New Contribution to Ross Ice Shelf (Antarctica) Boundary Conditions: Basement Depths and Sediment Thickness Determined from Aeromagnetic Data

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Abstract

The Ross Ice Shelf (RIS) has long obscured the structure of the extended crust of the southern Ross Embayment. Here, we use airborne magnetics data from the ROSETTA-Ice project to estimate the depth to crystalline basement and sediment thickness beneath the RIS. We estimate the depth to the top of the magnetic crust, using a Werner deconvolution in a 2-D moving window applied to aeromagnetic data at 10 km line spacing. The result is then filtered, clustered, and gridded solutions to achieve a continuous basement surface. This method was tuned with seismic acoustic basement in the Ross Sea and magnetic basement determined from Operation Ice Bridge flight line data over both the Ross Sea and the RIS. Sub-RIS sediment thickness was then calculated relative to bathymetry. Shallow basement and thin sediments beneath the RIS define two major basement highs. A throughgoing, wide basement high is located midway across the RIS, and appears to form a southward continuation of the Ross Sea’s Central High. The other prominent basement feature underlies Roosevelt Island, with a continuation SE to the grounding zone. An elongate basin between the two highs deepens southward, reaching its greatest depth beneath Siple Dome. A deep oval basin flanks Crary Ice Rise. Both basins contain >2 km sediment. Bordering the Transantarctic Mountains (TAM) there is a deeper and broader basement basin that contains a narrow, linear, NW trending basement ridge. The magnetic basement is shallower toward Marie Byrd Land and deeper near the TAM/East Antarctica, consistent with contrasts in magnetic and gravity signatures of the crust on either side of the mid-RIS high. The trend of basement highs and basins parallel to the central TAM front suggests that the basement relief >2 km is structurally controlled, and is a product of regional extension. Basin sediments may be a source of deformable subglacial bed conditions for grounded ice, and basin flanking faults may control geothermal flux and subglacial water transport. These considerations have a bearing on sub-RIS boundary conditions that are important for cryosphere-ocean numerical modelling frameworks. Our work extends the current knowledge of sub-RIS sediment distribution, continental rifting orientations and the likely locations of basin flanking faults.
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BACKGROUND:
Basement rock depths under the Ross Ice Shelf (RIS) gives insight into the interplay of geology, tectonics, and glaciation of the region.

METHODS:
1. Determine depth to top of magnetic crust (basement surface) with Werner deconvolution of airborne magnetic data
2. OIB magnetic data ties ROSETTA-Ice basement (RIS) to Ross Sea seismic basement
3. Merged RIS results with regional basement depths
4. Difference from bathymetry gives sediment thickness

RESULTS:
• Horst / graben structures from West Antarctic Rift System
• 2 basement highs, likely locations for initialization of Oligocene ice
• Mid-Shelf High separates East/West Antarctic geology
• East Ant. is deeper, wide basin, stops at Shackleton Glacier
• West Ant. is shallower, with linear, narrow, deep basins
• Siple Coast basins indicate active rifting
• Faults concentrate GHF / groundwater transport
• RIS has continuous drape of sediment 50-3800m thick

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Imaging sub-Ross Ice Shelf geology with airborne magnetics

Siple Coast cross-section (A-B):
• Ice surface, ice base, and bathymetry from Bedmachine
• Basement from this study
• Moho from Shen et al. 2018
• Ice is colored by velocity
• Sediment layer shows interpreted faults, offset beds, aquifers, and water transport
• Lower crust, between -25km and Moho, shows GHF model
• Upper crust is theoretical GHF, guided by inferred faults locations
• Lower panel shows ROSETTA-Ice gravity

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