EM Studies in Polar Regions

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SUMMARY

Polar Regions provide the opportunity to investigate fundamental questions in earth studies ranging from climate change and its impact, to tectonic processes, both active & extinct. Thick snow and ice covers the majority of the surface in polar environs necessitating geophysical methods to investigate the processes occurring beneath the snow and ice coverage. Magnetotellurics (MT) with its wide bandwidth is ideally suited for addressing problems occurring over broad depth scales. The minimal ground disturbance and environmental impact, together with manageable logistics requirements make MT an increasingly important tool in polar research. Collecting MT data at high latitudes presents challenges unique to these regions, which may result in significant measurement errors including. (1) The very high contact resistance between electrodes and the surficial snow and ice cover (commonly MΩ), results in distortion of the electric field measurement. This is overcome by using custom designed buffer amplifiers to transform the high impedance contact input into an output resistance of ~50 Ω. (2) The proximity to the geomagnetic poles requires verification of the fundamental assumption in MT that the magnetic source field is a vertically-propagating, horizontally polarised plane-wave. Behavior of the polar electrojet must be assessed to identify increased activity (high energy periods) which create strong current systems and may generate non-plane-wave contributions. (3) The generation of 'blizstatic', localised random electric fields caused by the spin drift of moving charged snow and ice particles which produce significant noise in the electric fields during periods of strong winds. At wind speeds of >8m/s the effect of the distortion created by the moving snow is white noise (affecting all frequencies). Station occupation times need to be of sufficient length to ensure data is collected when wind speed is low. (4) Working on glaciated terrain introduces additional safety challenges e.g. weather, crevasse hazards etc. Inclusion of a mountaineer in the team, both during the site location planning and onsite operations, ensures these hazards are properly managed. As an example of the application of MT at high latitudes, the enigma of high topography at the edge of thin rifted crust is nowhere better exemplified than the Transantarctic Mountains. MT data from a 550 km transect through the central portion of the Transantarctic Mountains indicate that a cold stable state persists into the upper mantle from which it can be inferred that the uplift of the mountains results from mechanical rather than thermal mechanism. The non-thermal mechanism for the tectonism has potential implications for stability of the large ice sheets which influence climate trends.

Keywords: magnetotellurics, Antarctica, source field, instrumentation, Polar Regions, tectonics, magmatism