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Subglacial processes and the geomorphological impact of cold-based ice sheets

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A continuously growing body of literature describes "relict" landforms, such as tors, blockfields and patterned ground, in areas formerly glaciated by ice sheets. In almost all cases where former ice cover can be convincingly demonstrated or safely assumed, this surprising preservation of often small-scale and fragile landforms is ascribed to frozen-bed conditions sustained throughout the last glacial event. During the last decade, the antiquity of many of these landforms has been demonstrated through cosmogenic dating, and the overriding by an ice sheet (as opposed to preservation on nunataks) demonstrated by cosmogenic dating of "young" erratics on the landforms. Based on these observations, a widely held view is that cold-based ice cover essentially preserves any pre-existing landform, and that the erosion potential of cold-based ice is zero or minimal. However, contradictory glaciological field evidence exists from cold-based valley glaciers, where significant basal sliding, and/or deformation in sandy-silty substrata has been observed. Sliding and deformation are processes intrinsically linked to change of preexisting morphology and landform production. At face value, these two sets of observations are therefore contradictory.

We here review the glaciological context of the different data sets that have a bearing on the issue of landform production under cold-based parts of ice sheets, paying particular attention to factors such as ice thickness, type of substratum, position along flowline, temperature and probable thermal history. It is found that no significant contradiction exists between the two sets of observations because of important differences in the glaciological context. In addition, we describe a datset that allows a closer anlysis of a "minimal disturbance" case where a relict surface on a formerly frozen-bed upland in Sweden is of such a layout and degree of preservation that it allows identification of horisontal change (transport) rates on the order of 1m/1000yrs with minimal

vertical changes. Based on the observations and considerations above, a scheme for more detailed classification of "relict" landforms and surfaces is presented, with the aim that it shall be useful in an inversion context, i.e. for deducing probable formative glaciological conditions and evolution from preserved landform assemblages.