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Characterization of the englacial drainage system in Scott Turnerbreen, Svalbard, by speleological mapping and ground-penetrating radar

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In spring 2008 the englacial drainage system of the polythermal glacier Scott Turnerbreen in Svalbard was mapped using speleological techniques. Detailed maps and scale drawings were made and photos were taken to find out how the englacial channel had developed.
The storage and drainage characteristics of glaciers are of fundamental importance to determining glacial mass balance, glacial runoff and climatic impact on glaciers. So far study of glacial hydrology has been concentrated on temperate glaciers. Almost no information exists about the hydrology of non-temperate glaciers.
Englacial conduit formation in polythermal glaciers cannot be explained using traditional models, which invoke the growth of vein networks aligned along potential gradients within the ice. Direct exploration of conduits in Svalbard glaciers indicates that at least two alternative mechanisms are responsible for their formation: (1) the incision and closure of supraglacial streams on uncrevassed glaciers; and (2) hydrologically-driven fracturing in areas of actively straining ice. Both mechanisms can allow surface meltwater to reach the bed, but only the second appears to be capable of establishing hydraulic connections between surface and bed within a single melt season.
Direct exploration of the conduits in Scott Turnerbreen showed that the drainage system was formed by “cut and closure”. This means that the meltwater stream incises over many melt seasons from the surface to the glacier bed. At the bottom the water pressure prevents the channel from being squeezed shut whereas the conduit roof can be closed by ice creep, snow or rafted ice blocks leading to the development of a subglacial channel.

The two kilometer long channel comprises low-gradient sections interrupted by steep steps marking nick-points in the stream. The canyon is constantly meandering. Roof closure by collapsed ice blocks and false floors were observed. No evidence for creep closure was found. There was clear evidence for water reaching the bed. At the bed till, basal crevasses and shears were found indicating that a surge has happened.

Ground-penetrating radar profiles were collected at the glacier surface with 25, 50 and 100 MHz. The travel times, position of the channel, the glacier bed and the channel shape were analyzed and compared to the drawings that had been made inside the glacier.
The GPR technique offers an important alternative for monitoring remote englacial channels from the glacier surface.