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Unveiling lithosphere heterogeneity beneath the East Antarctic Ice Sheet in the Wilkes Subglacial Basin

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The Wilkes Subglacial Basin in East Antarctica hosts one of the largest marine-based and hence potentially more unstable sectors of the East Antarctic Ice Sheet (EAIS). Predicting the past, present and future behaviour of this key sector of the EAIS requires that we also improve our understanding of the lithospheric cradle on which it flows. This is particularly important in order to quantify geothermal heat flux heterogeneity in the region.

The WSB stretches for almost 1600 km from the Southern Ocean towards South Pole. Like many intracratonic basins, it is a long-lived geological feature, which originated and evolved in different tectonic settings. A wide basin formed in the WSB in a distal back arc basin setting, likely in response to a retreating West Antarctic Paleo-Pacific active margin from Permo-Triassic times. Jurassic extension then led to the emplacement of part of a huge flood basalt province that extends from South Africa to Australia. The region was then affected by relatively minor upper crustal Mesozoic to Cenozoic(?) extension and transtension, producing narrow graben-like features that were glacially overdeepened, and presently steer enhanced glacial flow of the Matusevich, Cook and Ninnis glaciers.

Here we present the results of our enhanced geophysical imaging and modelling in the WSB region performed within the 4D Antarctica project of ESA, which aims to help quantify the spatial variability in subglacial Antarctic geothermal heat flux (GHF), one of the least well constrained parameters of the entire continent.

We exploit a combination of airborne radar and aeromagnetic data compilations and crustal and lithosphere thickness estimates from both satellite and airborne gravity and independent passive seismic constraints to develop new geophysical models for the region. To help constrain the starting models, including depth to basement beneath the Permian to Jurassic cover rocks, we applied a variety of depth to magnetic and gravity source estimation approaches from both line and gridded datasets. Given the huge differences between recent satellite gravity estimates of crustal thickness (Pappa et al., 2019, JGR) and sparse seismological constraints, we examine different scenarios for isostatic compensation of Rock Equivalent Topography and intracrustal loads, as a function of variable effective elastic thickness (Te) across the WSB and its flanks.

Our models reveal a major lithospheric-scale boundary along the northeastern margin of the WSB, separating the Ross Orogen from a cryptic and composite Precambrian Wilkes Terrane. At the onset of enhanced flow for the central Cook ice stream, we image a Precambrian basement high with a felsic bulk composition. We suggest based on the similarity in potential field signatures that it represents late Paleoproterozoic to Mesoproterozoic igneous basement as exposed in South Australia, where it also associated with high GHF (80-120 mW/m^2), primarily caused by anomalously radiogenic granitoids.

We hypothesise that the differences in basement depth and metasediment/sediment thickness, coupled with differences in intracrustal heat production give rise to significantly greater heterogeneity in GHF beneath different sectors of the WSB than previously recognised. To help quantify such heterogeneity we develop a suite of new probabilistic thermal models for the study region.