

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

Matthew Tankersley¹, Christine Siddoway², Huw Horgan¹, Fabio Caratori Tontini³, and Kirsty Tinto⁴

¹Victoria University of Wellington

²Colorado College

³University of Genoa

⁴Columbia University

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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.

New contribution to Ross Ice Shelf (Antarctica) boundary conditions:

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BACKGROUND:

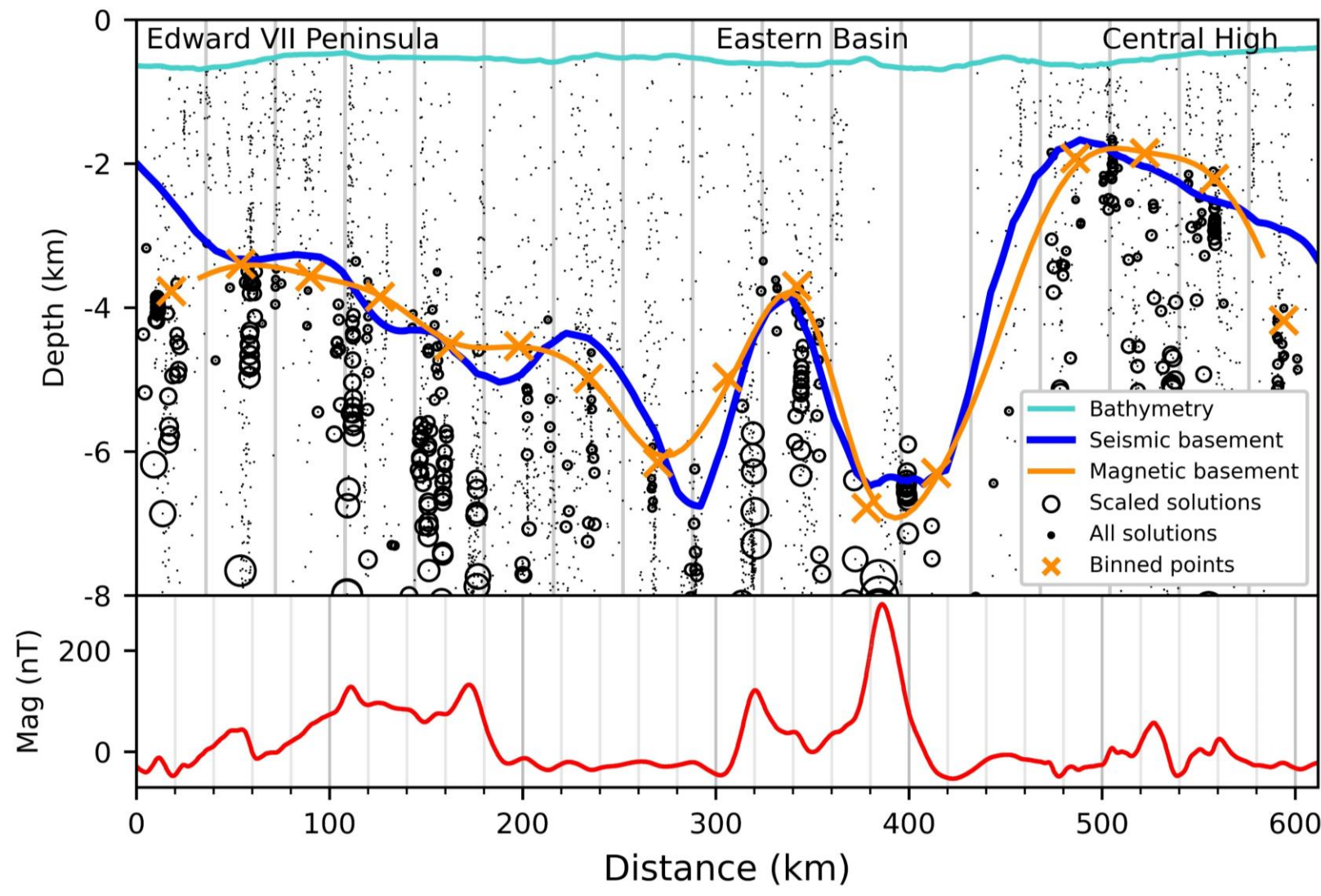
Basement rock depths under the Ross Ice Shelf (RIS) gives insight into the interplay of geology, tectonics, and glaciation of the region.

