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Invited review

Reconstruction of changes in the Amundsen Sea and Bellingshausen Sea sector of the West Antarctic Ice Sheet since the Last Glacial Maximum

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ABSTRACT

Marine and terrestrial geological and marine geophysical data that constrain deglaciation since the Last Glacial Maximum (LGM) of the sector of the West Antarctic Ice Sheet (WAIS) draining into the Amundsen Sea and Bellingshausen Sea have been collated and used as the basis for a set of time-slice reconstructions. The drainage basins in these sectors constitute a little more than one-quarter of the area of the WAIS, but account for about one-third of its surface accumulation. Their mass balance is becoming increasingly negative, and therefore they account for an even larger fraction of current WAIS discharge. If all of the ice in these sectors of the WAIS were discharged to the ocean, global sea level would rise by ca 2 m.

There is compelling evidence that grounding lines of palaeo-ice streams were at, or close to, the continental shelf edge along the Amundsen Sea and Bellingshausen Sea margins during the last glacial period. However, the few cosmogenic surface exposure ages and ice core data available from the interior of West Antarctica indicate that ice surface elevations there have changed little since the LGM. In the few areas from which cosmogenic surface exposure ages have been determined near the margin of the ice sheet, they generally suggest that there has been a gradual decrease in ice surface elevation since pre-Holocene times. Radiocarbon dates from glacimarine and the earliest seasonally open marine sediments in continental shelf cores that have been interpreted as providing approximate ages for post-LGM grounding-line retreat indicate different trajectories of palaeo-ice stream recession in the Amundsen Sea and Bellingshausen Sea embayments. The areas were probably subject to similar oceanic, atmospheric and eustatic forcing, in which case the differences are probably largely a consequence of how topographic and geological factors have affected ice flow, and of topographic influences on snow accumulation and warm water inflow across the continental shelf.

Pauses in ice retreat are recorded where there are “bottle necks” in cross-shelf troughs in both embayments. The highest retreat rates presently constrained by radiocarbon dates from sediment cores are found where the grounding line retreated across deep basins on the inner shelf in the Amundsen Sea, which is consistent with the marine ice sheet instability hypothesis. Deglacial ages from the Amundsen

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Sea Embayment (ASE) and Eltanin Bay (southern Bellingshausen Sea) indicate that the ice sheet had already retreated close to its modern limits by early Holocene time, which suggests that the rapid ice thinning, flow acceleration, and grounding line retreat observed in this sector over recent decades are unusual in the context of the past 10,000 years.

1. Introduction

1.1. Recent ice sheet change

Over recent decades, rapid changes have occurred in the sector of the West Antarctic Ice Sheet draining into the Amundsen and Bellingshausen seas (Fig. 1). These changes include thinning of ice shelves and thinning, flow velocity acceleration and grounding line retreat of ice streams feeding into them (Rignot, 1998, 2008; Pritchard et al., 2009, 2012; Scott et al., 2009; Wingham et al., 2009; Bingham et al., 2012). Ice shelves and ice streams in the ASE have exhibited the highest rates of change. These ice streams include Pine Island Glacier (PIG) and Thwaites Glacier, which are the outlets from large drainage basins in the centre of the WAIS with a combined area of 417,000 km^2 (basin "GH"; Rignot et al., 2008). This amounts to about 60% of the area of the entire Amundsen-Bellingshausen sector as defined in Fig. 1 (ca 700,000 km^2).

