Regional-scale electrical structure of the Slave craton

Alan G. Jones [a, *], Ian J. Ferguson [b], Alan D. Chave [c], Rob. L. Evans [d], Pamela Lezaeta [c], Xavier Garcia [a,c]

[a] Geological Survey of Canada, 615 Booth St., Ottawa, Ontario, K1A 0E9, Canada
[b] Department of Geological Sciences, University of Manitoba, Winnipeg, Manitoba, R3T 2N2, Canada
[c] Deep Submergence Laboratory, Dept. of Applied Ocean Physics and Engineering, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, U.S.A.
[d] Dept. of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole MA 02543, U.S.A.

SUMMARY

The Slave craton in northwestern Canada is a relatively small craton (600 km x 400 km), but is ideal as a natural laboratory for investigating the formation and evolution of Mesoarchean and Neoarchean sub-continental lithospheric mantle. Excellent outcrop and the discovery of economic diamondiferous kimberlite pipes in the center of the craton during the early 1990s have led to an unparalleled amount of geoscientific information being available. Over the last five years four types of deep-probing electromagnetic surveys were conducted, using the natural-source magnetotelluric (MT) technique, as part of a variety of programs of study of the Slave craton to determine the regional-scale electrical structure. Two types of surveys involved novel acquisition; one through frozen lake ice along ice roads during winter, and the second deploying ocean-bottom instrumentation from a float plane onto the lake bottoms. MT measurements were made at over 150 locations across the craton, with the highest density along the winter roads and across the Yellowknife fault.

One principle goal for the MT surveys was to determine the geometry of the topography of the lithosphere-asthenosphere boundary (LAB) across the Slave craton. However, the MT responses revealed serendipitously a remarkable anomaly in electrical conductivity in the SCLM of the central Slave craton, named the Central Slave Mantle Conductor (CSMC). This anomaly is modeled as a spatially-confined region of extremely low resistivity (<30 Ω.m) beginning at depths of ~80-120 km and striking NE-SW. Where precisely located, it is spatially collocated with the Eocene-aged kimberlite field in the central part of the craton (the so-called "Corridor of Hope"), and also with a geochemically-defined ultra-depleted harzburgitic layer interpreted as oceanic or arc-related lithosphere emplaced during early tectonism. New three-dimensional (3-D) modelling of the CSMC shows that its top surface lies within the NE-SW striking G10

geochemical boundaries defined by Grütter, and that it dips to the NW (see below). This geometry is suggestive of lithospheric formation by imbrication of slabs from the SE (present-day coordinates), and is consistent with the G10-3 garnet trends described by Grütter.

The conductor may be interpreted in terms of either ionic conduction from hydrogen diffusion or electronic conduction due to the presence of carbon in graphite form, and neither explanation can be excluded based on existing data. The tectonic processes that emplaced this geophysical-geochemical body are likely related to the subduction of a craton of unknown provenance to the south during 2630-2620 Ma.