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Subglacial thermal organisation and ice sheet stability

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Ice sheets are the most dynamic components of the Earth´s topography, growing and shrinking in response to global climatic changes. During the full-glacial conditions of the Neogene and Quaternary, the contemporary Greenland and Antarctic ice sheets grew in volume and extent and new ice sheets developed in the mid-latiudes to form the Laurentide (LIS), Cordilleran (CIS), Fennoscandian (FIS) and British-Irish (BIS) ice sheets. In the search for the causes and controls on quasi-cyclic climate signals on the 5 to 100 -kyr scale displayed in ice cores and marine records, a key issue is whether or not ice sheets, through internal thermomechanical feedbacks involving bed coupling, can behave in an unstable fashion, with rapid collapses and mass loss. In order to investigate the dynamics and stability of these palaeo-ice sheets, we explore the dynamics of the coupled frozen patch/ice-stream system using the geomorphological record of the exposed beds of the LIS, CIS, FIS and BIS as reflected in remotely sensed data and digital terrain data. Detailed pattern similarities exist between the flow organisation of the former mid-latitude ice sheets and the flow organisation in parts of the contemporary Antarctic Ice Sheet as revealed by RADARSAT-1 Antarctic Mapping Project (RAMP) data. Our results suggest that frozen-bed patches were ubiquitous in the last mid-latitude ice-sheets, and of fundamental importance for their stability by laterally isolating ice stream catchments, and by retarding ice flow in sheet-flow areas. Calculated upper limits for the potential sea-level effect of internal ice-sheet instability events (frozen- to thawed-bed conversion) for the LIS based on ice-stream catchment sizes and realistic pre- and post-surge profiles indicate that it is unlikely that the critical Hudson Bay catchment contributed more than 1.6 m of ice-equivalent global sea level during any single thawing/surge event. We conclude that the paleo-ice sheets interacted with the atmosphere primarily through slow configuration and sur-

face elevation changes and with the ocean through their long-term effect on sea-level and ocean volume, rather than by previously suggested rapid collapses governed by internal dynamics.