A Glacial Geologic History of Tucker Glacier, Antarctica

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Abstract

Tucker Glacier, which drains from East Antarctica through the Transantarctic Mountains (TAM) into the northwestern Ross Sea, is located just north of the proposed Last Glacial Maximum (LGM) grounding line. This project used glacial landform mapping and till analysis including grain size, lithology, roundness and shape to identify past changes in the extent and thickness of Tucker Glacier. Till was collected from three ice-free areas at the confluence of Tucker and Whitehall Glaciers, 30 km from the Ross Sea. At two of these field sites there is an increase in 4 mm to 30 mm sized clasts at lower elevations. There is also a noticeable decrease in the different lithologies at higher elevations along Tucker Glacier. Till analysis from the three ice-free areas indicate an increase in relative age with elevation at Tucker Glacier. Based on the elevations of granite erratics, ice at Tucker Glacier reached a minimum of ~200 m a.s.l. in the past. This elevation is between two published reconstructions of LGM ice in this area.

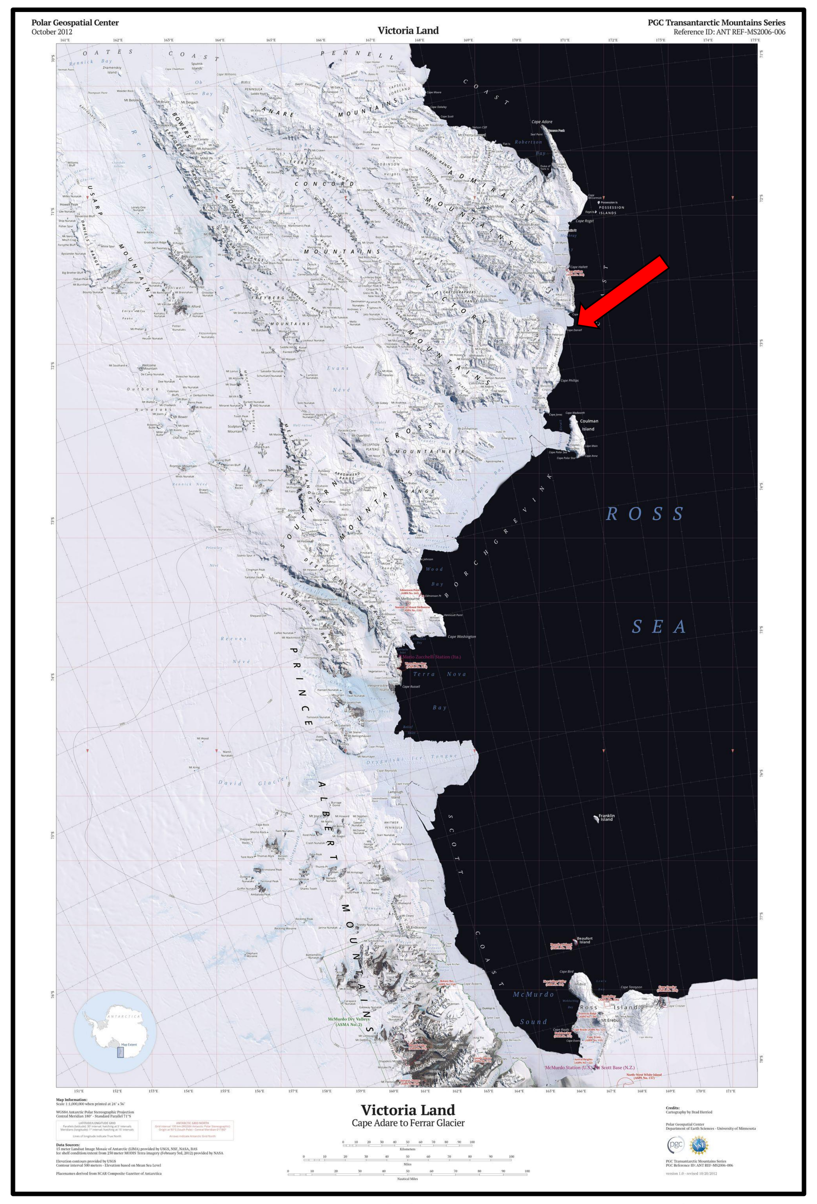

Figure 1: Reference map of the western Ross Sea; the red arrow is pointing to Tucker Glacier. Map credit: Polar Geospatial Center

Field Area

- Tucker Glacier is located in the northwestern Ross Sea just north of the proposed LGM grounding line (fig. 1); deposits at Tucker Glacier may help to constrain the extent and thickness of Ross Sea ice.
- Two previous reconstructions of LGM ice in the Ross Sea show conflicting elevations in this area: ~400 m (Denton and Hughes, 2002), and sea level (Bentley, 1999).
- Three rock types are present in this area: granodiorite, mafic extrusive volcanic rocks and metasedimentary rocks (fig. 2;Harrington et al., 1963; 1968)

Field Methods

Glacial Landform Mapping

- Erratics and moraines were mapped using a Trimble base station, a handheld GPS and a Kestrel barometer. Extent of weathering was documented for boulders including the amount of staining, and roughness.

