A surprisingly large marine ice cap on Heard Island during the Last Glacial Maximum?

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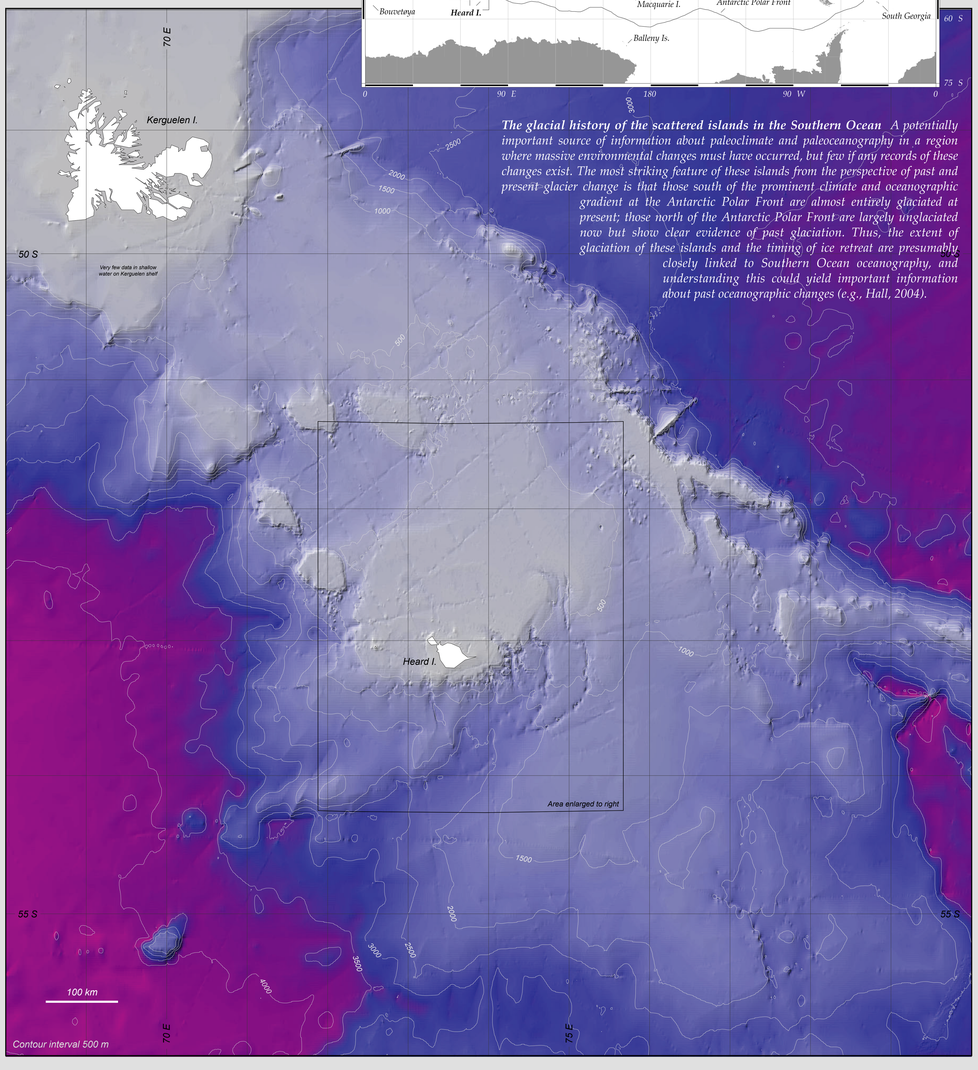
Summary *A new compilation of bathymetric surveys surrounding Heard Island appears to show geomorphic evidence that the island and surrounding submarine plateau were covered by a 100-km-wide tidewater ice cap at some time in the past. If this ice cap existed, it presumably did so at the last glacial maximum when relative sea level was lower than present. Even so, it would have been grounded in at least 180 m of water and therefore must have been several hundred meters thick.*

