# Initial results from International Thwaites Glacier Collaboration cruise NBP20-02

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## Abstract

Thwaites Glacier (TG, Fig. 1) is more vulnerable to unstable retreat than any other part of the West Antarctic Ice Sheet. This is due to its upstream-dipping bed, the absence of a large ice shelf buttressing its flow and the deep bathymetric troughs that route relatively warm Circumpolar Deep Water (CDW) to its margin. Over the past 30 years the mass balance of TG has become increasingly negative, suggesting that unstable retreat may have already begun. The International Thwaites Glacier Collaboration (ITGC) is an initiative jointly funded by the US National Science Foundation and the Natural Environment Research Council in the UK to improve knowledge of the boundary conditions and drivers of change at TG in order improve projections of its future contribution to sea level. The ITGC is funding a range of projects that are conducting on-ice and marine research, and applying numerical models to utilize results in order to predict how the glacier will change and contribute to sea level over coming decades to centuries.

RV *Nathaniel B Palmer* cruise NBP20-02, from January to March 2020, was the second ITGC multi-disciplinary research cruise, building on results from NBP19-02, which took place last year. Thwaites Offshore Research Project (THOR) aims during NBP20-02 included: extending the bathymetric survey in front of TG, collecting sediment cores at sites selected from the survey data, and acquiring high-resolution seismic profiles to determine the properties of the former bed of TG that is now exposed. Detailed bathymetric data reveal the dimensions and routing of troughs that conduct CDW to the glacier front and image seabed landforms that provide information about past ice flow and processes at the bed when TG was more extensive. The sediment cores, together with ones collected recently beneath the ice shelf via hot-water drilled holes, will be analysed to establish a history of TG retreat, subglacial meltwater release, and CDW incursions extending back over decades, centuries and millennia before the short instrumental record. Thwaites-Amundsen Regional Survey and Network Project (TARSAN) researchers visited islands and ice floes via zodiac boats to attach satellite data relay loggers to Elephant and Weddell seals. The loggers record ocean temperature and salinity during the seals' dives, greatly increasing the spatial extent and time span of oceanographic observations. In addition to work that is part of the THOR and TARSAN projects, another cruise objective is to recover and redeploy long-term oceanographic moorings in the Amundsen Sea. Here we report initial results from NBP20-02.

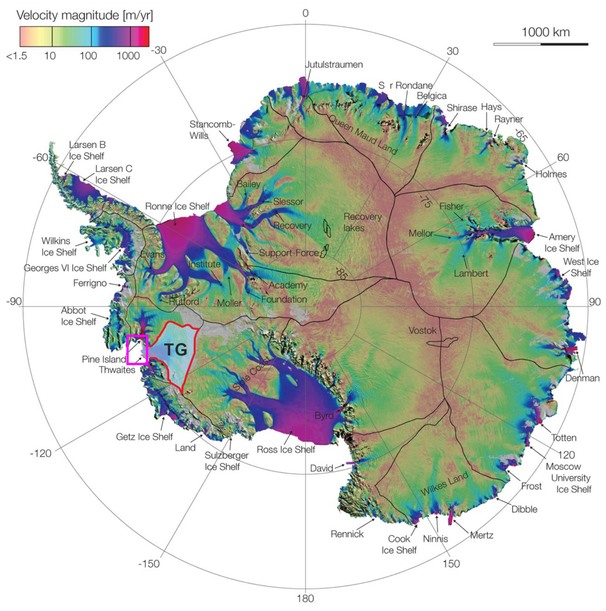


Fig. 1. Thwaites Glacier drainage basin extent (TG) overlaid on ice flow velocity map from Rignot et al. (2011). Magenta box indicates extent of Fig. 3.

## Sea ice constraints on area of operation

The TerraSAR-X image below shows the sea ice extent near Thwaites Glacier in early March this year, which was close to its minumum extent during the season. As fast ice north of the Glacier Tongue and densely-packed sea ice east of the Eastern Ice Shelf remained throughout the season, cruise NBP20-02 working areas were further to the north and east. Multibeam bathymetry data and sediment cores were collected in the area that was covered by fast ice this year on cruise NBP19-02 during the previous season.

