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A community-based geological reconstruction of Antarctic Ice Sheet deglaciation since the Last Glacial Maximum

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A B S T R A C T

A robust understanding of Antarctic Ice Sheet deglacial history since the Last Glacial Maximum is important in order to constrain ice sheet and glacial-isostatic adjustment models, and to explore the forcing mechanisms responsible for ice sheet retreat. Such understanding can be derived from a broad range of geological and glaciological datasets and recent decades have seen an upsurge in such data gathering around the continent and Sub-Antarctic islands. Here, we report a new synthesis of those datasets, based on an accompanying series of reviews of the geological data, organised by sector. We present a series of timeslice maps for 20 ka, 15 ka, 10 ka and 5 ka, including grounding line position and ice sheet thickness changes, along with a clear assessment of levels of confidence. The reconstruction shows that the Antarctic Ice sheet did not everywhere reach the continental shelf edge at its maximum, that initial retreat was asynchronous, and that the spatial pattern of deglaciation was highly variable, particularly on the inner shelf. The deglacial reconstruction is consistent with a moderate overall excess ice volume and with a relatively small Antarctic contribution to meltwater pulse 1a. We discuss key areas of uncertainty both around the continent and by time interval, and we highlight potential priorities for future work. The synthesis is intended to be a resource for the modelling and glacial geological community.

1. Aim and rationale

This paper provides an overview of, and introduction to, a community-based reconstruction of the deglaciation of the Antarctic Ice Sheet. Reconstructing the Antarctic Ice Sheet through its most recent (post-Last Glacial Maximum; LGM) deglacial history is important for a number of reasons (Bentley, 2010). Firstly, ice sheet modellers require field data against which to constrain and test their models of ice sheet change. The development of a practical approach to modelling grounding line dynamics (Schoof, 2007) has led to a new generation of models (e.g. Pollard and DeConto, 2009; Pattyn et al., 2012) that require such field constraints. Secondly, the most recent millennia of Antarctic Ice Sheet history are important for evaluating the response of the ice sheet to various forcing agents (e.g. sea-level rise, atmospheric and oceanographic temperature influences) and constraining past rates of grounding-line retreat. Thirdly, the use of recent satellite gravity measurements (e.g. GRACE), and other geodetic data such as GPS, for estimating ice-sheet mass balance requires an understanding of Glacial-Isostatic Adjustment (GIA). In the case of GRACE, the satellite-pair cannot distinguish between changes in mass from ice, and those from transfer of mass in the mantle. This means that robust ice-sheet reconstructions are required to generate GIA corrections and it is these corrections that are regarded as the greatest limiting factors for gravimetric estimates of ice-sheet mass balance (Chen et al., 2006; Velicogna and Wahr, 2013). There have been notable attempts to develop models of ice-sheet extent and thickness as a basis of GIA corrections (Ivins and James, 2005; Whitehouse et al., 2012a; Ivins et al., 2013) but it is not clear if these are comprehensive in their inclusion of all available marine and terrestrial glacial geological data. In addition, ice-sheet reconstructions are also important for constraining the location of biological refugia during glaciation (Convey et al., 2008) and understanding climatic and oceanographic change during the glacial–interglacial transition.

Several decades of work have produced a large body of geological data constraining Antarctic Ice Sheet history. There have been a number of attempts to synthesise the data but many of these reconstructions have focussed only on LGM ice-sheet extent (Denton and Hughes, 1981; Anderson, 1999; Bentley, 1999; Anderson et al., 2002; Denton and Hughes, 2002; Wright et al., 2008; Livingstone et al., 2012) and in some places they have been