Subglacial Access Working Group (SAWG)
Access Drilling Priorities in Ice Shelves and Ice Streams – Thwaites Glacier Region

1) Summary: Since the 1990s, satellites have shown accelerating ice-loss in the glacier basins that drain more than one-third of West Antarctica into the Amundsen Sea. The rate of ice-loss has doubled in the last six years and now accounts for a significant fraction of global sea-level rise. However, considerable uncertainty remains in projections of future ice-loss from West Antarctica. Numerical simulations have identified Thwaites Glacier as having the greatest potential, of Antarctic glaciers and ice streams, for contributing to future ice loss and consequent sea level rise on time scales of concern for human communities. Reducing uncertainty in the projected contribution of Thwaites Glacier to sea level rise requires substantial and coordinated collaborations involving a multidisciplinary, international scientific community. Projection of rates and amount of sea-level rise over the next decades to century has been identified as the highest priorities for Antarctic research by the US National Academies of Sciences and this view was endorsed by SCAR (NAS report on "A Strategic Vision for NSF Investments in Polar Science" (2015) and the SCAR Horizon Scan (2016)).

2) Compelling research questions:
Important questions that could be answered with access to the bed of Thwaites Glacier include:
2.1 Quantifying the ongoing changes in ice-flow and mass balance in West Antarctica;
2.2 Provide robust projections of change with uncertainties on rates and magnitude;
2.3 Understanding past changes in WAIS, both as a window on the future, and as the crucial tool for validation of ice-sheet models;
2.4 Identifying and understanding the oceanographic and atmospheric processes driving past, recent and probable future ice-loss from West Antarctica;
2.5 Improving the projections of the contribution of Antarctica to sea-level rise, and understanding the potential for rapid ice-sheet collapse.
2.6 Adding to our understanding of the role of subglacial microbial ecosystems and flux of basal-derived nutrients to proglacial ecosystems.

3) Scientific rationale:
Many separate lines of evidence cited throughout the SAWG workshop discussion highlighted Thwaites Glacier as the key site focus for future research. The primary outcome of access drilling at Thwaites would be the ability to quantify processes at the bed that strongly modulate the flow of the glacier.

The processes associated with sliding of ice over its bed are poorly known, and numerical models do not incorporate realistic basal physics. Accessing the bed of Thwaites Glacier would allow us to sample basal material, measure properties of water, ice, till, and rock at the bed, and examine relations between dynamics of ice flow and external forces such as ocean and atmospheric influences.

There is international interest and the potential for collaboration and synergies among research programs in the Amundsen Sea region. For example NERC has made Thwaites

Glacier research a priority and anticipates providing logistics over the course of the next 5 years.

4) Drilling Parameters:

- Thwaites Glacier thickens from 600m at the grounding line to an average of 2.5 km in the main trunk; we require a 10-cm-diameter hole that will remain open for long enough to extract basal material and install instrumentation (1 day?)
- In order to address ecological stewardship and maintain the scientific integrity of the biota at the bed for researchers interested in geomicrobiological analyses, we require clean access that meets the SCAR Code of Conduct standards.
- Much of Thwaites Glacier is accessible for surface transport and tractor traverse from, e.g., WAIS Divide or Byrd Surface Camp. The subglacial access drill must be transportable by towing on the surface.
- Access to multiple locations in a season (2-3?), which suggests a drilling time of 10 days per location.
- These requirements likely point towards a hot water drill.
- Separate but related work by US and international collaborators will access the Thwaites Glacier ice-shelf from ships; this drilling will be conducted via US and UK collaboration

5) Sampling requirements

- Till samples for geotechnical analysis, for microbiological sampling, for microfossil identification, for ice sheet history over the last glacial and interglacial. Till samples to a few meters depth are proposed, as appropriate with the technology and time on site. The purpose is to characterize the rheology, the hydraulic connectivity, and the structure of the till.
- *In situ* observations include water pressure, temperature, till deformation, tiltmeters, and geothermal flux. These observations will continue for a period of time after the hole freezes shut and as long as the cabling is intact to the bed.
- We propose to instrument the borehole with geophysical tools such as thermistors, radar, and seismic tools in order to continue to monitor the conditions of the ice and bed.

6) Target locations (where):

The primary locations are along the Thwaites Glacier main flowline at areas identified to have representative basal till conditions. Regions of high and low basal friction are likely to have different bed properties that we can characterize. In addition, we propose to access the bed through the shear margin (likely the eastern shear margin between Thwaites and Pine Island Glacier). We will propose to drill one hole as close to the grounding line as is safely accessible.

7) Target timeline (when):

We anticipate multiple drilling field seasons starting in 2019-20 for 2 or 3 seasons.

8) Support requirements (how):

Hot water drills to access the bed of Thwaites do not currently exist in the US inventory, though BAS does have such a drill (to be deployed at Rutford Ice Stream in 2017). The technology for the drill is comparable to the Scalable Hot Water Drill (ScHWD), the WISSARD Drill, and the Roving Hot Water Drill.

This white paper was prepared by during the SAWG Workshop 22-23 May, 2016
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