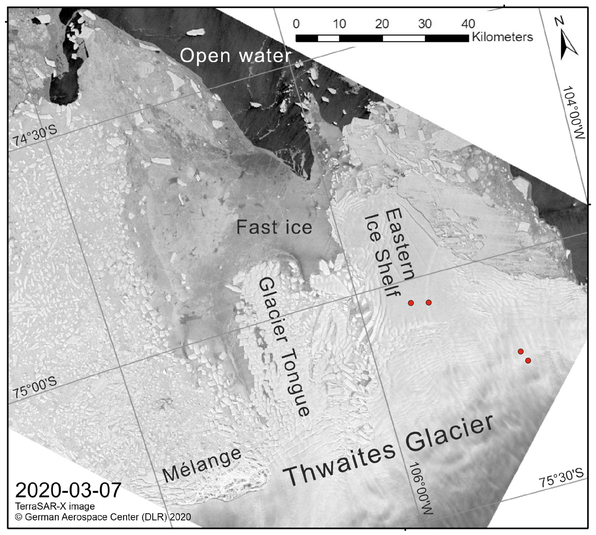


Fig. 2. TerraSAR-X image of Thwaites Glacier area on March 7th, 2020, provided by the German Aeropsace Center (DLR). Red dots mark locations of sediment cores recovered from beneath the ice shelf via hot-water drilled holes.

## Multibeam bathymetry data

The main areas in which new multibeam bathymetry data were collected on cruise NBP20-02 are outlined by blue boxes in Fig. 3, overlaid on a compilation of previously collected data (Hogan et al., 2020). The magenta boxes outline areas in which most data were collected last year on cruise NBP19-02.

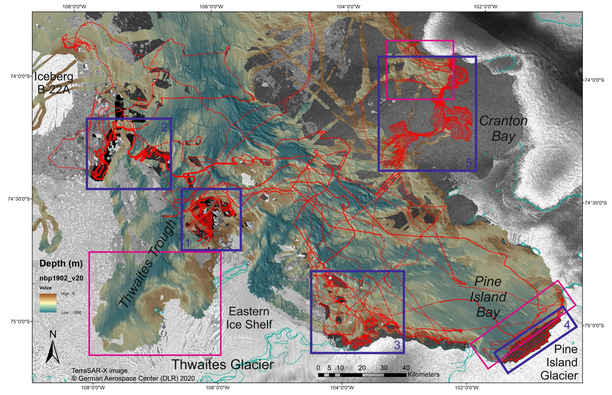


Fig. 3. Main multibeam bathymetry data collection areas on cruise NBP20-02 (blue boxes): 1. Former pinning point north of Eastern Ice Shelf; 2. Banks on west side of Thwaites Trough; 3. Gaps in coverage east of Eastern Ice Shelf; 4. In front of Pine Island Glacier; 5. Cranton Bay. Red lines are NBP20-02 tracks. Background satellite image is same TerraSAR-X image from the DLR as in Fig. 2, mosaiced with Sentinel-1 SAR images.

## Sediment coring

Sediment cores were collected at 31 discrete sites on cruise NBP20-02 (Fig. 4). Two or more coring devices were deployed at most sites:

30 kasten cores (KC), recovering a total of 63.5 m,
8 piston cores (JPC), recovering 71.9 m,
7 gravity cores (JGC), recovering 29.7 m
25 megacores
4 box cores

