The loose tooth: rifting and calving of the Amery Ice Shelf

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Eastern end of the active rift looking along the main rift in the direction of propagation (south east), where it is cutting across smaller pre-existing crevasses that have formed upstream as the strain in the ice shelf has accumulated. A huge block of ice has broken from one of the walls and slumped into the rift.

Most of the mass loss from the Antarctic ice sheet takes place at the fronts of ice shelves and glacier tongues, via iceberg calving, or by basal melting from below. Icebergs separate from the parent ice along rifts – fractures through the total thickness of ice – that progressively form with the deformation and flow of the ice. Ice shelf rifting is an important glaciological process about which we know very little. Rifts in floating ice shelves that surround Antarctica are the largest crevasses seen in the glaciological world and understanding the mechanisms of rifting and their formation and evolution is critical to quantifying the overall mass balance of the Antarctic ice sheet and assessing the long term stability of its ice shelves.

Calving in ice shelves happens when large sections of the floating ice shelf break off. The resultant icebergs break up into smaller icebergs, which subsequently melt as the various sections are carried away by the ocean currents. The nature and frequency of such calving events is of interest, especially to understand if any link exists with global climate change – that is, whether the oceans are warming and causing increased calving and melting of the ice shelves.

Our region of study is the Amery Ice Shelf, which is the largest ice shelf in East Antarctica. This ice shelf drains the grounded portion of the Lambert Glacier Basin–Amery Ice Shelf system, which accounts for 1.6×10^6 km^2 of the grounded East Antarctic ice sheet – 16% of its total area. The ice that flows out from the Lambert Glacier Basin region passes through the front of the Amery Ice Shelf, which occupies only 2% of the

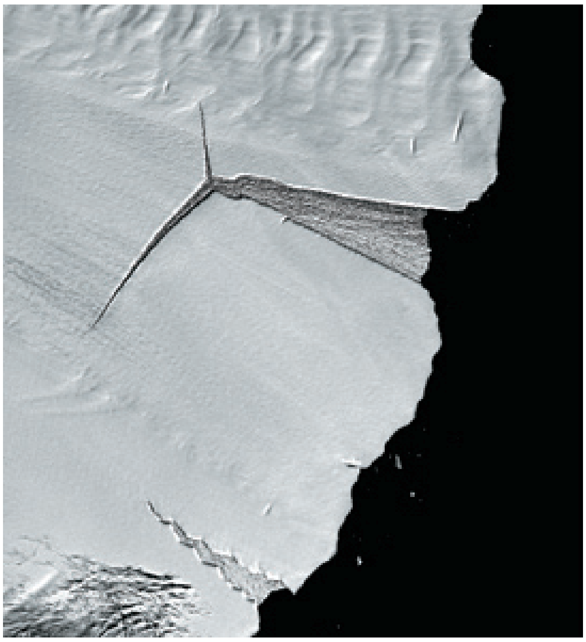

Figure 1: Satellite image detail of the 'loose tooth'. Data acquired 2 March 2003 by the Landsat-7 ETM instrument and supplied by USGS/EDC LP-DAAC.

