New insights into the Ross Ice Shelf region ice, ocean, bathymetry, and lithosphere through IcePod airborne geophysical data

Authorship: Christine Siddoway[1], Kirsteen J. Tinto[2], Joel Wilner[3], Robin R. Bell[2], Alec Lockett[1], Laurence Padman[4], Scott Springer[4], Helen A. Fricker[5].

[1] Geology Dept., Colorado College, Colorado Springs, CO, USA, csiddoway@coloradocollege.edu;
[2] Lamont -Doherty Earth Observatory, Columbia University, Palisades, NY, USA;
[3] Geology Dept., Middlebury College, Middlebury, VT, USA;
[4] Earth and Space Research, Seattle, WA, USA;
[5]Scripps Institution of Oceanography, University of San Diego, La Jolla, CA, USA

Abstract

The Ross Ice Shelf (RIS) plays a critical role in our understanding of the history and future of the Antarctic ice sheets. The RIS is composed of continental ice flowing in from both West and East Antarctica, and acts as a buttress for the ice sheets. RIS behavior under changing climate depends on its interaction with the bathymetry; however, existing maps of sub-ice-shelf bathymetry are interpolated from the coarse grid of points sampled during the 1970s Ross Ice Shelf Geophysical Glaciological Survey (RIGGS) by active seismics. The lack of resolution in bathymetric data hinders modeling of ice sheet advance and retreat in response to changing surface mass balance and ocean forcing that removes mass from the ice shelf base.

The interdisciplinary ROSETTA-ICE program (Ross Ocean and ice Shelf Environment, and Tectonic setting Through Aerogeophysical surveys and modeling) is actively acquiring critical datasets that address these limitations, via an airborne geophysical campaign using LC130 aircraft in 2015-2017. ROSETTA-ICE uses the IcePod instrument suite, including shallow and deep ice radars, lidar, gravimeters and magnetometer. The survey grid includes 91 east-west lines at 10 km spacing, and 15 north-south tie lines at 55 km spacing, aligned to overfly RIGGS points. The objective is a benchmark dataset at 10 km resolution, to include ice shelf height, thickness, draft and internal structure, sea floor bathymetry and sub-ice-shelf geology. Gravity data are inverted to provide 10 km resolution of bathymetry, using RIGGS data as a control. Air deployed oceanographic sensors, launched in 2016, are gathering temperature and salinity profiles along the RIS front, to aid in improvement of models of ice-ocean interactions within the ice shelf cavity.

Here, we highlight ROSETTA-ICE preliminary results based on the completed portion of our survey, emphasizing new understanding of sea floor bathymetry, basement topography, and bedrock structure. We used Werner deconvolution of the ROSETTA-Ice magnetic data to determine the depth to basement and delineate sediment-filled basins and troughs. This newly discovered crustal structure bears upon ocean circulation and grounding line processes, and illuminates the tectonic development of the southern Ross Embayment. Along selected transects, we developed 2D gravity and magnetic models of the distribution of crustal elements that account for observed density variations. The pattern of sediment troughs and highs is distinctly different from the basin trends in the Ross Sea. The Eastern Basin and the adjacent Central High extend southward from the RIS front for 250 km before curving southeastward. The Central Trough and Coulman High both extend SSE, and are truncated at intervals by NE trending transfer zones. The Nimrod Glacier transfer zone is a cross-cutting feature that marks the southern boundary of deep bathymetry and dense rock underneath the RIS, and may be a remnant grounding zone.

Keywords: Ross Ice Shelf, geophysics, bathymetry, crustal structure, ocean-ice sheet interactions