Subglacial water and sediment transport across the grounding zone of Whillans Ice Stream, West Antarctica

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Much of the threshold behavior of marine ice sheets is thought to result from processes occurring in the grounding zone, where the ice sheet transitions into the ice shelf. At short timescales (decades to centuries), grounding zone behavior is likely to be influenced by processes not included in the current generation of ice sheet models. Here we report on two such processes: the flow of subglacial water beneath the ice sheet, and the associated transport, and deposition, of sediment. We present a ground-based geophysical study across the grounding zone of a major West Antarctic Ice Stream (Whillans Ice Stream (WIS)). Using a combination of active-source seismology and radio-echo sounding (RES) data, we image the outlet of a large subglacial drainage system. The geophysical data indicate that the grounding zone in this area of WIS is an estuary, which consists of a hydropotential low upstream of the grounding zone, which is linked to the ocean by a hydropotential trough and a large subglacial channel. Pressure differences along the trough axis are within a range that can be overcome by tidally-induced processes, making the interaction of subglacial and ocean water likely. The ocean water column within the embayment is everywhere less than 12 m thick, implying that the estuary is well mixed by tidal processes. RES reflectivity indicates that subglacial deformation, subglacial water flow, and the ocean water column likely transport sediment along the base of the ice sheet and eventually the ice shelf. These findings have implications for the evolution of grounding zones and the basal melt of ice shelves and their proper inclusion in whole-ice-sheet models.