SCAR Prince of Asturias Fellow, 2003—Minghong Cai

Final Report

The studies on the marine ice from the Amery Ice Shelf, East Antarctica

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Brief Introduction and aims of the project:

Antarctic ice shelves are important components of the global climate system, and basal melting and freezing processes underneath an ice shelf can impact larger scale ocean circulation (e.g. Foldvik and Gammelsrød, 1988; Nicholls et al, 1991). Processes of ocean-ice interaction beneath some ice shelves include accretion of marine ice onto the underside of the shelf from platelet ice that crystallizes in the ocean cavity (Fig 1).

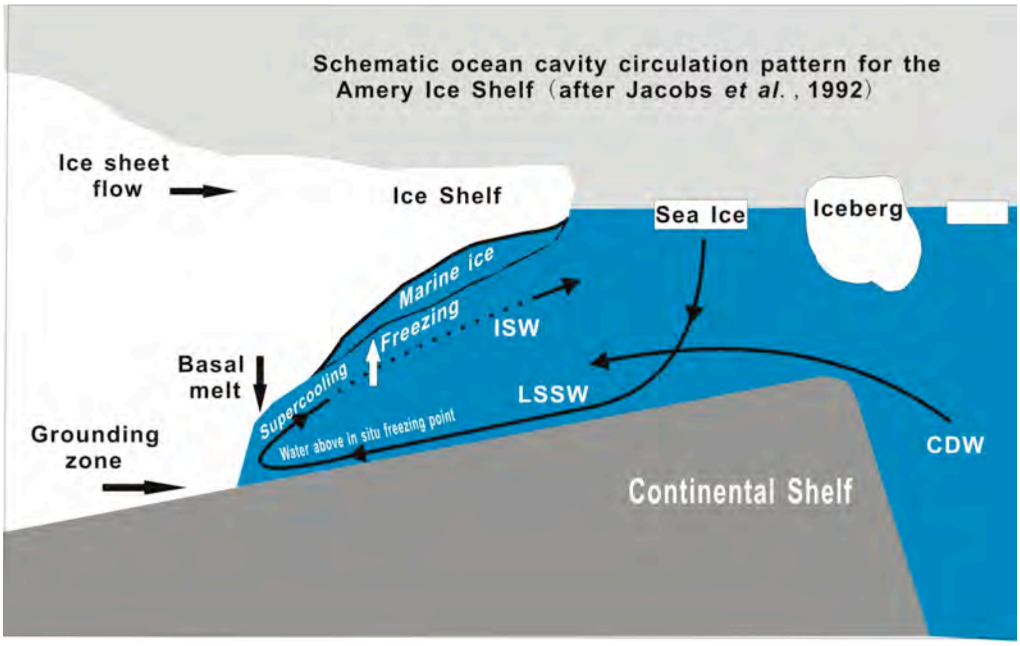
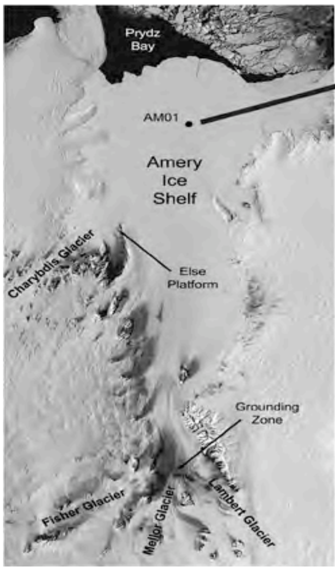


Fig 1 Schematic diagram showing the processes at work in the creation of marine ice (after Jacobs et al., 1992).

In the 2002/03 season a glaciological team from the 19th Chinese National Antarctic Research Expedition (CHINARE-19) recovered a 296 m long continuous ice core from site AM01 at 69°26.2'S, 71°25.9'E (Fig.2) where the total thickness of the AIS is 479 m. This core penetrated about 20 m into a marine ice layer on the underside of the ice shelf.