METHODS:

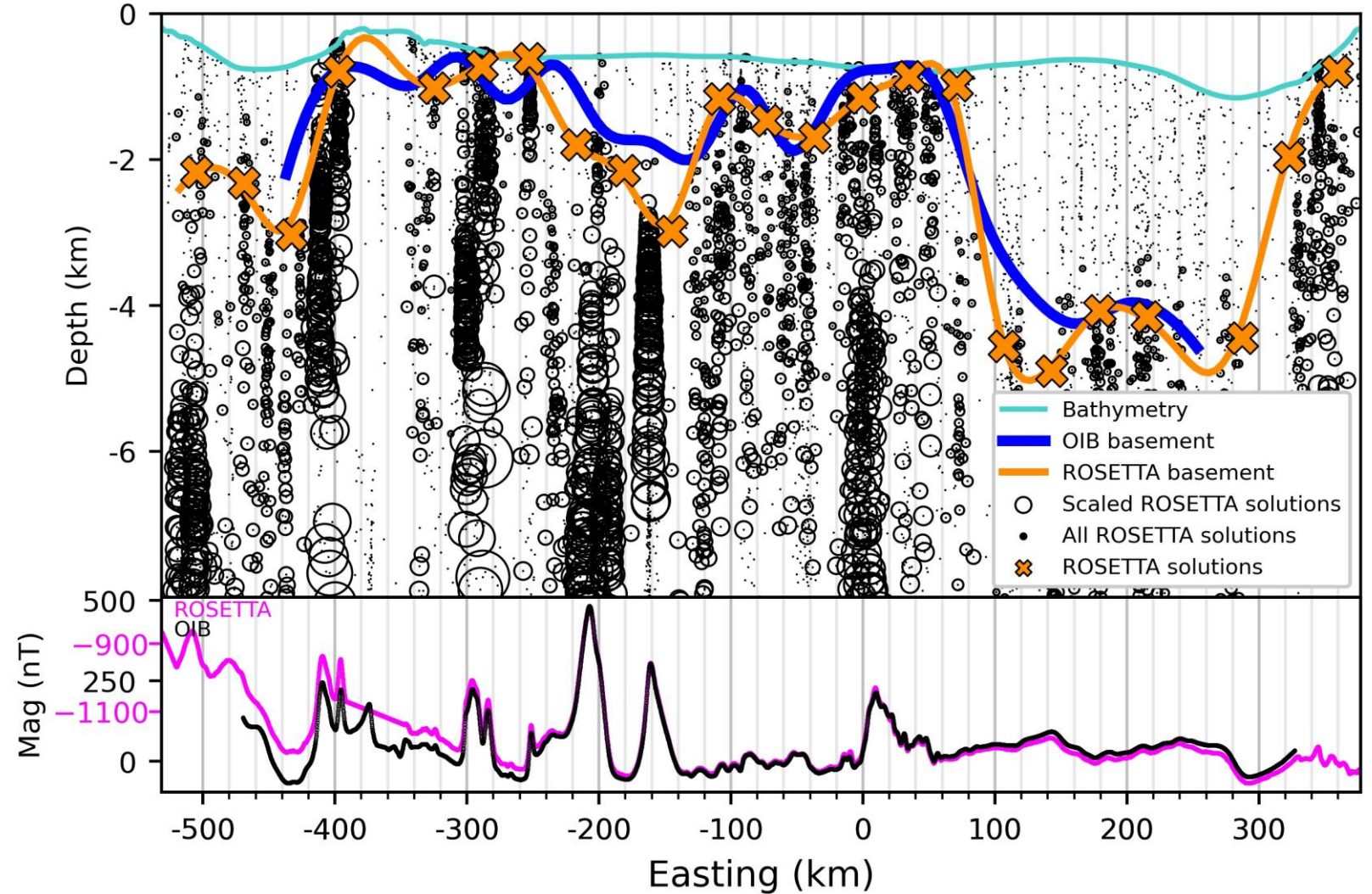
- 1. Determine depth to top of magnetic crust (basement surface) with Werner deconvolution of airborne magnetic data
- 2. OIB magnetic data¹ ties ROSETTA-Ice² basement (RIS) to Ross Sea seismic basement³
- 3. Merged RIS results with regional basement depths⁴
- 4. Difference from bathymetry⁵ gives sediment 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