Till Sampling

- Till sample locations were selected to represent different elevations above the ice surface and to avoid areas influenced by rock fall and patterned ground. Pits were dug 8 to 30 cm deep depending on the compaction of the till (fig. 3). The depth to moisture and slope of the surface were also documented.

Lab Methods

- The till samples were dry sieved using a RoTap machine with screens ranging from 4 mm to 62.5 µm (Bromley et al., 2010). Clast axis measurements were entered into a tri-plot spreadsheet to determine the shape of the clasts, and Powers (1953) roundness table was used to document roundness of clasts greater than 3 cm.

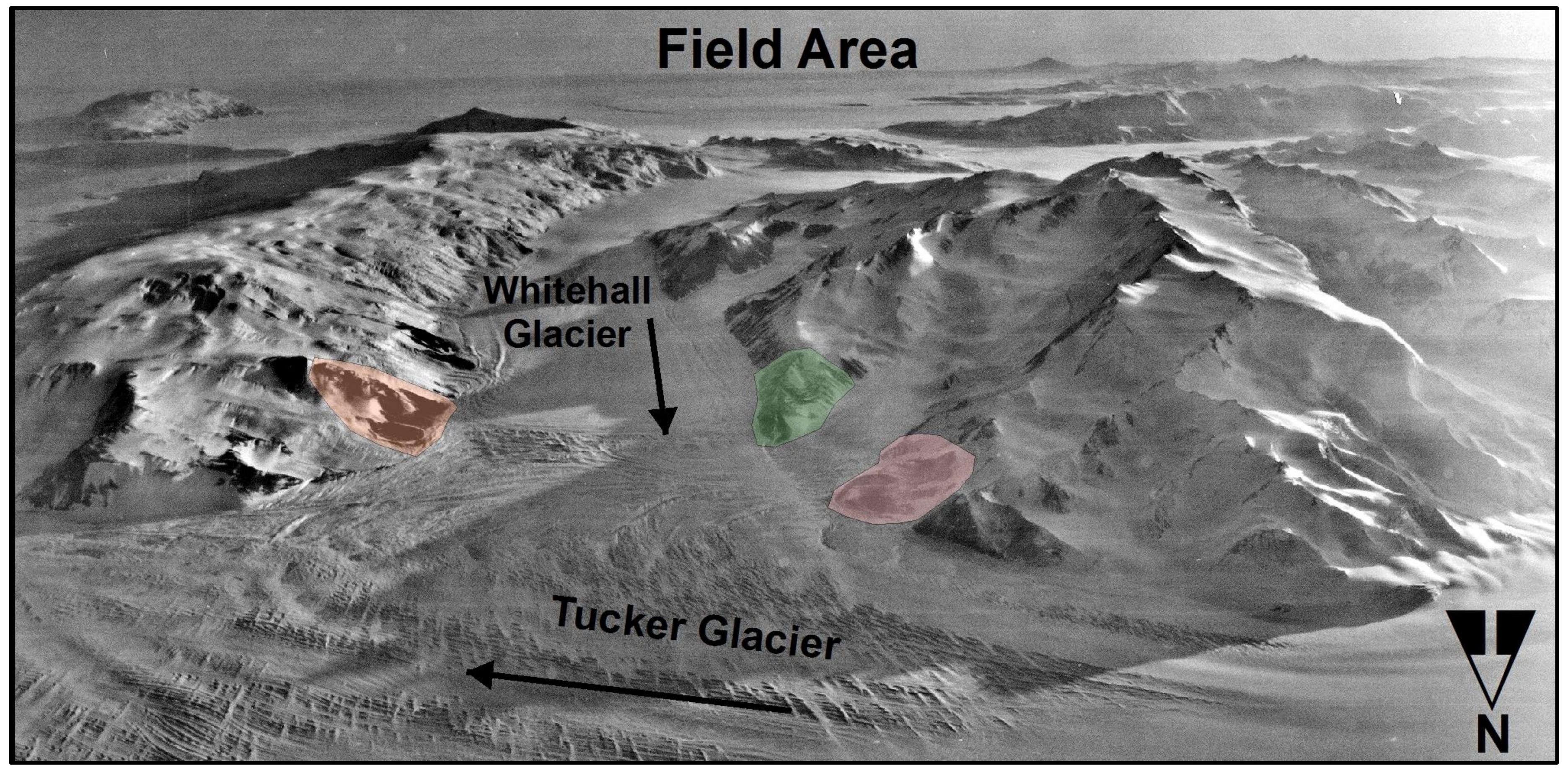