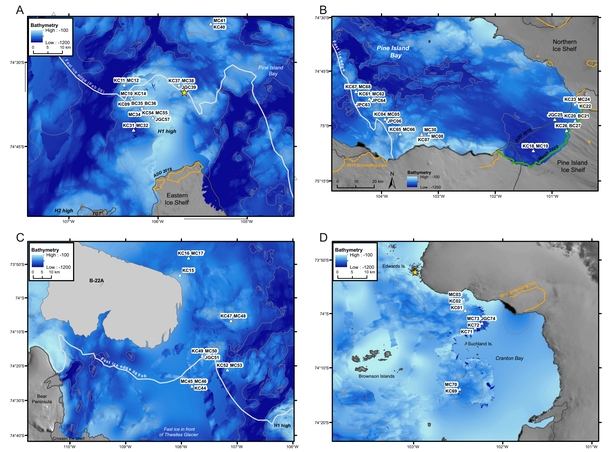


Fig. 4. Cruise NBP20-02 core site locations. A. North of Thwaites Glacier Eastern Ice Shelf; B. East of Thwaites Glacier Eastern Ice Shelf and in area in of front of Pine Island Glacier that opened up after a major calving event in early February; C. On west side of Thwaites Trough and near Iceberg B-22A, the former Thwaites Glacier Tongue; D. Cranton Bay. Yellow stars in A and D mark locations where seals were tagged.

## Sediment cores from beneath the ice shelf

Sediment cores collected at sea will be analysed together with ones collected from 4 sites beneath the ice shelf (Fig. 5). These cores were recovered by deploying a percussion corer through holes in the ice shelf made with hot water drilling systems, primarily for oceanographic studies, by the ITGC TARSAN and MELT project teams.

Fig. 5. The set of sediment cores collected from sites beneath the ice shelf. Locations of the sites are marked in Fig. 2.

## Seismic reflection profiles

460 line-km of high resolution seismic reflection profiles were collected on the inner shelf in front of Thwaites and Pine Island glaciers to investigate the nature of bed and former pinning points that the glaciers of have retreated from (Fig. 6).

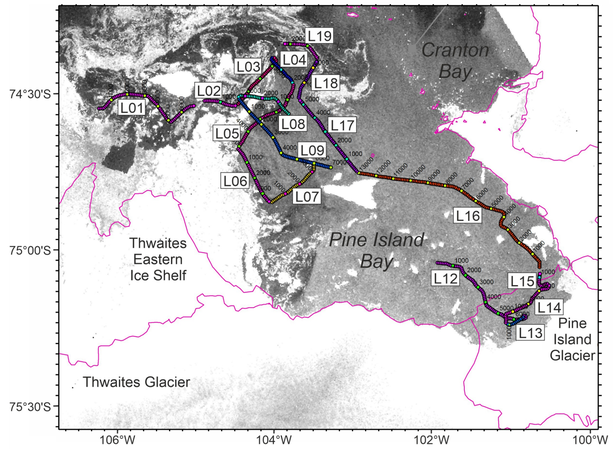


Fig.6. Locations of high-resolution seismic reflection profiles collected on cruise NBP20-02 overlaid on Sentinel-1 SAR image acquired on March 9th, 2020. Common mid points are annotated at intervals of 1000. Magenta lines are 2016 coastline and ice shelf fronts from the Antarctic Digital Database of the Scientific Committee on Antarctic Research.

## Seal tagging

Oceanographic satellite data relay loggers ('tags'; Fig. 7) were attached to 8 Weddell seals and 3 Elephant seals on ice floes north of the Eastern Ice Shelf and on the Edwards Islands (yellow stars on Figs 4A and 4D). The tags record and transmit ocean temperature and salinity profiles from the seals' dives for up to a year before they are shed during the next annual moult. This work is conducted according to strict ethical guidelines and with a permit under the UK Antarctic Act.

Fig. 7. A Weddell seal tagged with an oceanographic satellite data relay logger.

## Oceanographic moorings

One oceanographic mooring that had been deployed near the southern coast of Pine Island Bay during cruise NBP19-02 last year was recovered and relaid. A second mooring was deployed at a location in the middle of the bay where one had been recovered last year but not relaid. Two moorings on the outer shelf that were deployed several years ago could not accessed because of dense sea ice cover that persisted throughout the season.

## Acknowledgements

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