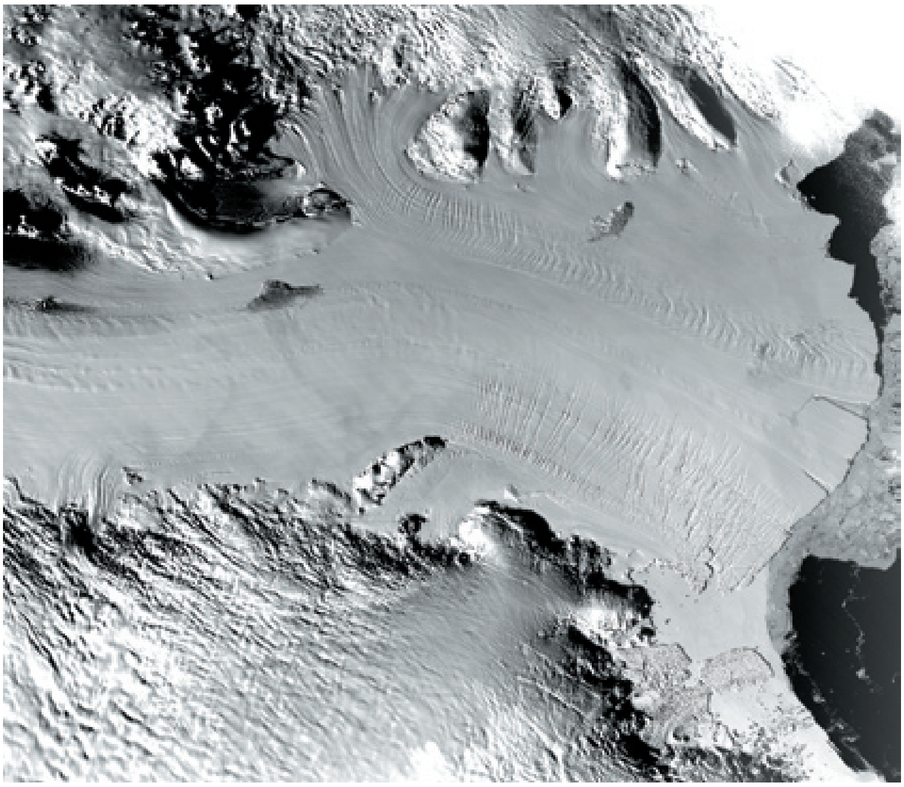

Figure 2: Satellite image showing the Amery Ice Shelf with the 'loose tooth' clearly visible at the front of the shelf. The rate of the transverse fracture suggests that the tooth will calve within the next 5–7 years or so. Data acquired 2 December 2000 by the MODIS instrument on NASA's TERRA satellite, and supplied by NASA/GSFC/DAAC.

East Antarctic coastline, making the Amery an ideal region to study as a sensitive indicator of change in the global climate system.

The last major calving event on the Amery occurred in 1963–64 and we are studying a section at the front of the ice shelf, affectionately termed the 'loose tooth'. The 'loose tooth' is an area of about 30 by 30 km, and consists of two longitudinal-to-flow rifts, which started to open around 15 or more years ago, and two transverse-to-flow rifts that formed about seven to eight years ago. The longitudinal flow lines are clearly seen in Figure 1 and are boundaries of ice streams from the Charybdis Glacier on the western side and the Fisher/Mellor Glacier flows on the east. These latter ice streams have merged together approximately 500 km upstream to form the ice shelf. The rifts at the front of the ice shelf form as the flow lines are forced apart, in regions where the transverse (lateral) strain rate is high. About 30 km from the front of the ice shelf, on the western side, two transverse rifts are seen, with the eastern rift much longer than the western transverse rift. The eastern transverse rift is currently lengthening or opening up at approximately 7–10 m/day (see Figures 1 and 2). In other words, over one year the transverse fracture will extend further eastwards by about 2–4 km and it will widen as the 'loose tooth' progressively separates from the main ice shelf. The ice shelf in this region is moving forwards in a north-easterly direction at about 1200 m/yr.

During the summer season of 2002–2003, we undertook a project to monitor the propagation (widening and elongation) of the rift and vertical displacement of the 'loose tooth' by measuring the horizontal and vertical movements in an area near the tip of the eastern transverse rift. We used Global Positioning System (GPS) units for measurement of displacement across the rift and an array of seismometers was deployed to 'listen' to the cracking and snapping of the rift systems. The GPS array consisted of six sites, positioned around the tip of the rift system (within 10 m to 2 km away), that continuously recorded data every 30 seconds over a seven-week period. Helicopter support was vital to enable us to land in regions close to rifts and crevasses, and made for some interesting fieldwork (see photograph below).

Preliminary analysis of the GPS data from this season indicated a widening of the rift near its tip of about 2–4 metres over the seven-week period and lateral movement across the rift of the order of 12 metres. If the current rate of eastern rift propagation continues, it is likely that the 'loose tooth' section will calve from the Amery Ice Shelf within the next 5–7 years. Further fieldwork is planned for the next two summer seasons to measure the active dynamics of this rift system and to understand the processes involved in ice shelf calving.

This project is being done collaboratively with researchers from the University of Tasmania (Richard Coleman), Scripps Institution of Oceanography, USA (Helen Fricker and Jeremy Bassis), the Cooperative Research Centre for Antarctic Climate and Ecosystems (Neal Young) and the University of Canberra (Peter Morgan).

Richard Coleman, University of Tasmania & ACE CRC; Neal Young, AAD & ACE CRC.

A seismic monitoring station closest to the position of the propagating tip of the rift. The site is at the junction of the recently-formed main rift and one of the smaller cross crevasses, with a Squirrel helicopter for scale. The snow bridge that was previously spanning the smaller side crevasse has slumped into it as summer temperatures have warmed. The rift widened about 2-4 m at this site during the summer season.

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