Chemical and physical images of the central Slave craton crust and mantle

H. S. Grütter (Monopros Limited)
W. J. Davis and A. G. Jones (Geological Survey of Canada)

Objective of this contribution

To explore the vertical correlation of crust-mantle features through the Moho (crust-mantle boundary) by comparing crustal isotopic-tectonic domains with upper mantle domains defined remotely using magnetotelluric data and kimberlite-based depth profiling.

The central Slave Pb line (and tectonic divide?)

Initial ratios for Pb in sulphides and Nd in granitoids of the central Slave craton can be divided into a western domain with an isotopically evolved signature allied to Mesoarchean rocks, and an isotopically juvenile eastern domain allied to <2.8 Ga Neoarchean rocks (Thorpe et al., 1992; Davis and Hegner, 1992). This well-known Pb divide trends approximately north-south in the central Slave craton and, for most of an ~ 500 km length, follows the inferred eastern edge of the stratigraphically unique Central Slave Basement Complex (CSBC, Fig. 1). The CSBC appears to terminate eastward in 2.73-2.69 Ga high-strain zones (Bleeker et al., 1999), but a distinct crustal Nd divide can still be measured in unfoliated post-tectonic granitoids that intruded across the whole Slave craton at ca. 2.58 Ga. It seems reasonable to infer that if the ca. 2.7 Ga high-strain event represents tectonic dispersal or juxtaposition of vastly different crustal provinces, then the upper- to mid-crustal isotopic reservoir(s) of the ***western*** Slave craton remained intact throughout the ca. 2.7 Ga tectonism and subsequent 2.58 Ga magmatism. The central Slave craton cooled and stabilized reasonably soon afterwards (mica $^{40}Ar/^{39}Ar$ dates are 2.45 to 2.38 Ga), implying that the north-south trending central Slave Pb and tectonic divide may be thought of as a crustal divide that exists at present-day depths of ca. 15-30 km. But does this tectonic and isotopic divide extend deeper? Does it cross the Moho? And which way does it dip in three dimensions?

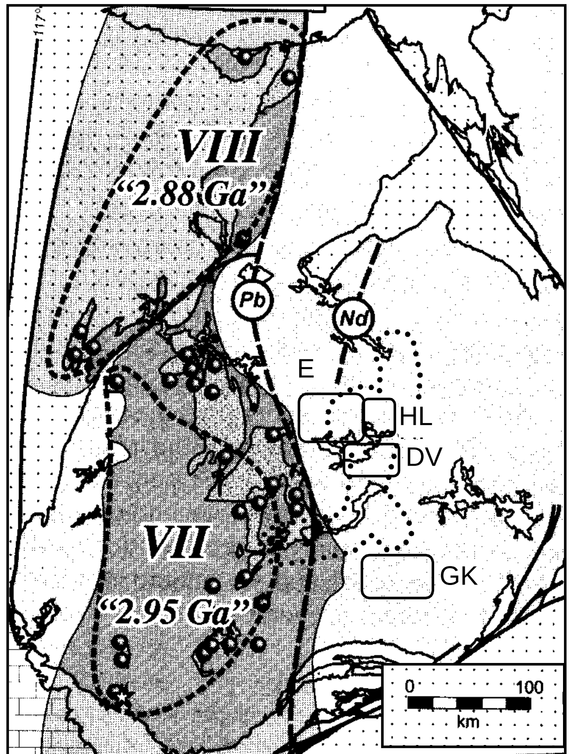

Fig. 1: Exposures of 4.0 to 2.7 Ga CSBC (spheres) occur only west of north-south trending Pb-in-sulphides divide. On the < 2.8 Ga eastern Slave, a shallow mantle conductor (outline stippled) is located beneath the Ekati (E), Hardy Lake (HL) and Diavik (DV) kimberlite projects, but not below Gahcho Kué (GK).

An almost flat-lying mantle conductor at 80 to 110 km depth

New long period magnetotelluric (MT) imaging of the central Slave (Jones et al., 1999) has outlined a strongly conductive mantle zone that underlies the Ekati (E), Diavik (DV) and Hardy Lake (HL) kimberlite projects (Fig. 1), but is absent from the mantle underlying the Gahcho Kué (GK) kimberlite project. This spatial distribution correlates well with mantle chemical domains mapped by xenocryst garnets in the kimberlites concerned (Grütter et al., 1999). The existing MT data locate the upper surface of the conductor at ~80 km depth from HL to near GK, with a slight dip to the west or southwest, hence passing underneath the trace of the crustal Pb divide to reach a depth of

~110 km below the CSBC (Fig. 1). A likely consequence of this arrangement is that the central Slave Pb and tectonic divide probably has a shallow eastward dip (Bleeker, pers. comm.) and/or that it does not extend appreciably beyond the Moho, if at all. Such an architecture would allow 3.02 Ga zircons in a lower crustal xenolith from Ekati (Bleeker and Davis, 1999) to be correlated with Mesoarchean mid- and upper crustal signatures on the ***western*** Slave craton. This would in turn suggest that the <2.8 Ga eastern Slave crust in the Ekati area is likely underlain by >3.0 Ga peridotitic lithosphere at depths extending from about the Moho to possibly inside the diamond stability field. Can this mantle architecture find support from kimberlite-based depth profiling?

Depth-projected garnet xenocryst data from kimberlites

Griffin et al. (1999) have utilized the trace and major element compositions of xenocryst garnets in the Diavik project kimberlites to construct a geochemical depth section through the central Slave mantle. A globally unique feature is the presence of shallow west-dipping ultradepleted low-CaO garnet harzburgite at depths of <100 to ~150 km (i.e. a G10 dominated garnet peridotite "layer" mostly inside the graphite stability field) that is in turn sharply underlain by more fertile CaO-saturated garnet lherzolite from depths of ~150 km to the base of the petrologic lithosphere (i.e. a G9 dominated garnet peridotite "layer" mostly inside the diamond stability field). Xenocryst data collected by Monopros from the Hardy Lake kimberlite project confirms this unique G10 above G9 mantle zonation at similar depths, while the data presented by Fipke et al. (1995) indicate that it may also be valid for the mantle sampled by kimberlites in the Ekati mine area. The depth zonation implies that many G10 garnets from the central Slave lithospheric mantle cannot be related to diamond potential. By contrast, xenocryst data for the Monopros-Mountain Province joint venture on the Gahcho Kué kimberlites shows a lherzolite-dominant G9-type garnet peridotite signature throughout the entire mantle section; the distinctive shallow G10-dominated "layer" is absent, but high-chrome G10-type mantle is distributed at depths well inside the diamond stability field. Taken together, the mantle depth sections strongly suggest that the upper (shallowest) surface of the central Slave G10 "layer" is intricately related to the shallow mantle conductor imaged by magnetotelluric methods; the relevant conduction mechanism is however currently unknown.

Four low-angle boundary zones for the central Slave craton

At least four low-angle boundary zones can hence be inferred with depth for the central Slave craton: 1) an east-dipping crustal suture, 2) the Moho, 3) a west-dipping conductive upper surface of an extremely depleted G10 peridotite "layer" and 4) a west(?)-dipping lower surface of the G10 "layer". Resolution of the genesis, temporal and spatial relations of these four boundary layers will require integrated petrologic, isotopic and petrophysical studies on a variety of crustal and upper mantle xenoliths. Irrespective of the detailed conclusions reached from such work, it is suggested here that the distinct peridotitic upper mantle depth profile(s) below the central Slave and Gahcho Kué areas implies decoupling of the crust and mantle at Moho depths and/or below layer 4.

References

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