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Glacier surges past and present

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Investigations of the glacial geologic record commonly use modern analogues to underpin reconstructions of former environments. While this approach is very powerful, it is not without problems and is vulnerable to changing paradigms (or fashions) in glaciology. A well-known example is the ascendancy of the ́deforming bed ́model in the 1980s and 1990s, which was subsequently challenged by the ́ploughing bed ́model. These models have contrasting implications for till genesis and subglacial sediment transport, but rigorous testing is hampered by the difficulty of directly observing modern glacier beds and the lack of unambiguous diagnostic criteria for interpreting ancient tills.

We address this issue by examining sediment-landform assemblages formed by surging glaciers in Svalbard. Surges leave a distinctive imprint on fjord floors, including fluted subglacial till, crevasse-fill ridges, thrust block moraines, and extensive proglacial mud flows. The latter have been interpreted as either masses of extruded subglacial till or the collapsed fronts of oversteepened thrust moraines. The éxtrusion hypothesisímplies significant subglacial sediment flux towards the margin, consistent with a metres-thick deforming layer, whereas the ́moraine failureh ́ypothesis implies dominantly proglacial transport.

We show that both fjord-floor and terrestrial ́mud apronsćonsist of masses of marine sediment which were pushed in front of the advancing glacier, while undergoing more or less continuous gravitational failure. The subaqueous moraines and mud flows are therefore interpreted as end-member glacitectonic landforms, formed by similar processes to thrust-block moraines. These results indicate highly episodic glacial sediment transport in Svalbard fjords, accomplished largely by ice-push during surges. The survival of transverse (moraine) ridges below megaflutings in some fjords suggests that subglacial sediment transport is relatively unimportant, and that the ́ploughing modelb ́est describes the behaviour of the ice-bed interface during surges. We suggest that similar glacitectonic processes may have been important for delivering sediment to the margins of Pleistocene marine ice sheets.