Mantle Composition, Age and Geotherm beneath the Darby Kimberlite field, West Central Rae Craton

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New geological and geophysical research on Canada's Rae Craton are providing an increasingly good understanding of its diamond potential. This study uses mantle xenoliths and xenocrysts from the Darby property, located ~ 200 km southwest of the community of Kugaaruk, Nunavut, to provide new insight into the lithospheric mantle and diamond potential of the western portion of the central Rae Craton. Peridotite xenoliths containing fresh olivine have a median Mg# of 92.5, indistinguishable from the median value of 92.6 typical of cratonic peridotites globally. Four of the fourteen peridotitic xenoliths contain garnet, one sample classifies as harzburgitic with a minimum pressure of 4.7 GPa using the P_{38} geobarometer, while garnets from three peridotites and 98 % of peridotitic concentrate classify as lherzolitic. Lherzolitic diopsides from kimberlite heavy mineral concentrate indicate a lithospheric thickness of at least ~ 200 km. The peridotitic garnets from xenoliths and concentrate yield two distinct modes in mantle sampling depths using Ni thermometry, when projected to the clinopyroxene geotherm. Several samples with high Ca/Cr lherzolitic garnets equilibrated at 765 to 920 °C, while a group of samples with low Ca/Cr lherzolitic garnets with anomalously high Ti concentrations yield super-adiabatic T_{Ni} values. The aluminum-in-olivine thermometer applied to "garnet-facies" olivines from concentrate clearly indicate mantle sampling from the diamond stability field, but is not reflected by garnet Ni temperatures. Pyroxenitic/eclogitic type xenoliths are found at each Darby kimberlite target. New geochemical screening techniques indicate that these rocks likely originate close to the crust-mantle boundary. The abundance of this mafic material may reflect derivation from a body of mafic composition evident in the layered structure of the Rae Craton mantle root defined by new seismic studies. Osmium isotope analyses of the peridotites reveal whole-rock Re-depletion ages ranging from Mesoarchean to Paleoproterozoic. The pyroxenite/eclogite xenoliths have very radiogenic Os isotope compositions and provide the first age information from pyroxenites/eclogites beneath the Rae Craton. Their resulting Archean whole rock T_{MA} ages are consistent with a Mesoarchean age of the West central Rae lithosphere, older than the lithosphere beneath the Repulse Bay block in the East section of the Rae Craton. The highly depleted olivine compositions, thick cold lithosphere, and Archean ages of the Darby peridotite xenoliths clearly indicate the presence of ~ 200 km thick cold cratonic lithospheric mantle beneath the western segment of the central Rae Craton circa 540 Ma.