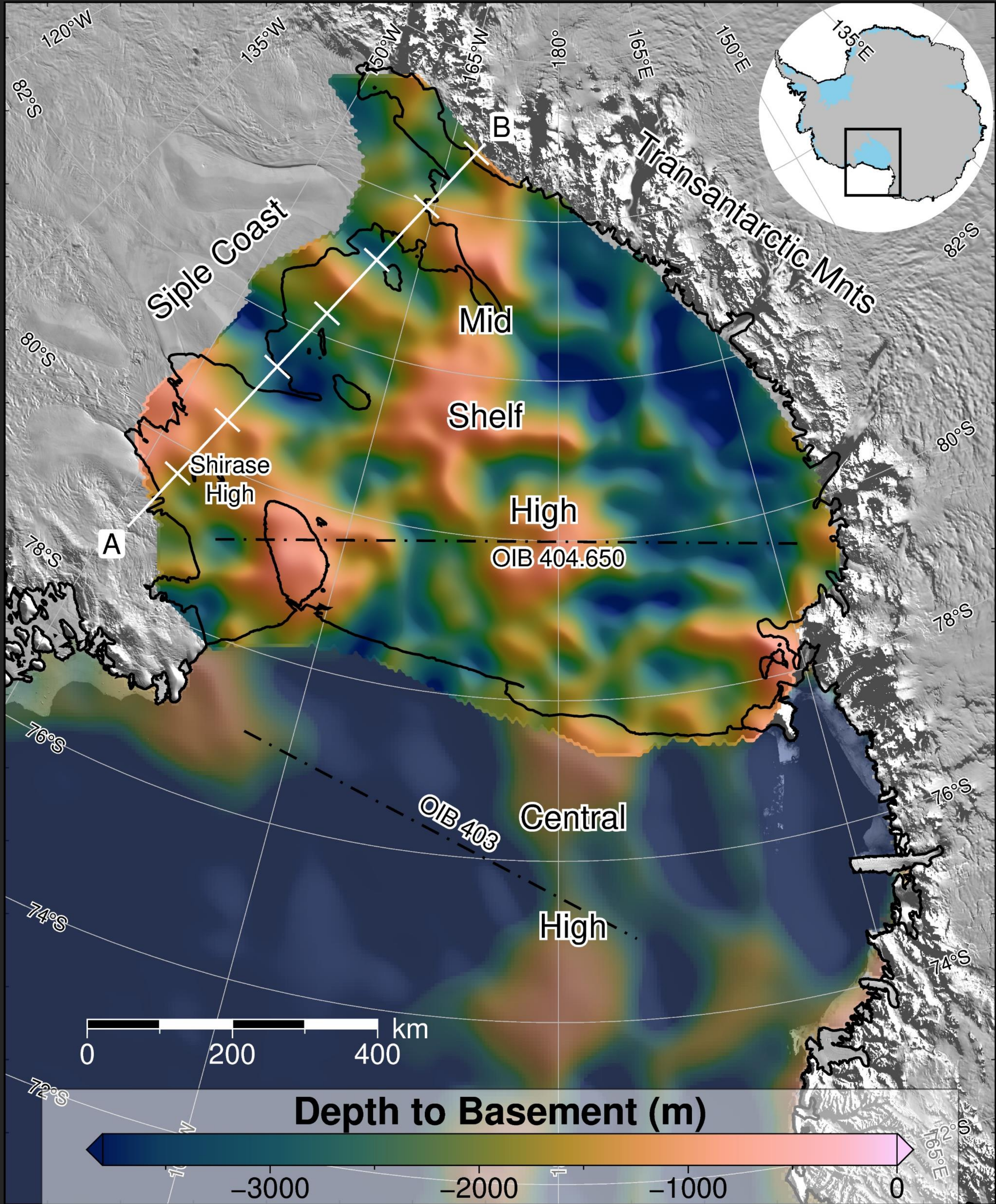


OIB line 403 (orange) to ANTOSTRAT (blue) comparison. Mean absolute difference between lines is 332m.

