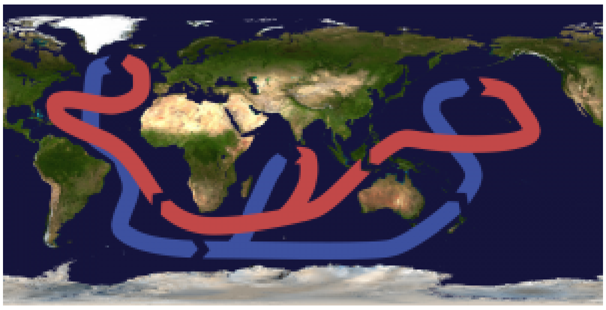
Why study Antarctic Glaciers?

A global system


Global thermohaline circulation. From: Wikimedia Commons

Why should we study Antarctic glaciers? What can we learn from them? Antarctica plays a vital role in the global oceanic and climatic systems. Cold water is formed in Antarctica. Because freshwater ice at the surface freezes onto icebergs, this water is not only cold, it is salty.

This cold, dense, salty water sinks to the sea floor, and drives the global ocean currents, being replaced with warmer surface waters from the equatorial regions. This is the global thermohaline circulation, and these ocean currents keep Britain warm, and drive the earth's climatic system.

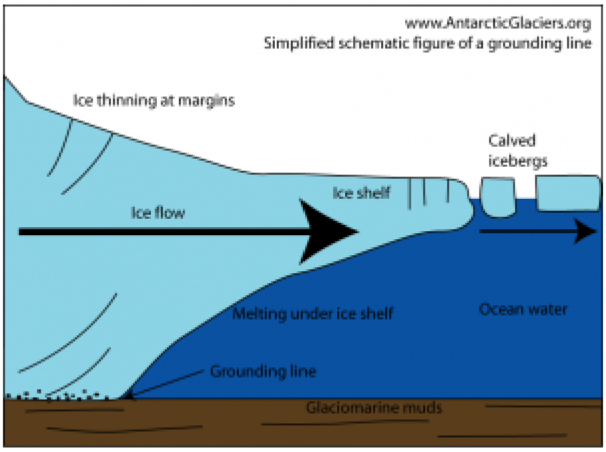
Water from melting glaciers in Antarctica also has the potential to raise global sea levels. How likely this is to happen, and at what rate, is an important research question that scientists are now trying to answer.

Dynamic ice streams

The Antarctic continent is drained by numerous large ice streams. They have considerable variability at short (sub-decadal) timescales, with recent observations of thinning, acceleration, deceleration, lateral migration and stagnation[1].

The mechanisms controlling these variations and advance and recession of *grounding lines* include a number of potential forcings, such as oceanic temperatures, sea level changes, air temperatures, ocean tides, subglacial bathymetry, geomorphological features, subglacial meltwater, thermodynamics, and the size of the drainage basin[1].

Rapid changes



Simplified cartoon of a tributary glacier feeding into an ice shelf, showing the grounding line (where the glacier begins to float).

Around the Antarctic Peninsula, a number of ice shelves have recently dramatically collapsed[2-4], resulting in glacier acceleration, thinning and *grounding line* retreat[5-7]. In fact, Antarctic ice shelves appear crucial to the stability of their tributary glaciers[8], and melting ice shelves could have catastrophic consequences for many glaciers.

This is particularly concerning for the West Antarctic Ice Sheet, which is largely grounded below sea level[9], and removal of this could raise sea levels by 3.3 m[10, 11]. *Grounding line* recession here could be irreversible, leading to rapid glacier thinning and recession, and sea level rise – see Marine Ice Sheet Instability.

The past is the key to the present

Although the Antarctic Peninsula is currently warming rapidly[12-14], the duration of instrumental observations in Antarctica (ca. 100 years) means that it is difficult to differentiate between natural cycles and occurrences, and dynamic behaviour that is beyond the norm. Are ice-shelf collapses a normal part of ice-sheet behaviour, or are they something more sinister?

Glaciers in Antarctica are largely currently receding and shrinking[15] (see Antarctic Peninsula Glacier Change), but is this a reaction to long-term climate change and natural climatic cycles during the *Holocene*, or is the rate of shrinkage and recession faster than ever before?

In order to answer these questions, we must look at the palaeo record – how the Antarctic ice sheet, ice shelves and ice streams have behaved over the last few thousand years (see Ice Sheet Evolution).

It is vital to determine what thresholds control ice-sheet behaviour, and whether these have been crossed in the past. By gaining a deeper understanding of past processes, rates of change, rates of ice sheet thinning, and previous temperatures and environmental conditions, we will be better placed to understand how the Antarctic continent as a whole will behave in the future.

Reconstructing ancient ice sheets

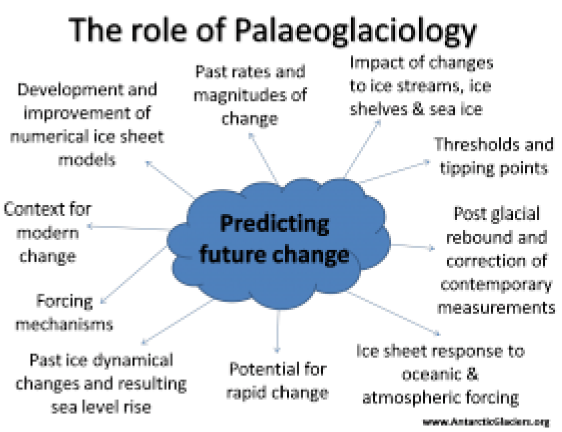

Geologists taking rock samples on James Ross Island

We have many tools with which to do this. Terrestrial glacial geologists (such as ourselves) can gain information of past glacial behaviour from mapping and dating former ice sheet extents, and determining the rates at which they receded and thinned, [e.g., 16, 17-19].

Marine geologists do much the same thing on the continental shelf, but use different tools, such as *swath bathymetry* and marine sediment cores, dated using radiocarbon dating, palaeo-magnetism and other methods, [e.g., 20, 21-24].

Quaternary scientists can use micro-organisms preserved in marine muds and onshore in lakes[25-27] to reconstruct past temperatures, ocean currents, rates of environmental change[28] and previous ice shelf collapses[29-31]. Other researchers look at raised beaches [32] and palaeo lakes to record previous rates of isostatic uplift and rates of sea level rise[33, 34]; this can help constrain previous ice volumes and rates of ice loss.

A large jigsaw with many pieces



Why should we study palaeoglaciology?

Working with the geologists are numerical modellers, who use the data to test, train and tune numerical models and simulations[35-37].

Through these models, we can make better predictions of future ice sheet behaviour and rates of sea level rise, and ultimately provide policy makers with improved estimates of future change. For an example of some recent modelling work on the former British-Irish Ice Sheet, see the BritIce Modelling Project.

Further Reading

- Palaeo ice sheet reconstruction
- Glaciers and climate change

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