Geophysical Research Abstracts
Vol. 15, EGU2013-3367, 2013
EGU General Assembly 2013

Morphometry and pattern of a large sample of Canadian eskers: new insights into ice sheet meltwater drainage

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Meltwater drainage systems beneath ice sheets are a poorly understood, yet fundamentally important environment for understanding glacier dynamics, which are strongly influenced by the nature and quantity of meltwater entering the subglacial system. Contemporary sub-ice sheet meltwater drainage systems are notoriously difficult to access and monitor, but it is possible to utilise the exposed beds of past ice sheets to further our understanding of subglacial drainage. In particular, eskers record deposition in glacial drainage channels and are widespread on the exposed beds of former ice sheets, although they have rarely been studied in detail at the ice sheet scale. This paper presents the results of a remote sensing investigation of a large sample (>20,000) of eskers mapped from Landsat imagery of Canada and formed under the North American Ice Sheet Complex. Within a GIS framework, we investigate their spatial arrangement and morphometry, including length, fragmentation, sinuosity, spacing, frequency and tributaries. Results indicate that the channels in which eskers formed were often very long (hundreds of km) and often very straight (mean sinuosity approximates 1). In some locations, the lateral distance between neighbouring eskers is remarkably consistent and results indicate a preferred spacing of around 12 km. In other locations, typically over soft sediments, esker patterns are more chaotic, as predicted by theory. Significantly, comparison to an existing ice margin chronology reveals that the meltwater drainage system of the ice sheet became more organised and efficient during deglaciation: the number of eskers at the ice margin increased as deglaciation progressed and eskers became more closely spaced. The data presented in this paper provide an alternative perspective on the problems surrounding ice sheet meltwater drainage and are particularly suitable for: (i), assessment of the factors that control esker location and formation; (ii), rigorous testing of numerical models of meltwater drainage routing, and (iii), a refined understanding of ice margin configurations during retreat of the Laurentide Ice Sheet.