Figure 2: Aerial image from the US Navy of the confluence of Tucker and Whitehall Glaciers. The colored areas are indicating the three field sites where till samples were collected. Different colors indicate the primary rock type of each field area: orange (ice-free area 1) is primarily mafic extrusive volcanic rocks, green (ice-free are 2) is metasedimentary rocks, pink (ice-free area 3) is primarily granite and granodiorite. Arrows associated with glacier names indicate flow direction.

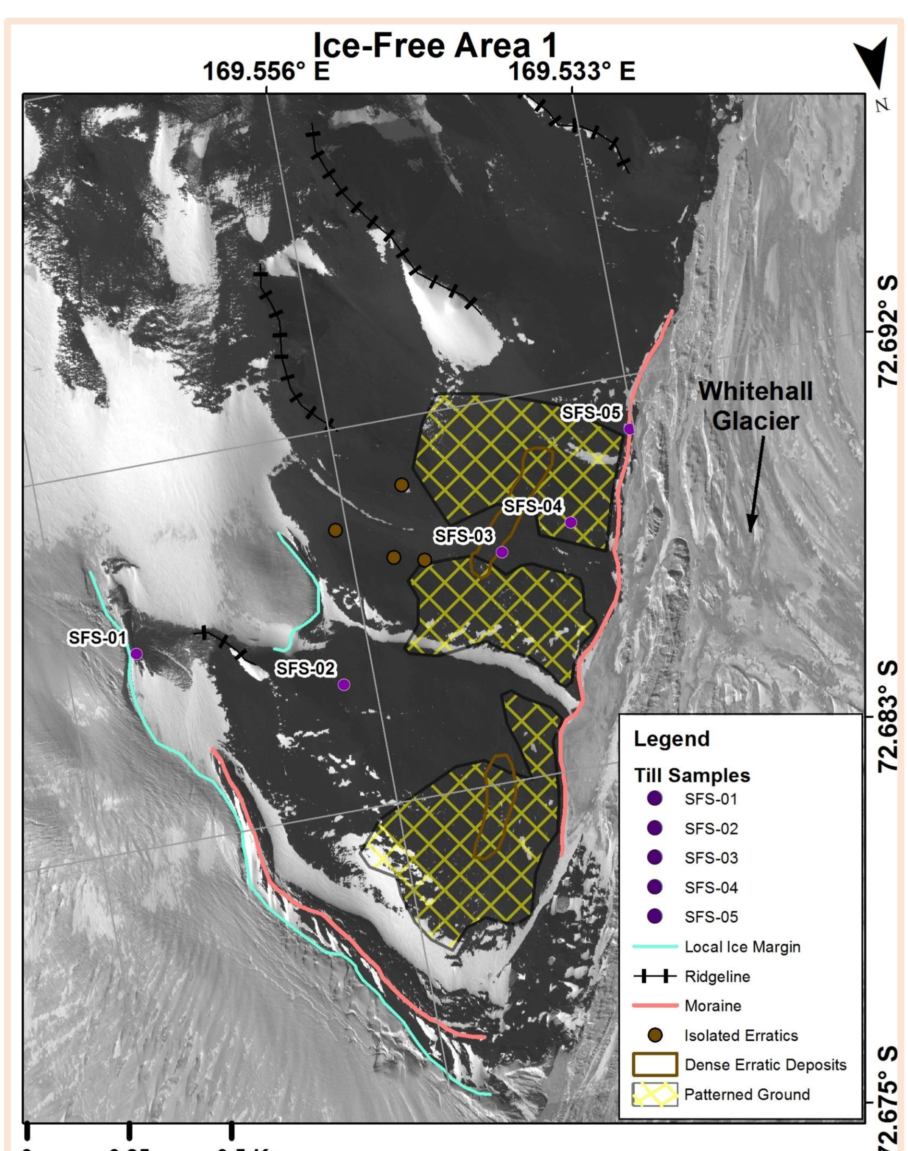

Figure 5: Glacial geologic map of ice-free area 1; there were two large granite boulder clusters present here as well as numerous boulders scattered throughout the field area. The ice in the lower left corner of the map is a large local glacier.