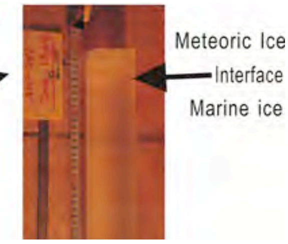


Figure 2 Amery Ice Shelf region showing the AM01 borehole site ($69^0$26.2'S, $71^0$25.9'E) and an image of the interface between meteoric and marine ice at 276 m depth.

The marine ice accreted under the Amery Ice Shelf contains entrapped marine organic material, both particulate and dissolved. We aimed for better understanding of the processes of circulation, crystallization and accretion beneath the Amery Ice Shelf by studying the physical, chemical and biological analyses of marine ice samples from the Amery Ice Shelf.

Duration:

Period of Antarctic field work: November 2002-April 2003
Period of laboratory analyses at AAD and ACE& CRC, University of Tasmania:
First Period: August 2004-June 2005
Second Period: May 2006-July 2006

Significant findings to date:

Data analysis and interpretation is been continued by the cooperative partners. However, the significant findings to date include:

A. Marine ice properties near the transition zone

Chemical analyses of the marine ice shows that there is a similar pattern of variability in the sea salt trace ions (Mg^{2+}, SO_4^{2-} and Cl^-), bulk conductivity and _^{18}O, which all increase with depth to a peak around 285m, and then remain relatively constant, or slowly decrease. The ratio of trace chemicals is the same as in sea water. The particulate concentration (estimated from flow cytometry) tends to be anti-correlated with the other properties (Fig 3).

The variation in oxygen isotope ratios, trace chemicals and particles in the marine ice near the interface is possibly a result of different rates of accretion, with high accretion rates resulting in higher sea salt concentrations due to increased brine inclusion rates (i.e. quicker close off of brine channels). Particulate concentrations will also depend on the accretion rate through the scavenging process.

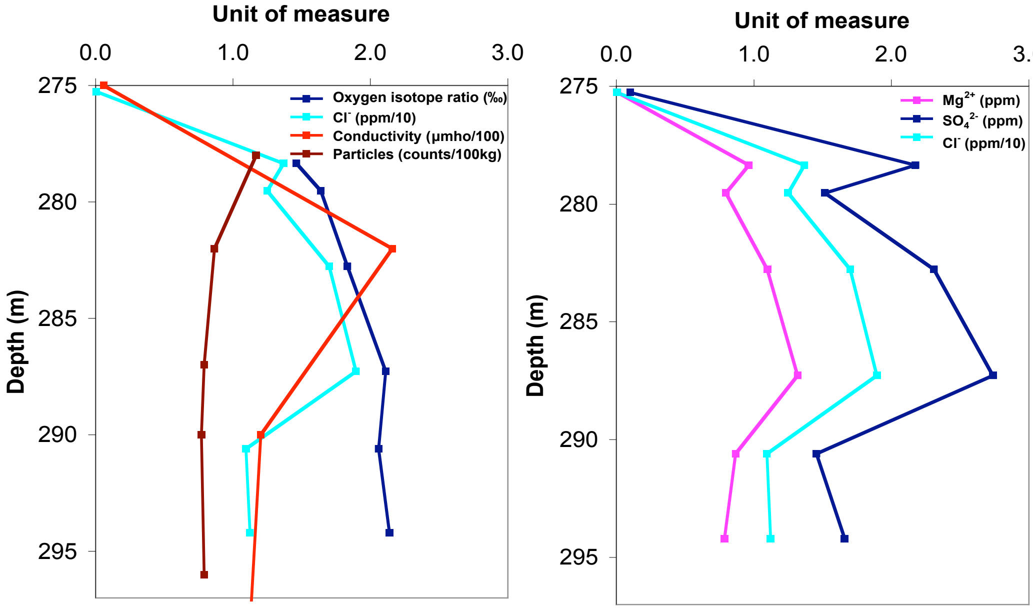


Figure 3 The depth profile of oxygen isotope ratio, Cl^- concentration, conductivity and autotrophic particles (left) and of mean ion concentrations (Mg^{2+}, SO_4^{2-} and Cl^-) through the marine ice transition zone (right).

