Thickness and Structure of the Crust beneath the Thwaites Glacier Catchment, West Antarctica

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By studying the properties of the earth's crust (such as thickness and changes in density), we can learn more about the ice-crust boundary and how its spatial variability may impact ice flow. Specifically, to understand the evolution of Thwaites Glacier, we need to determine the extents of the West Antarctic Rift System (WARS), the Marie Byrd Land crustal block, and the Thurston Island crustal block- the three tectonic areas that are hypothesized to exist in the Amundsen Sea Embayment of West Antarctica.

Only two techniques for studying the earth's crust are available over an area the size of the Thwaites Glacier Catchment: airborne gravity and magnetics. Here, we consider only the airborne gravity data, which was collected in the austral summer 2004-2005 by the University of Texas at Austin and the British Antarctic Survey. The Thwaites Glacier gravity data covers the entirety of the catchment and reaches slightly beyond into the surrounding areas. The free-air gravity anomalies have an rms crossover error of 7 mGals and a spatial resolution of 9 km. The Bouguer gravity anomalies are fully 3D terrain corrected using a new DEM (Bamber, pers. comm.) for the ice surface and published radar sounding depths for the subglacial bedrock terrain. Errors for the Bouguer anomalies are comparable to the free-air anomalies' errors in areas with good surface DEM coverage. We do not calculate Bouguer anomalies for areas with high surface slopes (such as the Executive Committee Range volcanoes) because the features are not well-defined in the DEM.

The Bouguer anomalies show that the Thurston Island block does not exist in the Thwaites Glacier catchment. Likely, the block is much smaller than previously thought and is confined to the area in and around Pine Island Glacier, though this is yet to be confirmed. On the other hand, both the WARS and the Marie Byrd Land block are immediately discernable as broad Bouguer anomalies, positive and negative respectively. The WARS covers much of the eastern portion of the survey area and indeed underlies the majority of Thwaites Glacier. The Marie Byrd Land block appears to contain most of the known volcanoes, though perhaps not all because the absolute boundary between Marie Byrd Land and the WARS is difficult to identify. Further quantitative analysis of the gravity data for crustal thicknesses is required to pinpoint this boundary.

Our approach to refining the crustal structure (including thicknesses) of each areas is to estimate radial power spectra from gridded free-air anomalies, thus providing spatially-averaged crustal properties over large areas. We calculated power spectra over areas ranging from 438 x 542 km to 200 x 200 km. Areas too much smaller than 200 km square do not provide the long-wavelength information needed to resolve the depth of the Moho. The power spectra, when plotted on a log-log scale, form roughly-linear segments. The segments are fit with linear regression and the slopes of the best-fit lines yield the depths for major density boundaries, such as the Moho. Error estimates for the boundaries' depths are provided by the rms of the residuals from the best-fit line. Initial estimates show that the average Moho depth of the WARS is 24.7 km +/- 2.5 km and that there is an intermediate crustal boundary at 11.1 +/- 0.7 km. For Marie Byrd Land, we find a Moho depth of only 20 km +/- 1.3 km, with an intermediate crustal boundary comparable in depth to the WARS' (at 10.6 +/- 0.9 km). Inversion of gridded Bouguer anomalies will be needed to better resolve the 3D variations in crustal properties at the WARS / Marie Byrd Land boundary.