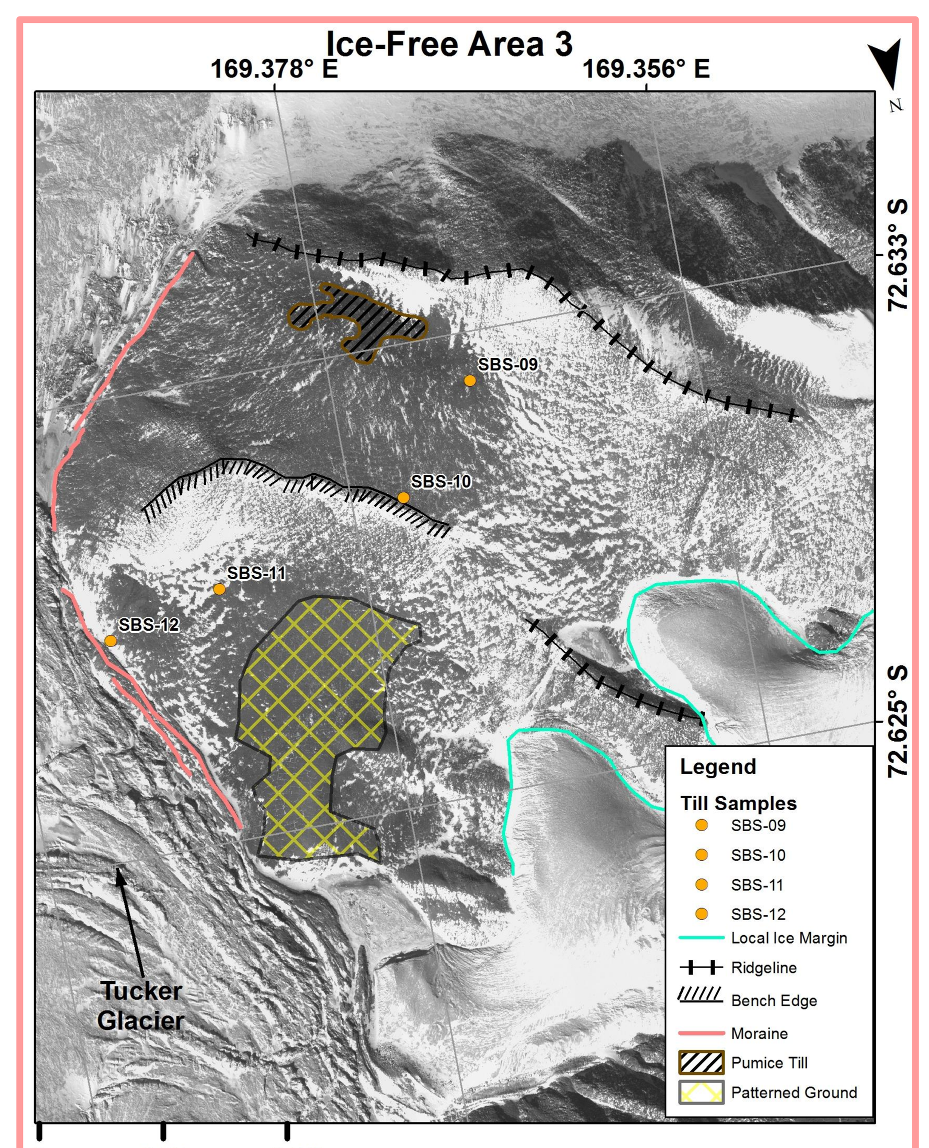

Figure 8: Glacial geologic map of ice-free area 3; there was a large deposit of pumice located in this field area which is the primary source of non-local material. There are also two local glaciers present in this area.

