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Constraints on the distribution, composition, and lithology of eclogite-pyroxenite xenoliths from the central Slave Craton mantle root

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Introduction

Eclogites hosted by kimberlite are derived from the subcratonic lithospheric mantle (SCLM) and can have a variety of compositions and accessory minerals. These characteristics are useful to trace the geologic history of the eclogites themselves, as well as that of the cratonic mantle. The spatial distribution of eclogites within sections of subcratonic lithospheric mantle is still poorly constrained in many regions.

We expand the dataset for eclogite and pyroxenite xenoliths from the central Slave craton to produce an overview of the geochemical diversity of eclogite and pyroxenite from this locality. We report the first comprehensive set of oxygen isotope compositions for low-Cr garnets in eclogites and pyroxenites from the central Slave craton and use it to identify unique oceanic crust packages that were subducted into the lithospheric mantle through time.

Dataset

We compiled a new set of 226 eclogite and pyroxenite microxenoliths from the A154, Panda, and DO-27 pipes in the Lac de Gras region of the central Slave craton, Northwest Territories, Canada. For paired garnet and clinopyroxene in all samples we determined major-element compositions using a JEOL 8900R electron probe microanalyser and trace-element compositions (including REE, Sr, Zr, Y, Nb, Ba, and Hf) via sector-field laser ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS). All samples contain garnet with Cr_2O_3 < 1 wt%. The $\delta^{18}O$ values of garnet from 160 microxenoliths were determined using secondary ion mass spectrometry (SIMS). We also compiled data for 195 additional published eclogites and pyroxenites with low-Cr garnet from the central Slave craton (Westerlund 2005; Schmidberger et al. 2007; Aulbach et al. 2007, 2011, 2019, 2020; Jacob and Fung, in press).

The majority of compiled samples are bimineralic, though rutile is reported commonly in xenoliths from A154, and orthopyroxene±olivine from DO-27 and Panda. Kyanite, corundum, and ilmenite are occasionally reported as additional accessory minerals. Diamond is reported in a subset of published A154 and Panda eclogite and pyroxenite xenoliths.

Results and Discussion

Garnets in this study have a diverse range of compositions and classify samples as “high-Ca” (garnet Ca# - molar Ca/[Ca+Mg+Fe+Mn]) > 0.2, “high-Mg” (garnet Ca# ≤ 0.2 and Mg# - molar Mg/[Mg+Fe]) > 0.6),

and "low-Mg" (garnet Ca# ≤ 0.2 and Mg# ≤ 0.6), using the compositional criteria of Aulbach et al. (2020). A154 has a much larger proportion of high-Ca eclogite-pyroxenite than DO-27 or Panda.

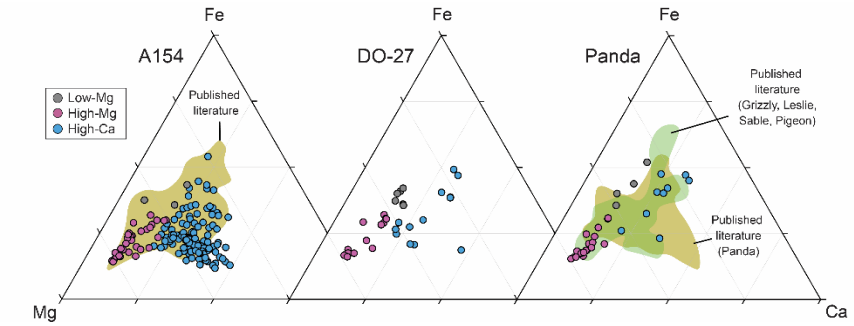

Figure 1: Mg-Ca-Fe major-element compositions of low-Cr garnets from (A) A154, (B) DO-27, and (C) Panda. Data from published literature are shown as light brown or green fields. Sources of published literature data are given above, in section *Dataset*.

