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Controls on bedrock bedform development at the base of the Uummannaq Ice Stream System, West Greenland

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This research investigates the glacial and non-glacial controls on glacially eroded bedrock bedforms beneath the topographically confined upstream fjord region of the Uummannaq Ice Stream (UIS), West Greenland. The UIS was a cross-shelf ice stream system that operated during the Last Glacial Maximum (LGM), formed of 10 coalescent outlet glaciers. Reconstructions suggest that palaeo-glaciological conditions were similar for all sites in the study, characterised by thick, fast flowing ice moving over a rigid bedrock bed. Areally scoured terrain were mapped using remotely sensed imagery to assess regional-scale patterns of glacial erosion and to select suitable field locations. In the field, bedform measurements were taken from four discrete areas within two neighbouring fjords in the northern Uummannaq region (Rink-Karrat and Ingia). Classic bedrock bedforms indicative of glacially eroded terrain were mapped, including p-forms, roche moutonnées, and whalebacks. Bedform long axes and plucked face orientations display close correlation with palaeo-ice flow directions inferred from striae measurements. Across all sites, elongation ratios (length to width) varied by an order of magnitude between 0.8:1 and 8.4:1. Bedform properties (length, height, width, and long axis orientation) from the four sample areas form individual morphometrically distinct populations. However, bedform populations display high inter-area variability despite their close proximity, and hypothesised similarity in palaeo-glaciological conditions.

The relationship of bedforms to palaeo-glaciological conditions in this study is not simple, having been complicated by bedrock properties. Geological structures including: joint frequency; joint dip; joint orientation; bedding plane thickness; and bedding plane dip have provided lines of geological weakness along which glacial erosion has been able to focus, controlling bedform length and width. Lateral plucking, a mechanism previously described for the development of megagroove features, is invoked here for the formation of whaleback-type bedforms in Ingia Fjord. Bedding plane thickness and bedding plane dip relative to palaeo-ice flow direction and is shown to a key control on bedform morphology and ELR. Consequently, a knowledge of bedding plane dip relative to palaeo-ice flow can allow predictions to be made about likely bedform shape, relative length, amplitude, and wavelength. These predictions have important ramifications for understanding subglacial bed roughness, cavity formation, and likely ice-bed erosion processes. These observations demonstrate the direct link between bedrock bedform properties and underlying geological structure. This supports evidence which suggests that the use of bedrock bedform characteristics to directly infer palaeo-glaciological conditions must be approached with caution. In order to robustly understand bedform morphology, a full appreciation of local geological structure is necessary.