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The influence of supraglacial debris cover variability on de-icing processes – examples from Svalbard

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Extensive supraglacial debris covers are widespread near the margins of many cold-based and polythermal surging and non-surging glaciers in Svalbard. Despite their importance for current glacier dynamics and a detailed understanding of how they will affect the de-icing of ice-marginal areas, little work has been carried out to shed light on the sedimentary processes operating in these debris covers. We here present data from five different forelands in Svalbard. In all five cases, surfaces within the debris cover can be regarded as stable where debris cover thickness exceeds that of the active layer; vegetation development and absence of buried ice exposures at the surface support this conclusion, although test pits and geophysical investigations have revealed the presence of buried ice at greater depths (> 1-3 m). These findings imply that even seemingly stable surfaces at present will be subject to change by de-icing in the future. Factors and processes that contribute towards a switch from temporarily stable to unstable conditions have been identified as:

1. The proximity to englacial or supraglacial meltwater channels. These channels enlarge due to thermo-erosion, which can lead to the eventual collapse of tunnel roofs and the sudden generation of linear instabilities in the system. Along such channels, ablation is enhanced compared to adjacent debris-covered ice, and continued thermo-erosion continuously exposes new areas of buried ice at the surface. This works in conjunction with

2. Debris flows that occur on all sloping ground and transfer material from stable to less stable (sloping) locations within the debris cover and eventually into supraglacial channels, from where material is then removed from the system. Several generations of debris flows have been identified in all five debris covers, strongly suggesting that these processes are episodic and that the loci of these processes switch. This in turn indicates that transfer of material by debris flows downslope can lead to localised thickening of the debris cover, thereby resulting in the creation of new temporarily-stable areas in downslope locations.

3. The renewed and continued re-distribution of material causes de-icing to proceed in a stepwise fashion. While de-icing is ongoing, this results in the formation of debris cones or even larger ridges and mounds that have been termed “moraine-mound complexes” by previous workers (e.g. Graham et al., 2007). These are temporary landforms that will not survive de-icing over longer timescales, and projection of continued reworking into the future shows that perhaps an undulating spread of material will remain (cf. Lukas, 2007).

The formation of supraglacial lakes during overall melting can lead to the formation of thick sequences of sorted sediments that in turn insulate the underlying ice after lake drainage. The presence of such sorted sediments in current ridge-top locations in some of the debris covers gives further weight to the interpretation of a mode of stepwise de-icing; crumbling and erosion by snowmelt and wind attests the shortlived nature of such deposits in topographic highs.

Our findings strongly support an interpretation of a de-icing mode that takes place in a stepwise fashion that leads to several generations of sediment transfer within the debris covers and repeated relief inversion.

References

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