Glacial Geologic Mapping

- The only outcrop of granite is at ice-free area 3, up Tucker Glacier about 9 km from ice-free area 1 (fig. 4).
  - There are two large clusters of granite boulders present on ice-free area 1 which were transported by a thicker Tucker Glacier (fig. 5).
- The highest observed granite erratic at ice-free area 1 is 256 m a.s.l.
  - This elevation indicates a potential minimum LGM ice surface which is ~150 m lower than Denton and Hughes (2002), and ~250 m higher than Bentley (1999).
- Patterned ground was present at all three ice-free areas (figs. 5, 7, and, 8). The cracks ranged in depth from 10-15 cm (fig. 9).
- Ice-cored moraines were present along the margin of Whitehall Glacier at ice-free area 1 and along the margin of Tucker Glacier at ice-free area 3 (figs. 5 and 8).

Figure 3: Till sample pit 14-TUG-02-SFS, this pit was dug to 18 cm deep and moisture was reached at 11 cm.

Figure 9: This area of patterned ground is located at ice free area 1 and contains cracks that were about 10 cm deep and were up to ~40 cm across.

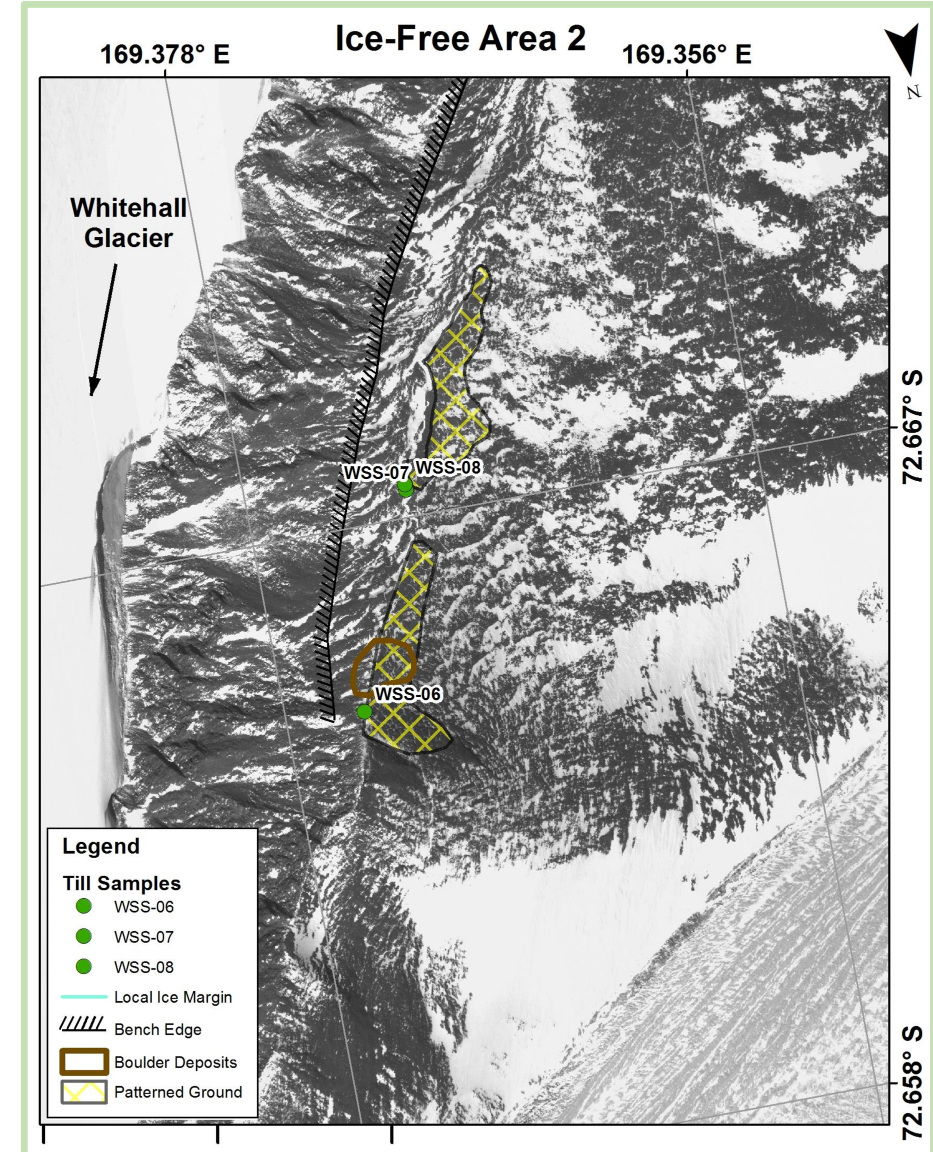

Figure 7: Glacial geologic map of ice-free area 2; this field area contains one large cluster of granite boulders. These boulders exhibit the highest amount of weathering at any of the three ice-free areas.