B. Particulate inclusions in the marine ice

The marine ice beneath the AIS contains debris inclusions which Roberts et al. (2006) report are both terregenic and biogenic (predominantly protists) in origin. We used flow cytometry to further investigate particulate inclusions in the top layers of the marine ice. We found no evidence of living biological material from either fluorescence or from DNA staining of the samples. The cytograms (Figure 4) show a broad spread of particulate distribution, with no clustering identifying individual organisms. This suggests that the particulate matter in the marine ice is predominantly detritus. This detritus does however include biological material (Figure 4, right).

Particulate matter is scavenged from the water column by platelet ice formation and accretion on the underside of the ice shelf. Some living material may possibly also use the initially porous marine ice as a habitat and then become trapped as channels close. There are both benthic and pelagic ecosystems in the ice shelf cavity beneath AM01, more than 50 km "inland" from Prydz Bay (Craven et al., 2005). Fricker et al., show that marine ice accretion commences nearly 150 km upstream of AM01 near Else platform, and we estimate that the marine ice near the transition would have formed there about 250 years ago, and the absence of living organisms is thus not surprising.

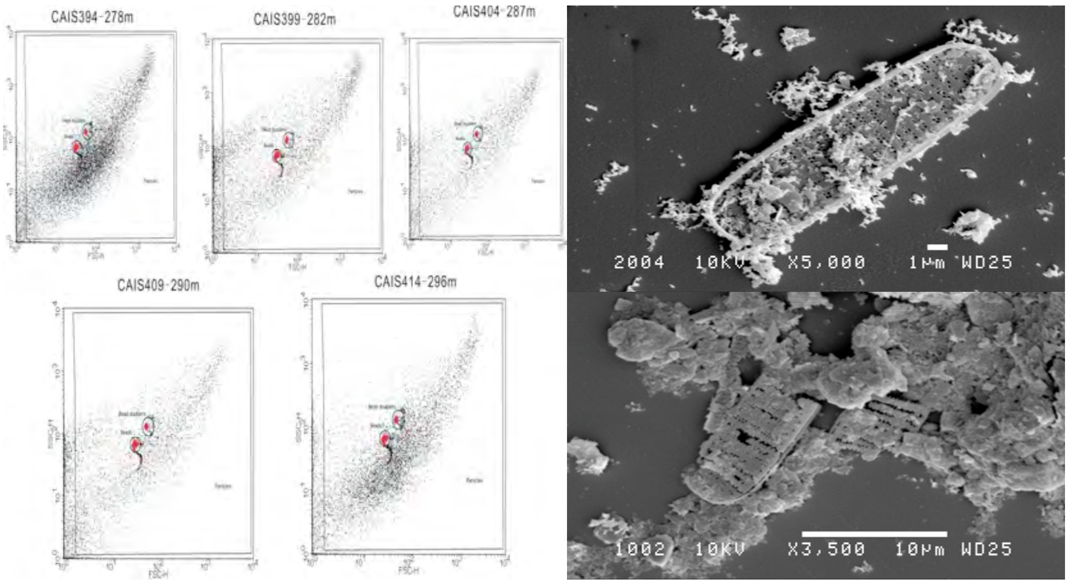


Figure 4. Left: Cytograms of melted AIS samples from 278, 282, 287, 290 and 296 m depth. Spherical, 2 _m calibration beads were introduced into the samples and their signature shows as the red clusters (single beads, lower left; coagulated doublets, upper right). The maximum particulate size shown is about 70 _m. **Right:** Scanning Electron Microscope (SEM) micrographs showing examples of *fragilariopsis curta* in the AIS marine ice (from 278 m & 282 m depth).

Publications arising from the work:

Cai M.-H, Li Y.-S, Allison Ian, Curran M.A.J: Chemical and Biological Properties of Marine Ice from the Amery Ice Shelf, East Antarctica. (preparing)

Roberts D., Craven M., Cai Minghong, Allison I., Nash G. (2006): Protists in the marine ice of the Amery Ice Shelf, East Antarctica. *Polar Biology* DOI 10.1007/s00300-006-0169-7.

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Roberts D, Craven M, Cai M, Allison I and Nash, G. (in press) Protists in the marine ice of the Amery Ice Shelf, East Antarctica. *Polar Biology.*

Acknowledgements
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