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An ice-sheet scale comparison of diagnosed subglacial drainage routes with esker networks

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Understanding the meltwater drainage networks that form and evolve at the bed of ice sheets is important because of their influence on ice flow. Two main modes of drainage are typically envisaged: (i) an efficient channelized system that develops in response to high discharges; and (ii) an inefficient distributed system associated with low discharges. Eskers are widely believed to be the residue of channelized drainage deposited within conduits, gradually building up over time or as they debouch into water at the ice margin; and comprise sinuous ridges of sediment, which can extend for tens to hundreds of kilometres and reach up to 50 m high. Eskers may therefore provide vital information on the nature of channelized drainage and sediment transport and deposition within the channels.

This presentation compares the distribution of mapped eskers beneath the former Laurentide Ice Sheet with diagnosed subglacial drainage routes. We analyse (i) how well the mapped esker network agrees with the diagnosed concentration of meltwater along discrete drainage routes; and (ii) the upstream connectivity of eskers with the diagnosed subglacial drainage directions at snapshots in time. Our results indicate a proclivity for esker formation within the gaps between the dominant drainage arteries diagnosed from the modelled ice sheet. This seems counter to theory, which predicts that the largest channels are associated with the highest discharges and are the most stable because they will grow preferentially to those around them, and these are the ones expected to host eskers. We therefore suggest the greater flux and variability of meltwater drainage though the dominant subglacial drainage arteries can inhibit esker formation. In this presentation we discuss possible reasons for this, including: (i) switches in drainage morphology (between channelized and distributed); (ii) flushing of sediment out of conduits; and (iii) elevated basal pressures at the onset of large meltwater inputs increasing basal ice velocities and preventing esker preservation. Indeed, it may instead be the smaller channels characterised by smaller and less variable meltwater fluxes that are more suited to esker formation.

In using a simple model to investigate subglacial hydrological processes and sediment deposition a certain degree of fallibility is unavoidable. The main error terms relate to our simplified approach to diagnosing subglacial hydrology and the coarse resolution of the model. More work is therefore required with physically-based subglacial hydrological models fully coupled with ice-sheet models to further investigate the processes underlying esker formation.