Figure 4: Large granite cliffs located at ice-free area 3. In the background, ice-free area 1 can be seen.

Till Analysis

- There is an increase in grain size at lower elevations both at ice-free area 1 and ice-free area 2. In figure 10 we see the gravel size fraction (4 to 1 mm) increase from the highest sample (01-SFS) to the lowest sample (05-SFS).
  - These data along with observations made about boulders at these sample locations indicate a decrease in age with elevation (Bromley et al., 2010).
- There is a lack of rounded or well-rounded material at any of the three ice-free areas.
  - Roundness data in addition to the shape data from all three ice-free areas indicate passive transport (Benn and Ballantyne, 1994).
- There was a lack of visible granitic material in the till at the two highest sample locations on ice-free area 1 (table 1). The second highest till sample is below the highest granite boulder. We present three possible explanations for the lack of granite at these two highest sites.
  - Granite has been deposited by Tucker Glacier at these higher elevations, but it has since weathered to very small grain sizes
  - Granites deposited by Tucker Glacier on ice-free area 1 are deposited sparsely; thus, we would only expect to find pockets of weathered granite material
  - Till at higher elevations at ice-free area 1 was delivered by expanded versions of local glaciers, not Tucker Glacier ice.

Till Samples	Elevation of Till Sample (GPS)	Presence of Erratic Material	Type of Erratic
Ice-Free Area 1			
14-TUG-01-SFS	290 m	no	N/A
14-TUG-02-SFS	151 m	no	N/A
14-TUG-03-SFS	88 m	yes	Granite
14-TUG-04-SFS	61 m	yes	Granite
14-TUG-05-SFS	2 m	yes	Granite
Ice-Free Area 2			
14-TUG-06-WSS	281 m	yes	Mafic and Granite
14-TUG-07-WSS	280 m	yes	Mafic
14-TUG-08-WSS	278 m	yes	Mafic
Ice-Free Area 3			
14-TUG-09-SBS	193 m	yes	Mafic
14-TUG-10-SBS	183 m	yes	Mafic
14-TUG-11-SBS	58 m	no	N/A
14-TUG-12-SBS	3 m	no	N/A

Table 1: Presence of erratic material in till samples. The colors correspond with figure 2 showing the local rock type.

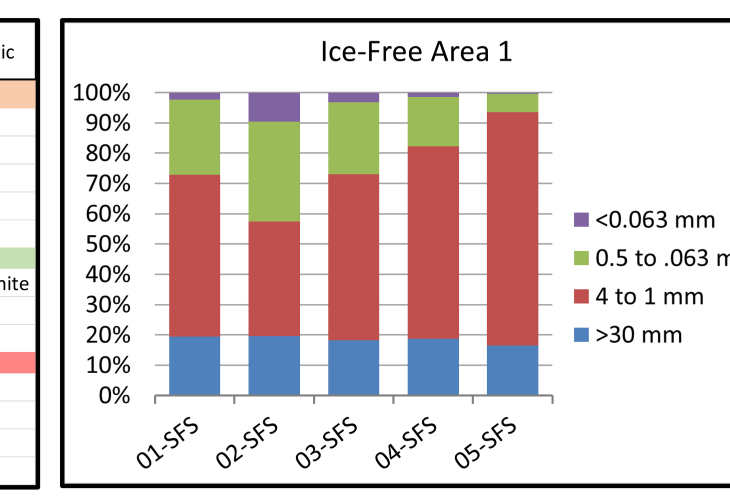

Figure 10: Grain size analysis of ice-free area 1. There is an increase in the 4 to 1 mm sized fraction at lower elevations. 01-SFS is the highest till sample at this ice-free area, and 05-SFS is the lowest till sample.

Figure 11: Granite boulders at ice-free area 1, looking across to the large granite cliffs (upper right corner of photo) of ice-free area 3.

Conclusions

- Tucker Glacier was thicker in the past; cosmogenic isotope analyses associated with this project will provide precise dates for thinning and retreat of ice in the Northwestern Ross Sea.
- If weathered granite boulder deposits along Tucker Glacier (fig. 11) represent LGM ice, then our data suggest ice thickness during the LGM was between two previously published reconstructions (Denton and Hughes, 2002; Bentley, 1999)
- The shape and roundness data indicate passive transport of material which was supraglacial in origin (Benn and Ballantyne, 1994). Most of the erratic material from ice-free area 1 appears to have fallen off the large granite cliffs of ice-free area 3 onto Tucker Glacier.

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