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Sediment transport and dynamics of marine ice streams: new evidence from 3D seismic data

Karin Andreassen and Monica Winsborrow
University of Tromsø, Department of Geology, Tromsø, Norway (karin.andreassen@uit.no; monica.winsborrow@uit.no)

The fast flow of ice streams, which discharge the majority of ice and sediments from ice sheets, is associated with subglacial sediment deformation. Beds of modern ice streams are not easy to reach, but beds of former ice streams provide a more accessible source of information on the spatial variability in sub-ice stream sedimentary processes, and may also reveal changes in ice-stream operation over longer time-scales. Here we present observations from 2000 sq.km of three-dimensional (3D) seismic data, revealing the geomorphology of buried beds of the former Barents Sea Ice Sheet (BSIS) and the internal sedimentary structure of till units below the glacially eroded horizons. The BSIS, located at the northern flank of the former Eurasian ice sheets, offers a good geological analogue to the contemporary West Antarctic Ice Sheet.

Repeated changes in ice dynamics are inferred from the observed successions of geomorphic features. Megablocks and rafts, aligned in long chains parallel to inferred ice-stream flow lines, and forming dipping plates that are thrust one on top of another are taken as evidence for conditions of compressive ice flow. Mega-scale glacial lineations (MSGL) and pull-apart of underlying sediment blocks suggest extensional flow. The observed pattern of megablocks and rafts overprinted by MSGL indicate a change in ice dynamics from a compressional to an extensional flow regime. Till stiffening, due to subglacial freezing, is the favoured mechanism for creating switches in sub-ice stream conditions. The observed pattern of geomorphic features indicates that periods of ice stream slowdown or quiescence were commonly followed by reactivation and fast flow during several glaciations, suggesting that this may be a common behaviour of marine ice streams.