History of the grounded ice sheet in the Ross Sea sector, Antarctica, at and since the LGM

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The behavior of the Antarctic Ice Sheet, especially the marine-based West Antarctic Ice Sheet (WAIS), remains a significant unresolved problem in predicting future sea-level change. In addressing this issue, the history of the ice sheet is an important guide to its present stability and likely evolution. In particular, the timing and style of deglaciation from the last glacial maximum (LGM) position on the continental shelf is critical for understanding the mechanisms, including sea-level fluctuations, oceanic temperature variations, and ice dynamics that control ice-sheet behavior.

Here, we review the history of the Ross Sea sector of Antarctica, which is one of the areas of greatest ice-volume change during the LGM and subsequent deglaciation. During the LGM, the Siple Coast grounding line of the WAIS advanced across the sea floor, merged with expanded East Antarctic outlet glaciers, and terminated near the continental shelf edge. The thickness of this ice sheet in the central interior remains uncertain, but along the TAMS front, the surface elevation was ~700 m a.s.l. on Ross Island and more than 1000 m a.s.l. in the southern and central TAMS. Gradual ice-sheet thinning was initiated as early as about 15,000 years B.P., with ice levels remaining high until after about 12,000 yrs B.P. Grounding-line retreat lagged thinning. Relative sea-level data show grounding-line recession along the northern Victoria Land coast at ~8000 yr B.P. and a period of rapid retreat between 7000-8000 yr B.P., during which ice receded as far south as Hatherton Glacier. Retreat continued past Roosevelt Island in the eastern Ross Sea at ~3000 years B.P., leading to an initial suggestion that deglaciation from the LGM position could be ongoing.

Our present work focuses on two East Antarctic outlet glaciers in the interior Ross Embayment. Reedy Glacier currently flows into the WAIS, whereas Scott Glacier enters the Ross Ice Shelf north of the Siple Coast grounding line. At the LGM, the level and behavior of both glaciers were affected by the ice sheet in the Ross Sea. Both glaciers thickened substantially in their lower reaches near the coast, while remaining relatively unchanged at the East Antarctic ice plateau. The resulting longitudinal surface profiles were flatter than exist today. Exposure ages of erratics indicate that Reedy Glacier started thinning sometime after 15,000 years B.P., with most surface-level drop occurring after 9000 years B.P. Exposure ages from the mouth of Scott Glacier indicate that the Ross Sea grounding line reached that glacier ~2000 years ago and has retreated only 30-40 km since that time. These new data suggest that Holocene retreat in the Ross Sea sector may have slowed and that the present grounding line may be approaching relative stability.

Antarctica has been suggested as a potential source for deglacial sea-level pulses, such as meltwater pulse 1A. However, the total amount of excess ice available from Antarctica and the time at which it was released into the ocean are generally not compatible with such hypotheses. Our data indicate that most of the thinning and nearly all of the grounding-line retreat in the Ross Sea sector occurred after meltwater pulse 1A. Thus, ice from the Ross Sea sector could not have contributed substantially to this event.