Trace-element compositions are diverse and include some with MORB-like patterns and REE concentrations, some with positive chondrite-normalized MREE-HREE slopes ("boninite-like;" Aulbach et al. 2007), and others with low ΣREE and strong positive Eu-anomalies. Oxygen isotope compositions are variable and include values within and outside the mantle range. High-Ca eclogite-pyroxenites with strong positive Eu-anomalies tend to have $\delta^{18}O$ values within or below the mantle range.

Using major-element compositions, we determine the depth of last equilibration for all samples by projecting garnet-clinopyroxene Fe-Mg exchange temperatures (Krogh 1988) onto an ~36 mW/m^2 geothermal gradient. Data in this study reveal that eclogite-pyroxenite occur throughout the entire SCLM beneath the central Slave (Figure 2). For A154 in particular, > 175 km depth the lithospheric mantle is comprised predominantly of high-Ca eclogites with positive Eu-anomalies and $\delta^{18}O$ values below the mantle range, indicating oceanic cumulate protoliths that experienced high-temperature seawater alteration prior to subduction. The shallow SCLM (< 175 km) is comparatively heterogeneous and comprised of eclogite-pyroxenites with high-Mg, low-Mg, and high-Ca compositions, variable trace-element compositions (including some that are MORB-like or "boninite-like"), and variable $\delta^{18}O$ values within, above, and below the mantle range. These data record subduction of diverse oceanic crust protoliths, including cumulates and lavas, into the shallow lithosphere, and primarily cumulate-type oceanic crust into the deeper SCLM.

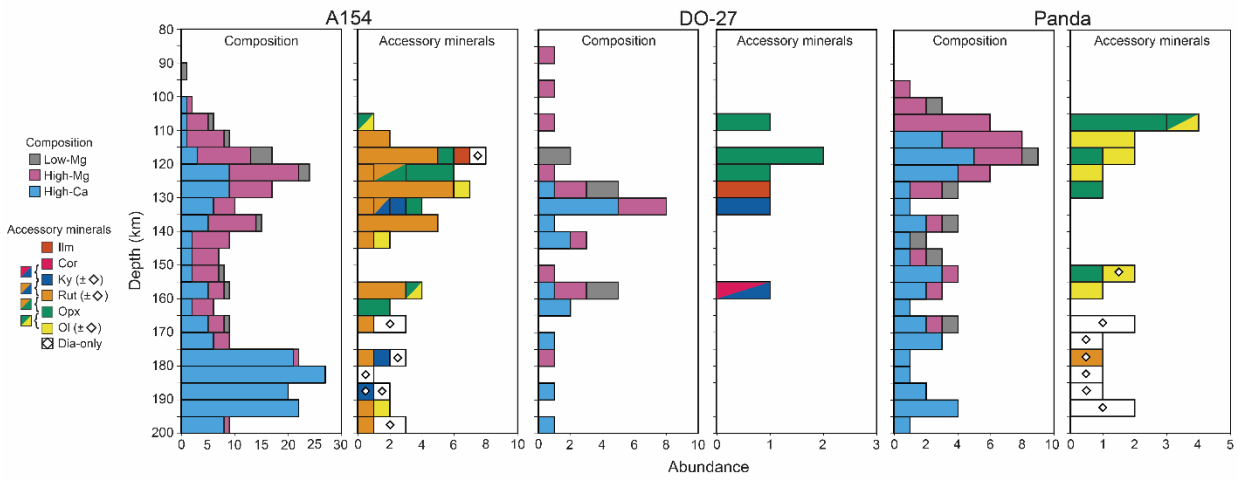

Figure 2: Depth sampling profiles of eclogite and pyroxenite from (A) A154, (B) DO-27, and (C) Panda based on elemental composition (left panels) and reported accessory minerals (right panels).

Conclusions

Eclogites and pyroxenites are dispersed throughout almost the entire central Slave craton SCLM (Figure 2). Differences in accessory mineral contents and elemental compositions between pipes likely relate to compositional differences in oceanic crust protoliths, manifesting as diverse mineralogies and elemental compositions upon subduction and metamorphism.

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