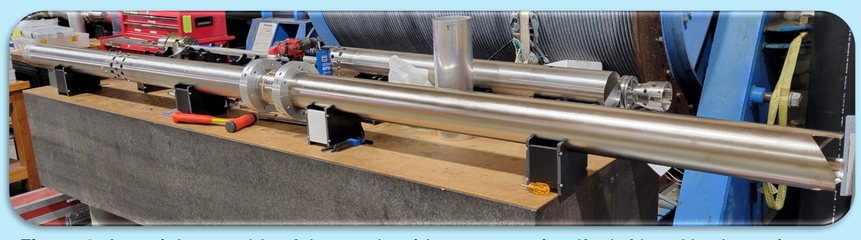


Figure 6. A partial assembly of the sonde with motor section (far left) and both sections of the outer barrel (center and right).

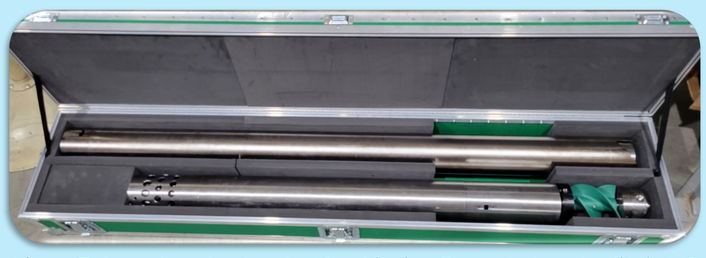


Figure 7. A new barrel set packed for shipping. The outer barrel splits into 2 sections: 1 houses the core barrel (top of case) and the other houses the hollow shaft assembly (bottom of case).

Figure 8. A hollow shaft assembly configured for wet drilling, including chip filtration screen and 3d printed booster (green).

- This drill needed to be developed within a 12-month period. To meet this deadline, IDP used existing designs and subsystems as much as possible, with a few modifications.
- The surface equipment is borrowed from the 700 Drill. The only difference between the systems is their core diameter.
- The 700 Drill's sonde produces a 70mm diameter ice core, which does not meet the science requirement of ≥ 98mm.
- Instead, IDP borrowed components from the Foro series of drills and fabricated a new barrel set that is short enough to fit on the 700 Drill's tower.

CORE DIAMETER: 98 mm
CORE LENGTH: 1 m
TRANSPORTABLE VIA TWIN OTTER
READY FOR USE IN 25/26 ANTARCTIC SEASON

MOTOR SECTION

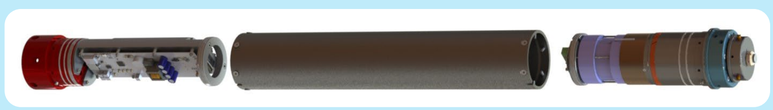


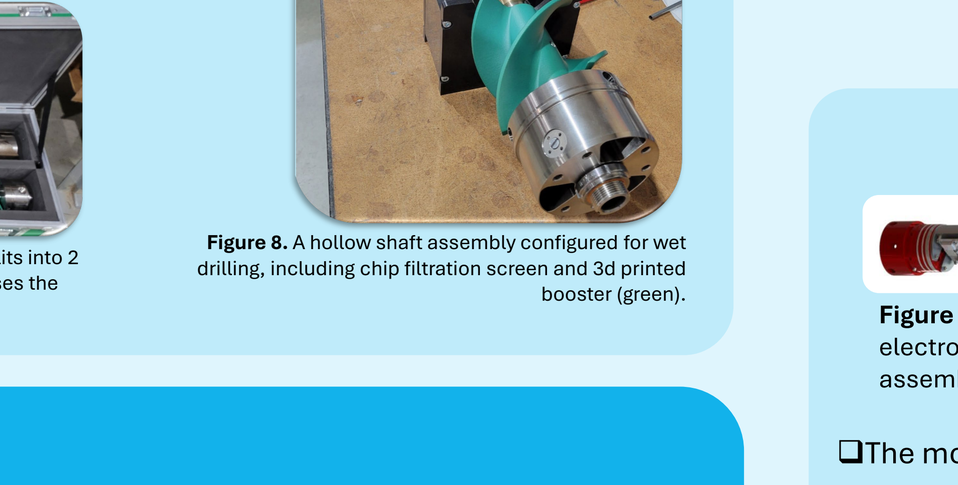
Figure 9. Exploded view of motor section with updated electronics package (left), housing (center), motor and gear box assembly (right).

- The motor section is borrowed from IDP's Foro 1650 Drill.
- An updated electronics package was designed and built to allow for control using the 700 Drill's control box.
- See Presentation #29 – Advancements in Drill System Electronics for more detail.

THREE NEW FEATURES FOR 25/26

TWO-PIECE HOLLOW SHAFT

MULTIPLE BOOSTER GEOMETRIES



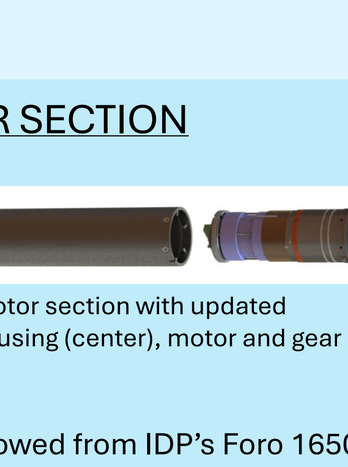
Pitch = Diameter
1 Flight

Pitch = Diameter
3 Flights

Pitch = 2 x Diameter
3 Flights

98mm INSERT CUTTERS

see Poster #23



References
[1] Nowak, A., Isaksson, E., Sunde, Ø. et al. Antarctic Blue Ice Areas are hydrologically active, nutrient rich and contain microbially diverse cryoconite holes. Commun Earth Environ **5**, 345 (2024). https://doi.org/10.1038/s43247-024-01487-4