Polar Ice as a Complex Propagation Media: Evidence from GPR Profiles of Prograding and Metamorphic Structures in East Antarctica

Steven Arcone
U. S. Army ERDC-Cold Regions Research and Engineering Laboratory
Hanover, NH 03755
Steven.a.arcone@usace.army.mil

Most GPR reflection profiles from West Antarctica reveal a simply layered structure within which reflections in the top 100 m result from density-related dielectric contrasts, such as from hoar layers, and then from conductivity-related contrasts, such as from sulfate layers, to over 4 km depth. In contrast, profiles obtained in East Antarctica over the past several years reveal vast areas of dielectric and stratigraphic complexity resulting from relatively larger glazed areas of no accumulation interspersed with relatively smaller areas of high accumulation. We present 200 MHz and 4 MHz GPR profiles recorded in East Antarctica, which show shallow and deep horizontally oriented packets of stratified, prograding snow, cross sections of the synclinal shaped basins in which they originate, and bounding layers of long term metamorphism. The stratigraphy is characteristic of the megadunes area but has a much larger scale. The metamorphic layers were once glazed and represent hiatuses in accumulation over which the prograding packets migrated. The metamorphism is caused by long term sublimation and mass redistribution, which eliminates density and chemical stratification. The 200 MHz profiles show packets up to 50 m thick and 25 km long and even longer metamorphic layers up to 15 m thick. The 4 MHz profile shows synclinal shaped deposits up to 250 m thick and buried over 1.5 km. Even with the most liberal estimates of concentrated accumulation rates at packet faces, a 25 km length must represent over 10,000 years of accumulation. This time span begs the question of how density stratigraphy has been maintained. Is slow snow metamorphism inactive at this depth, or has another dielectric differentiation process caused the reflections? The deep, stratified packets seen at 4 MHz suggest that conductive layers reside within them, and there are reflection horizons from the metamorphic layers that bound the packets. Given the destruction of chemical stratigraphy in metamorphic layers, why do they produce a coherent and consistent horizon at 4 MHz? Are the ions at the top and bottom edges of some of the prograded layers sufficiently concentrated to provide conductivity contrasts, or have the metamorphic layers dielectrically changed? In addition, why do some reflection horizons in the 4 MHz profile have twice the time duration as do the simple bottom reflection horizons? The shallow depths, yet great ages, of these features seen at 200 MHz lend themselves to relatively inexpensive core drilling that may answer these questions.