The new bathymetric data set *In 2005, Mike Sexton of Geoscience Australia and the Australian Antarctic Division compiled existing bathymetric surveys for the Heard Island region, and combined them with a large amount of new data generated by Australian fishing vessels. The resulting bathymetric map is significantly improved over previously available charts, especially in areas of shallow water and complex terrain where presumably there is good fishing. The data sources and gridding procedure are documented in Sexton (2005).*

The full bathymetric data set



The glacial history of the scattered islands in the Southern Ocean *A potentially important source of information about paleoclimate and paleoceanography in a region where massive environmental changes must have occurred, but few if any records of these changes exist. The most striking feature of these islands from the perspective of past and present glacier change is that those south of the prominent climate and oceanographic gradient at the Antarctic Polar Front are almost entirely glaciated at present; those north of the Antarctic Polar Front are largely unglaciated now but show clear evidence of past glaciation. Thus, the extent of glaciation of these islands and the timing of ice retreat are presumably closely linked to Southern Ocean oceanography, and understanding this could yield important information about past oceanographic changes (e.g., Hall, 2004).*

What next?

As far as I know, there exists only a very little information about the glacial history of Heard Island -- mostly summarized in Kiernan and McConnell (1999). It's in one of the most inaccessible and inhospitable places in the world, which rather limits research possibilities. If you have more information, have access to bathymetry from the Kerguelen Plateau, or are planning research in this area, I'm very interested to hear about it.

Regardless, the evidence that the seafloor on the Kerguelen-Heard plateau may preserve an important record of past glaciation, and by extension paleoclimate and paleoceanographic conditions in the Southern Ocean, clearly supports future efforts to acquire multibeam bathymetry in this region. In particular, the relationship between glacial features and shoreline features which are also presumed to exist on the shallow shelf would reveal the relationship between glaciation and sea-level rise, and thus the timing of ice cap formation and decay.

Geomorphic evidence for glaciation

Two features suggest extensive glaciation of the shelf surrounding Heard Island.

First, a linear ridge is approximately concentric with, and 50-80 km north of, the northern shoreline of the island. This ridge is up to 50 m high and its top is at 150-230 m water depth. Second, there are at least two elongate, overdeepened troughs immediately landward of and perpendicular to this ridge. Although these features are only roughly defined by the bathymetric grid, each is crossed by many individual fathometer tracklines; thus, they do not appear to be artifacts of the gridding process.

This combination of features strongly suggests that they were formed by glaciation. The overdeepened linear troughs are strongly diagnostic of formation by glacial erosion, as few other erosional processes are capable of eroding overdeepened basins. The ridge is concentric around the present island (the presumed center of any past ice cap), and in most places is wedge-shaped, steeper on its seaward than on its landward face. This asymmetry is characteristic of 'till tongues' or morainal wedges formed at glacier grounding lines, and the size and shape of this feature are similar to those of grounding zone wedges observed on the continental shelf around the Antarctic Peninsula (e.g., those of Heroy and Anderson (2005) given as an example below). Thus, these features appear to record a significantly expanded ice cap on Heard Island, that extended more than 50 km from the present shoreline onto the adjacent continental shelf.

Is it a glacier grounding line wedge?

Example from the Antarctic Peninsula

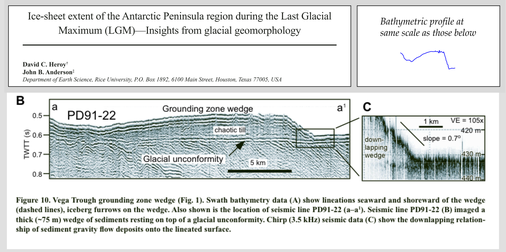
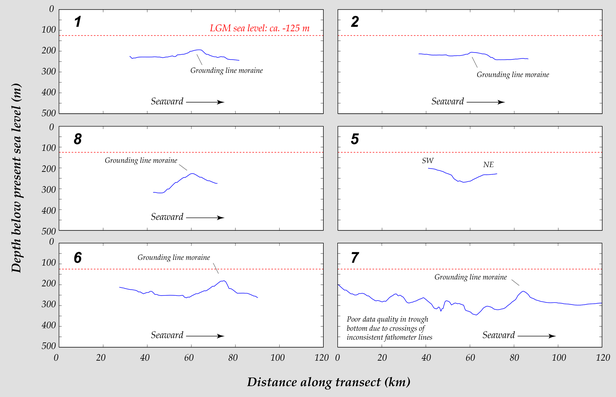


