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Evidence for multiple glacier advances in Svalbard recorded by push moraine complex-meltwater channel relationships: the case studies of Finsterwalderbreen and Grønfjordbreen

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Large ice-marginal push moraine complexes, also known as composite ridge systems, have a restricted distribution at active glacier margins, and are thought to be associated with a combination of specific glaciological conditions and the availability of deformable material in the glacier foreland. In Svalbard, it has been recognised that they are often found at the margins of glaciers thought to be of surge-type, and therefore may be a useful indicator of palaeo-surging when found in a Quaternary context elsewhere, although specific case studies are needed to confirm this. We describe geomorphological evidence from large push moraine complexes in front of Finsterwalderbreen and Grønfjordbreen, both of which have been described as surge-type glaciers but have never been observed to surge. A combination of fieldwork, aerial photographs and a digital elevation model were used to assess the relationship between individual ridges within the moraine complexes and meltwater channels, from which it is possible to identify multiple advances of both glaciers. Specifically, there is clear evidence for relict channels and associated outwash fans which breach outer ridges but have been blocked off by a ridge or ridges formed during a subsequent advance. Using this approach, it is possible to identify four separate advances of Finsterwalderbreen and two of Grønfjordbreen, which is consistent with their classification as surge-type glaciers. Further support is provided by both quantitative and qualitative relative-age indicators for the different ridges, including lichenometry, vegetation cover, frost-shattered lithologies and overall ridge morphology and composition. It is anticipated that this relatively simple way to detect multiple advances within composite ridge systems has a wider application across Svalbard as a method for identifying possible surge-type glaciers and, if used in conjunction with dating techniques, could provide important information on the frequency and magnitude of glacier advances and/or surges in Svalbard during the Holocene.