Mantle composition, age and geotherm beneath the Darby kimberlite field, west central Rae Craton

Garrett Harris

M.Sc. Thesis Abstract

The Rae Craton, northern Canada, contains several diamondiferous kimberlite fields that have been a focus of episodic diamond exploration. Relatively little is known about the deep mantle lithosphere underpinning the architecturally complex crust. Previous studies in the region have focused on peridotite mantle xenoliths from Pelly Bay and Repulse Bay-east Rae and Somerset Island-Churchill Province (north Rae), no previous studies have investigated the lithospheric mantle beneath the west central Rae, specifically the Darby kimberlite field.

This study presents bulk and mineral element and isotopic compositional data for peridotite and pyroxenite xenoliths from the Darby kimberlites representing fragments of the west central Rae lithosphere, as well as the first kimberlite eruption age of 542.2 ± 2.6 Ma (2 σ; phlogopite Rb-Sr isochron) for the Darby kimberlite field.

Darby peridotites have low bulk Al_2O_3 contents with highly-depleted olivine (median Mg# = 92.5), more depleted than peridotites from other locations on the Rae Craton such as Somerset Island and east central Rae kimberlites. These values are characteristic of cratonic lithosphere globally. Rhenium-Os T_{RD} model ages are the oldest measured to date from peridotites of the Rae lithosphere, having a mode in the Meso/Neoarchean and ranging to Paleoproterozoic in age (~ 2.3 Ga). One harzburgite xenolith contains a G10D garnet. Concentrate clinopyroxene defines a well constrained mantle geotherm indicating the existence of a ~ 200 km lithosphere thickness at the time of kimberlite eruption, greater than the lithosphere thickness beneath Somerset Island and in good agreement with present-day seismic constraints. Nickel-in-garnet thermometry in grains that do not record temperatures above the mantle adiabat, indicates mantle sampling mainly in the graphite stability field whereas the Al-in-olivine thermometer shows a distinct mantle sampling mode in the diamond stability field.

Abundant pyroxenite and eclogite (low-Cr garnet, Cr_2O_3 < 1 wt%) xenoliths found throughout the Darby bodies are also expressed as the dominant garnet type in kimberlite concentrate. Based on thermometry, these rocks range in likely depths of equilibration, from the lower crust into the shallow lithospheric mantle. They give variable Os model ages, with the oldest ages in the Mesoarchean. The abundance of this mafic material reflects derivation from a large mafic body, which may be evident in the layered structure of the Rae Craton mantle root defined by new seismic studies.