Figure 10. Vega Trough grounding zone wedge (Fig. 1). Swath bathymetry data (A) show lineations seaward and shoreward of the wedge (dashed lines), iceberg furrows on the wedge. Also shown is the location of seismic line PD91-22 (a–a'). Seismic line PD91-22 (B) imaged a thick (~75 m) wedge of sediments resting on top of a glacial unconformity. Chirp (3.5 kHz) seismic data (C) show the downlapping relationship of sediment gravity flow deposits onto the lineated surface.

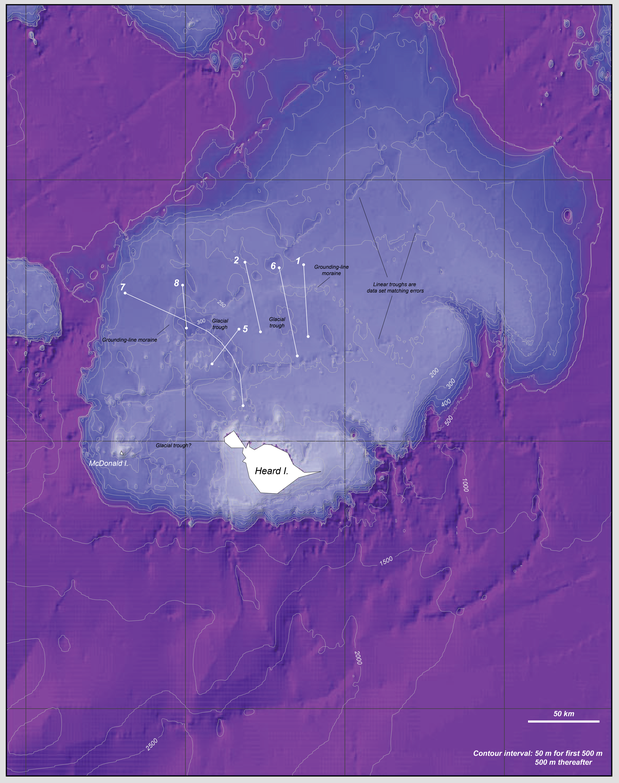
Bathymetric profiles across the Heard Island grounding line wedge

(locations of profiles shown at right)



A surprisingly large LGM ice cap? *If these features do record a significantly larger ice cap, it seems most likely that this ice cap would have been present during the last glacial maximum, when relative sea level would have been ca. 125 m lower than present. If sea level lay 125 m below present, the deepest part of the elongated trough highlighted in Figures 2 and 3, which is apparently near 300 m below sea level now, would still have been ca. 180 m below sea level. The top of the inferred grounding line moraine complex shown in Figure 3 would have been ca. 120 m below sea level. Thus, if the ice cap was present at the LGM, it must have been ca. 135 m thick at its margin, which, in turn, would require that it be several hundred meters thick at its center. At present, a minority of the glaciers on Heard Island actually reach tidewater, and none is grounded in a significant depth of water. Thus, for a large ice cap to extend well out onto the shelf and be grounded in ca. 120 m of water would require either that snow accumulation was significantly greater, or that ice loss by calving was less effective than present. The latter might be favored by an increased occurrence of sea ice in this area and thus a reduction in wave energy, or by colder temperatures that would reduce the availability of surface meltwater.*

Enlargement of the Heard Island platform



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References

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