Modern snow accumulation rates in the sector are, on average, more than twice those in the drainage basins of the Siple Coast ice streams that flow into the Ross Ice Shelf (Arthern et al., 2006). Consequently, although the Amundsen-Bellingshausen sector comprises just a little more than a quarter of the area of the WAIS, it collects about one-third of the total accumulation. If the ice sheet

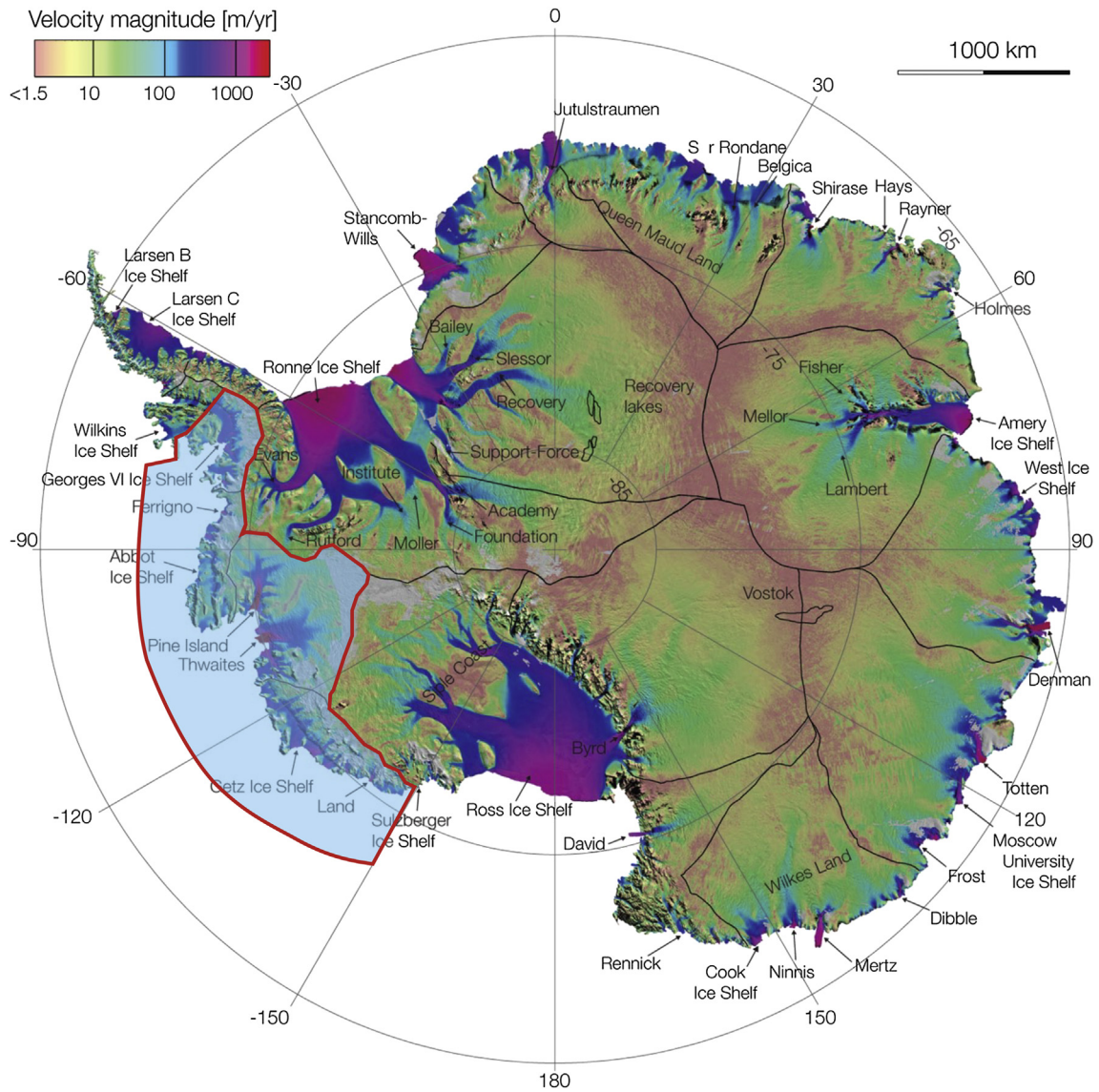

Fig. 1. Amundsen-Bellingshausen sector limits (red outline with semi-transparent blue fill) overlaid on map of Antarctic ice flow velocities and ice divides (black lines) from Rignot et al. (2011).

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