



Landscape formation by past continental ice sheets: insights into the subglacial environment

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Glaciers and ice sheets are known as most powerful, climatically driven agents of large-scale sediment redistribution and landscape formation in the Earth system. During the Quaternary, repeated waxing and waning of continental ice sheets contributed to profound reshaping of the Earth surface and set the scene for the development of ecosystems in the post-glacial time. Despite the well-established impact of glaciers on the upper lithosphere the specific processes of glacial erosion, transport and deposition and the formation landforms at the ice-bed interface are contentious. In particular, the relative importance of direct ice impact versus the impact of glacial meltwater is highly controversial. Here, we focus on the southern peripheral area of the Scandinavian Ice Sheet hosting thick successions of soft, deformable sediments and examine some spectacular sediment/landform assemblages found nowadays in both terrestrial and marine settings to illustrate the nature of the subglacial processes. In order to decipher the past ice sheet behavior field, experimental and numerical approaches are combined. It is shown that the strength of the coupling between the ice and the bed that controls the response of the substratum to ice overriding and stress propagation depends primarily on the ability of the glacial system to evacuate meltwater from ice-bed interface. Strong coupling, locally enhanced by subglacial permafrost resulted in deeply rooted (100's of meters) glaciotectionic deformation reflected on the surface as ice-shoved hills whereas weak coupling promoted by water accumulating under the ice triggered the formation of deep (100's of meters) tunnel valley networks. Under the arteries of fast-flowing ice known as palaeo-ice streams, remoulding of soft sediments generated mega-scale glacial lineations and drumlins that hold the key to understanding glacier dynamics. The subglacial environment is envisaged as a four-dimensional mosaic of stable and deforming spots transient in time and space whose impact is embedded in the properties of sediment/landform systems.