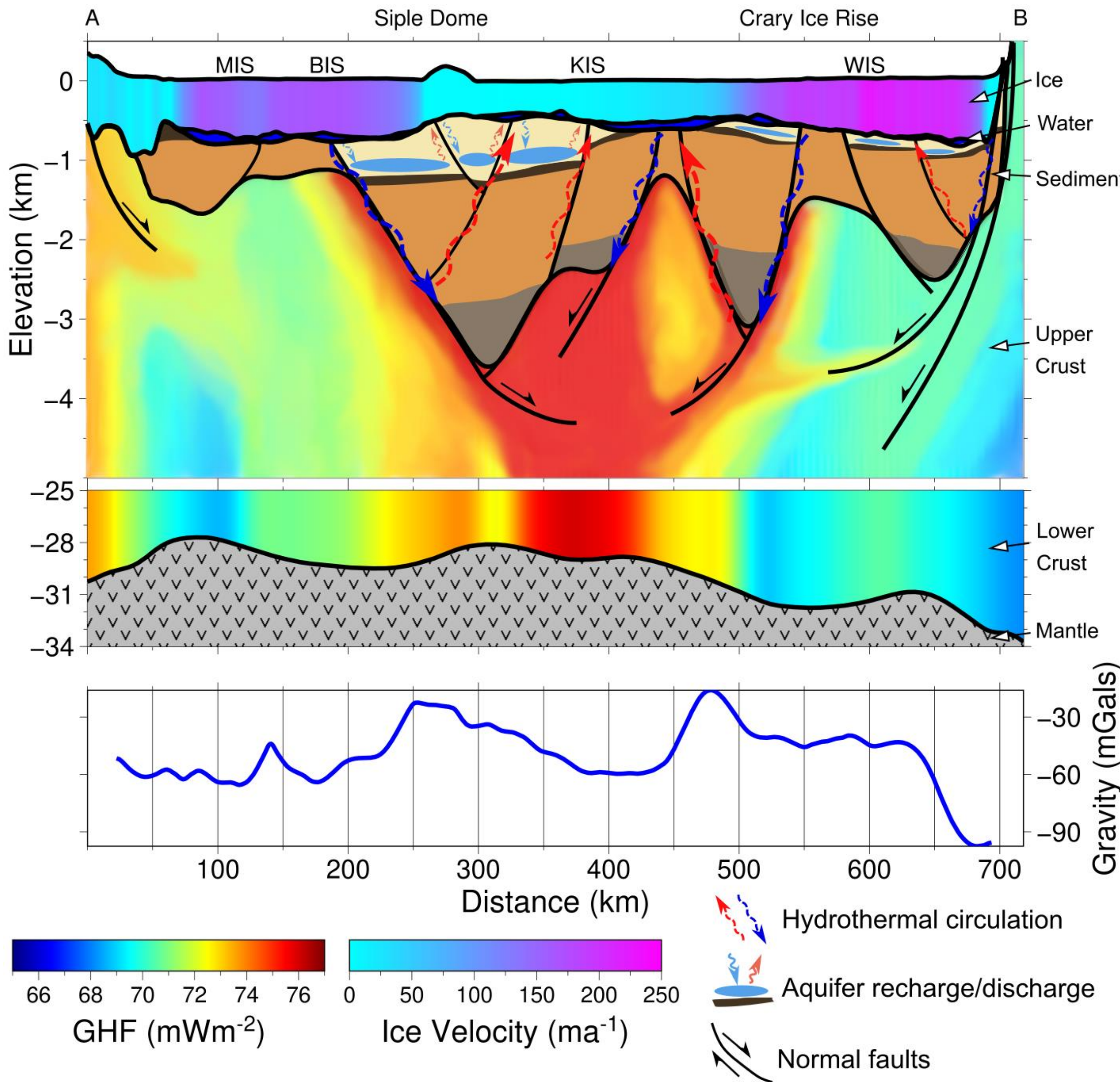


OIB line 404 (blue) to ROSETTA-Ice line 650 (orange) comparison. Mean absolute difference between lines is 387m.

Imaging sub-Ross Ice Shelf geology with airborne magnetics



Ross Embayment basement elevations. Data from the Ross Ice Shelf are results from this study. Data offshore (transparent) are from a regional compilation⁴, mostly ANTOSTRAT³ seismic basement for the Ross Sea. OIB flights paths used for the tie are shown. A-B cross-section profile shown in white.



Siple Coast cross-section (A-B):

- Ice surface, ice base, and bathymetry from Bedmachine2⁵
- Basement from this study
- Moho from Shen et al. 2018⁶
- Ice is colored by velocity⁷
- Sediment layer shows interpreted faults, offset beds, aquifers, and water transport
- Lower crust, between -25km and Moho, shows GHF model⁸
- Upper crust is theoretical GHF, guided by inferred faults locations
- Lower panel shows ROSETTA-Ice gravity

Matthew Tankersley^{1,2}, **Christine Siddoway**³, Huw Horgan¹, Fabio Caratori Tontini^{2,4}, Kirsty Tinto⁵

- 1. Antarctic Research Centre, NZ
- 2. GNS Science, NZ
- 3. Colorado College, USA

- 4. University of Genova, Italy
- 5. Lamont-Doherty Earth Observatory, USA

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