Controls on variations in sedimentary deposits produced by a retreating ice stream grounding line

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Abstract

The majority of glaciers draining the Antarctic Peninsula Ice Sheet are thinning and retreating rapidly[1]. It is widely understood that these changes are driven by both a warming ocean and atmosphere. However, there are other mechanisms, including pinning points created by bathymetric highs and a reverse bed gradient, that are thought to have an important control on ice stream behaviour (Weertman, 1974; Jamieson et al., 2012). Our understanding of the interplay between these mechanisms and time-scales over which they are important is currently limited in time to the advent of satellite monitoring. By reconstructing the cause and style of ice stream retreat following the Last Glacial Maximum (LGM; 25-19 ka BP), it is possible to gain a greater insight into the mechanisms which drive glacier retreat (Ó Cofaigh et al., 2014). Sedimentary sequences deposited during the LGM and the subsequent deglaciation on polar continental shelves, provide an important archive of past changes (Ó Cofaigh et al., 2014). Previous studies have typically identified three sediment facies assemblages; sub-glacial, transitional and open marine (Ó Cofaigh et al., 2014; Domack et al., 1988; Smith et al., 2011). Transitional sediment facies are deposited at the grounding line and are often targeted for radiocarbon dating, as they represent the onset of glaciomarine sedimentation following the retreat of grounded ice (Domack et al., 1988; Smith et al., 2014; Heroy et al., 1996). Despite the development of depositional models to help explain the processes occurring at grounding lines (Powell et al., 1995 and 1996), there is still significant uncertainty about the temporal and spatial variations in grounding line sedimentation along and across a palaeo-ice stream trough. Here we use a multi-proxy approach (water content, shear strength, magnetic susceptibility, density, contents of biogenic opal, Total Organic Carbon and $CaCO_3$, grain size distribution and X-radiographs) on marine sediment cores recovered from the Anvers-Hugo Palaeo-Ice Stream Trough (AHT), western Antarctic Peninsula shelf, to identify variability in transitional sediment facies deposited along and across the trough. We discuss possible controls on the variability in transitional sediment facies and how this is related to the rate and style of ice stream retreat. Our data reveal systematic variability in the types and volume of transitional sediments deposited during the last deglaciation of AHT. A detailed analysis of the transitional sediment facies shows that this variability reflects different phases of ice stream behaviour. Large volumes of ice proximal sediment facies recovered seawards of grounding zone wedges are indicative of episodes of grounding line still-stands. Re-advances of the grounding line, concurrent with a shallowing of the reverse bed gradient and a narrowing of the trough, appear to have occurred during the final stages of deglaciation. This is indicated by interlaminated ice-proximal and ice-distal sediment facies within inner shelf cores. Transitional sediment variability additionally captures the evolution of the ice stream during deglaciation, including the formation of a small ice shelf on the inner shelf.

Keywords: Antarctic Peninsula, Last Glacial Maximum, ice stream, sediment cores

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