The impact of changing ocean circulation on the Antarctic ice shelf

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Background and rational for the project

Global sea level is rising at an accelerating rate in response to increasing greenhouse gas emissions. The excess heat associated with industrial emissions, has warmed the atmosphere by ~1.0ºC and has mostly been absorbed by the oceans causing thermal expansion, melting of mountain glaciers, and the ice sheets of Antarctica and Greenland. In recent years, melting of the Antarctic ice shelves due to warming of the oceans and changes in the circulation around Antarctica, have been the major driver of increased ice discharge to the ocean.

The feedbacks and processes controlling the response of the Antarctic Ice Sheet to global climate warming are a major source of uncertainty in predictions of future sea level rise to 2100 and beyond. A robust understanding of the mechanisms driving Antarctic Ice Sheet mass loss is the crucial missing ingredient in current predictions of future sea level rise, and by extension in climate change adaptation policies.

To better understand the mechanisms of ice sheet retreat and sea level rise we need to look back in time, to past Earth warming events. Global sea level rose by approximately 120 m during the last deglaciation as temperatures rose by 4-5 ºC, when the Earth emerged from the Last Glacial Maximum about 20,000 years ago. The Antarctic Ice Sheet is thought to have contributed around 10 m to the global sea level increase, with most of the sea level change coming from the Northern Hemisphere ice sheets. However, reorganisation of ocean circulation around Antarctica has also been hypothesized to play an important role in melting of the Antarctic Ice Sheet over centennial to millennial timescales.

This project aimed to reconstruct changes in ocean circulation and ice sheet dynamics at sensitive locations along the East Antarctic margin, where Antarctic Bottom Water forms, and where the ice sheet is vulnerable to changes in ocean heat flux because it sits in a vast basin lying below sea level.

Technical achievements

The SIEF fellowship has supported the establishment of methodologies in trace metal and isotope geochemistry for seawater and sediments at the University of Tasmania, which include methods for:

- Extracting neodymium for isotopic analysis in seawater and marine sediment
- Isolating neodymium and the isotopes of thorium-230 and thorium-232 from the same sample of seawater
- Separating and analysing rare earth elements in seawater

Outcomes and impacts of the project

An important outcome of the project was a major review article in *Reviews of Geophysics* on “The sensitivity of the Antarctic Ice Sheet to a changing climate: Past, present and future”. This was a significant and time-consuming piece of work involving 22 co-authors across four major areas of Earth science research; oceanography, glaciology, geology and geophysics, and paleo-environmental reconstruction. The manuscript is in the final stages after addressing the comments from two referees.

A second outcome of this project is a much better understanding of the challenges and limitations of existing paleo proxies available to reconstruct changing ocean circulation in Antarctica. As part of the project the fellow undertook significant work on mapping the behaviour of several geochemical proxies and has developed a framework for interpreting these proxies so that we can better infer past changes in the environment.

The following will be submitted as scientific articles in international journals as a result of the research carried out during this project:

- Multiple geochemical assessment of seawater and sediments along the continental shelf of Adelie/George V Land that contributes to understanding the application of geochemical proxies for reconstructing past environmental conditions along the East Antarctic margin.
- An assessment of changes in Antarctic Bottom Water formation and ventilation of the Southern Ocean during the last deglaciation, from observations along the margin of East Antarctica.