Long term landscape and ice sheet evolution of the Wilkes Subglacial Basin, East Antarctica

Guy Paxman[1], Stewart Jamieson[1], Mike Bentley[1], Fausto Ferraccioli[2], Neil Ross[3], Duncan Young[4], Donald Blankenship[4], German Leitchenkov[5]

[1]Department of Geography, Durham University, Durham, UK guy.j.paxman@durham.ac.uk;
[2]British Antarctic Survey, Cambridge, UK;
[3]School of Geography, Politics, and Sociology, Newcastle University, Newcastle, UK;
[4]University of Texas Institute for Geophysics, Austin, TX, USA;
[5]Institute for Geology and Mineral Resources of the World Ocean, St. Petersburg, Russia.

Abstract

The Wilkes Subglacial Basin extends for 1,400 km from the margin into the interior of East Antarctica and hosts several major glaciers that drain a large sector of the East Antarctic Ice Sheet. The northern section of the Wilkes Subglacial Basin comprises several deep subglacial troughs that host the Cook, Ninnis and Mertz Glaciers and exploit the location of the underlying horst and graben basin architecture (Ferraccioli et al., 2009). The ice sheet bed within these troughs is up to 2.1 km below sea level, and hence these glaciers are potentially particularly sensitive to past and predicted future ocean and climate warming. Understanding the evolution of Wilkes Subglacial Basin bedrock topography since ice sheet inception at 34 Ma is important because as the topography has evolved, it is likely the sensitivity of the ice sheet to ocean and climate change has also changed. This has implications for predicting the past and future behaviour of the East Antarctic Ice Sheet using numerical ice sheet models. We aim to understand the processes that led to the generation of the modern Wilkes Subglacial basin, consider how the topography may have influenced past ice sheet behaviour, and reconstruct palaeotopography in this region.

We use newly collected and historical radio-echo sounding datasets to produce a new grid of Wilkes Subglacial Basin bedrock topography. Using a peak accordance method (Stern et al., 2005), we generate an estimate of the 3D distribution of glacial erosion within the basin and the neighbouring Transantarctic Mountains. Comparison of our estimated eroded volumes with offshore sediment thickness datasets in the Ross Sea and Wilkes Land margins (Lindeque et al., 2016) shows good agreement. We reconstruct bedrock topography from the present day back to 34 Ma by restoring the eroded material to the topography and correcting for associated flexural isostatic responses. Based on offshore sediment stratigraphy from IODP drill cores (Escutia et al., 2011; Tauxe et al., 2012) and analogy with geological and thermochronological evidence from the Lambert Glacier system (Hambrey and McKelvey, 2000; Thomson et al., 2013), we establish an approximate temporal history of glacial erosion and flexure, and the resulting bedrock topography of the Wilkes Subglacial Basin. This evolving bedrock topography model provides a boundary condition for long-term numerical ice sheet models.

Radar data also reveal extensive, flat-lying surfaces, separated by troughs, within the Wilkes Subglacial Basin. We show that these surfaces were situated close to sea level during periods of ice sheet retreat. During ice sheet retreat phases, we hypothesise that the presence of smooth bedrock highs near sea level would have been conducive to the formation of ice rises at the ice sheet margin, which would have a stabilising effect on the ice sheet, inhibiting further retreat.

Keywords: palaeotopography, landscape evolution, erosion, flexure

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