Rapid erosion and deposition of sediment, and water redistribution, beneath Rutford Ice Stream

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The movement of sediment and water beneath glaciers and ice streams affects the way they flow and the landforms they leave behind when they retreat. We present data from three seismic reflection surveys on Rutford Ice Stream in 1991, 1997 and 2004. All three surveys were conducted at the same geographic location and cover the same section of the ice stream bed, orientated perpendicular to the ice flow direction. The seismic data were used to determine the ice thickness and the acoustic impedance of the bed (the product of its density and seismic velocity), which is a useful indicator of the material beneath the ice. The whole of the bed in this area is made up of water-saturated sediments. In some places the sediments have high porosity (~0.4) and water pressure, and are probably deforming with the ice flow. Elsewhere, although still water-saturated, the sediments are lodged, porosity is lower (~0.3) and the ice is probably sliding over the bed.

Although there are few significant differences between the three surveys along most of the line, three sections of the bed show major changes in basal conditions over the intervening periods.

1. One 500 m wide section of bed in a basal sliding area, experienced 6m of erosion between 1991 and 1997. After 1997, erosion stopped and was followed by the transport of a large mound of deforming sediment, 50 m wide and 10 m high, which moved downstream on top of the underlying, less porous bed.

2. One boundary between deforming bed and basal sliding moved laterally into the basal sliding area between 1997 and 2004. In the process, a 100 m wide strip of lodged sediment increased in porosity, mobilised and became an area of deforming bed.

3. Between 1997 and 2004, the acoustic impedance of one lodged till area, 500 m wide, increased significantly, becoming (acoustically) harder.

These changes show rates of sediment erosion and deposition, as well as their initiation or cessation, which are much more rapid than we expected. They also show on-going, rapid variability in the subglacial water system.