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Geological controls on bedrock topography and ice sheet dynamics in the Wilkes Subglacial Basin sector of East Antarctica

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The Wilkes Subglacial Basin extends for 1,400 km into the interior of East Antarctica and hosts several major glaciers that drain a large sector of the East Antarctic Ice Sheet. The deep northern Wilkes Subglacial Basin underlies the catchments of the Matusevich, Cook, Ninnis and Mertz Glaciers, which are largely marine-based and hence potentially particularly sensitive to past and also predicted future ocean and climate warming. Sediment provenance studies suggest that the glaciers flowing in this region may have retreated significantly compared to their modern configuration, as recently as the warm mid-Pliocene interval, potentially contributing several m to global sea level rise (Cook et al.,Nature Geosci., 2013).

Here we combine airborne radar, aeromagnetic and airborne gravity observations collected during the international WISE-ISODYN and ICECAP aerogeophysical campaigns with vintage datasets to help unveil subglacial geology and deeper crustal architecture and to assess its influence on bedrock topography and ice sheet dynamics in the northern Wilkes Subglacial Basin. Aeromagnetic images reveal that the Matusevich Glacier is underlain by a ca 480 Ma thrust fault system (the Exiles Thrust), which has also been inferred to have been reactivated in response to intraplate Cenozoic strike-slip faulting. Further to the west, the linear Eastern Basins are controlled by the Prince Albert Fault System. The fault system continues to the south, where it provides structural controls for both the Priestley and Reeves Glaciers.

The inland Central Basins continue in the coastal area underlying the fast flowing Cook ice streams, implying that potential ocean-induced changes could propagate further into the interior of the ice sheet. We propose based on an analogy with the Rennick Graben that these deep subglacial basins are controlled by the underlying horst and graben crustal architecture. Given the interpreted subglacial distribution of Beacon sediments and Ferrar tholeiites and uplifted Ross-age basement blocks, we propose that these grabens were reactivated in post-Jurassic times, as observed from geological studies in the Rennick Graben.

A remarkable contrast in long-wavelength magnetic anomaly signatures is observed over the coastal and inland segments of the Cook ice stream glacial catchment. We attribute this, to the presence of several km thick early Cambrian to late Neoproterozoic(?) sedimentary basins in the coastal region, in contrast to a prominent Proterozoic basement high at the onset of fast glacial flow further inland. This suggests that there could also be a marked difference in geothermal heat flux at the base of the ice sheet in these two regions, which may in turn exert influences on basal melting and subglacial hydrology networks.

Further west, the deep Western Basins provide key topographic controls on the Ninnis Glacier, which is interpreted here, as controlled by a major Paleoproterozoic crustal boundary, separating an inferred linear Archean crustal ribbon from Paleoproterozoic rift basins, which are partially exposed along the coastal segment of the Terre Adelie Craton. The ca 1.7 Ga Mertz Shear Zone flanks the Mertz Glacier, and is interpreted here as a fault splay associated with this major crustal boundary.