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Controls on the formation of turbidity current channels associated with the Greenland Ice Sheet

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Submarine channels are a common feature of the world's oceans where large volumes of sediment are introduced into coastal waters, or where continental shelf and slope processes are episodic such as the advance and retreat of ice sheets to the shelf edge. These channels, and the sediment density flows which construct and navigate them, act as conduits for the transport of sediment, macro-nutrients, fresher water and organic matter from coastal environments to deeper waters. Where submarine channels are fed by rivers, their presence is commonly linked to rapid deposition of large volumes of sediment on sufficiently steep offshore gradients, leading to slope failures or the plunging of river flood discharges. However, the exact conditions that permit or preclude submarine channel formation in these locations remain poorly understood. In contrast, to the world's largest rivers, submarine channels are rarely associated with the largest ice streams and the trough-mouth fans which they produce. Nevertheless, perhaps the world's longest submarine channel, the Northwest Atlantic Mid-Ocean Channel, is found on a glaciated margin. The controls on submarine channel formation on glaciated margins are therefore even less well understood than river-fed margin.

Using a remarkably extensive bathymetry dataset from offshore Southeast and Northwest Greenland we investigate the controls on channel formation in fjords fed by marine-terminating glaciers. We investigate the impact of ice sheet history, climatic setting, drainage basin size, meltwater and ice discharge rates, and fjord morphology on the formation of submarine channels. Our analysis shows that channels only form where glacier stillstands have occurred as documented by moraines or grounding zone wedges. Fjords must also slope consistently seaward with gradients in excess of 1° and not contain overdeepenings. Our analysis also suggests that channels are more likely to be found in warmer climatic settings where meltwater sedimentation is more prevalent and are generally associated with larger catchments with greater ice and meltwater fluxes at the terminus.