East Antarctic Ice Sheets: Characterizing Ice Sheet Thickness and Hydrologic Potential of Sub-glacial Lake Environments

R. M. Justin[1], E. J. Cabret[2], and S. Anandakrishan[3]

[1,3]Department of Geosciences, Pennsylvania State University, University Park, PA, 16802, USA

[2]Department of Geology, University of Puerto Rico at Mayagüez, Mayagüez, PR 00681, USA

Abstract

The recent discovery of sub-glacial lakes in Earth's polar regions has sparked new interest in the scientific community. Through the application of remote sensing techniques, such as Radio-Echo Sounding (RES), scientists are seeking to find evidence of new microbial life in the unusual sub-glacial habitats of East Antarctica. It is believed that this microbial life may have evolved in isolation from surface life for millions of years. In addition, scientists hope to find new proxies of paleoclimatic conditions to aid in understanding the region's past and present geological setting. Aside from the biological and historical implications associated with this discovery, the characterization of these sub-glacial lakes can help scientists to more fully understand ice sheet dynamics in East Antarctica. The goal of this project was to establish conclusively the existence of a sub-glacial lake body within the surveyed area, and to subsequently learn more about its effects on the complex glaciological framework of the region. Data for this experiment was collected using Radio-Echo Sounding (RES) on a profile 10 km (kilometers) northeast of the South Pole in East Antarctica. This technique employs a geophysical method that enables a non-invasive study of ice sheets using electromagnetic energy instead of acoustic energy at frequencies in the decimeter (UHF) and meter (VHF) band portions of the radio spectrum. Data analysis for this study was conducted using a proprietary version of Matlab computer software designed by Dr. Sridhar Anadakrishnan and the Penn State Environment for Seismic Processing (PSESP) to enable the analysis and display of multi-channel seismic/radar data. Once in Matlab, the raw radar data were displayed in the picker window where points of geologic interest were manually identified, and then digitized as *time* and *amplitude* along a selected horizon. The interactive picker displays on screen as a cross-hair and allows users the flexibility to move in four directions (up, down, left, right) along the trace of a horizon. The following values were stored in each pick: *t (pick time), y (pick amplitude),* t_m *(time of maximum amplitude),* y_m *(amplitude at* t_m*),* y_{pp} *(peak-to-peak amplitude b/t* y_m*), and* y_{rms} *(*$_{rms}$ *amplitude of 1 1/2 cycle of data around "t").* After determining the

pick time for each specific data set, the elevation of the ice bed was calculated using: *t* (*pick time)* x $168 \text{ x } 10^{10} m/s$ (speed of light in ice). Because RES waves generally propagate in an oscillating manner, two-way travel time was also taken into account. Measurements of two-way travel time were achieved by dividing the preceding values of *pick time* x $168 \text{ x } 10^{10} m/s$ by a factor of 2. To calculate the total ice thickness of each data set, we used the equation: *surface elevation* (previously collected by field GPS) - *bed elevation*.

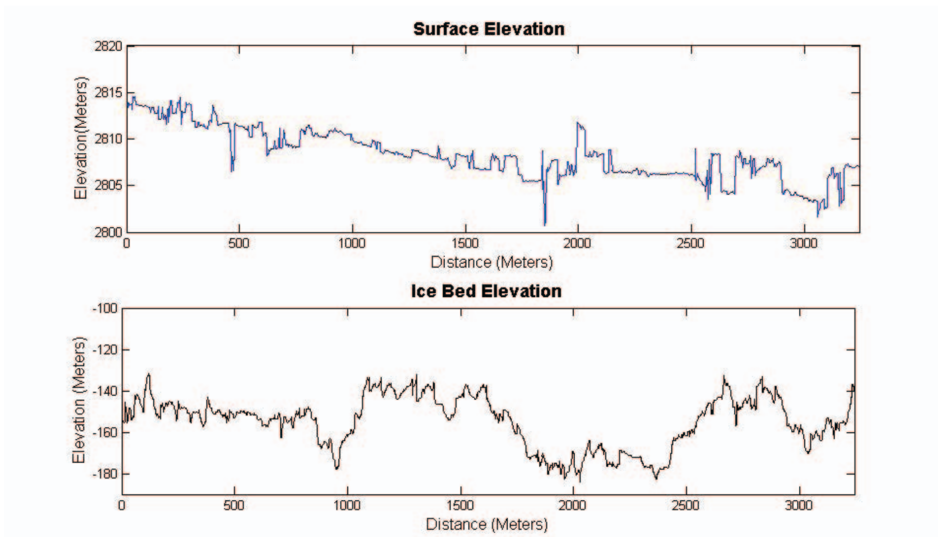

Figure 1. Plots showing surface and bed elevation profiles as determined from *t (pick time)* values using Matlab.

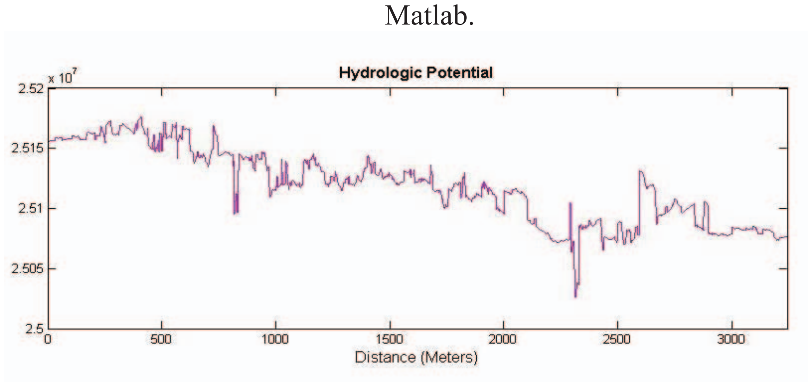

Figure 2. Plot showing the hydrologic potential profile (of the surveyed area) as calculated using values of *surface* and *bed elevation* along with Paterson's equation.

Using this method, we obtained thickness values (meters) at each point along a single trace. In turn, the thickness values, along with the surface and bed elevation were used to calculate hydrologic potential.