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Exploring controls on ice stream location

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As a key determinant of ice sheet dynamics, a powerful agent of erosion and a major source of sediment delivery to the continental margin, ice streams have a strong influence on the sedimentary processes, architecture and evolution of glaciated continental margins. Changes in the spatial and temporal dynamics of ice streams will therefore result in significant changes to the adjacent continental margin. This presentation will explore one question which is fundamental to improving our understanding of ice stream behaviour and longevity: what controls their location in an ice sheet?

Due to thermomechanical feedbacks streaming is an inherent component of ice sheets, but the observed irregularity of ice stream location in contemporary ice sheets indicates that additional factors control their location. This presentation will review and discuss seven potential controls on ice stream location which have been identified from the literature: topographic focusing, topographic steps, macro-scale bed roughness, calving margins, subglacial geology, geothermal heat flux and subglacial meltwater routing. The theoretical basis for each control will be briefly introduced, followed by an assessment of available evidence for its influence on the location of ice streams. The ability of each control to explain the location of known palaeo-ice streams in the Laurentide Ice Sheet is then examined.

Based on this assessment, we conclude that there is no single control on ice stream location, rather a number of potential controls of varying influence. We propose a hierarchy of factors, with those occurring at the top of the hierarchy exerting a stronger influence on ice stream location, and where present beneath an ice sheet, are very likely to be associated with fast flow. Those factors occurring lower down the hierarchy are less commonly associated with ice streaming but are influential in the absence of more common controls. In such a hierarchy, topographic focusing in the presence of a calving margin is the primary control. In the absence of this, ice streams will preferentially occur in areas with favourable subglacial meltwater routing and subglacial geology. In the absence of these, bed roughness, geothermal heat flux and topographic steps may promote ice streaming.

Significantly, the primary controls on a given ice stream location will influence its spatial and temporal dynamics, which in turn will influence the delivery of sediment to the continental margin. Ice streams governed by the presence of meltwater routing and/or calving processes might exhibit more variable behaviour because these controls can vary over relatively short time-scales compared to controls that vary over longer time-scales, e.g. geothermal heat flux, subglacial roughness, geology and topography.