

# RECENT FLUID PROCESSES IN THE KAAPVAAL CRATON, SOUTH AFRICA: OXYGEN ISOTOPE DISEQUILIBRIUM IN POLYMICT PERIDOTITE BRECCIAS

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## ABSTRACT

Oxygen-isotope mapping (Zhang et al., 1999) of primary and secondary phases in South African polymict peridotite xenoliths (Lawless et al., 1979) shows, for the first time, that significant oxygen isotope disequilibrium is preserved on a millimetre scale. Primary porphyroblastic phases (e.g. olivine, orthopyroxene, garnet, diopside) tend to have higher  $\delta^{18}\text{O}$  ratios than secondary minerals (e.g. mica, ilmenite, neoblastic olivine, orthopyroxene rims). On the scale of a thin section, minerals have oxygen isotope heterogeneity that extends beyond that observed in most mantle rocks (Matthey and MacPherson, 1993) including diamond-, garnet- & spinel-facies peridotites (Lowry et al., 1999) regardless of whether they are wet or dry (Chazot et al., 1997), low or high temperature, sheared or granular. Polymict minerals have a lower oxygen isotope composition than "average mantle" ( $\delta^{18}\text{O} = 5.2 \pm 0.3\text{‰}$ ), indicative of inter- and intra-mineral oxygen isotope disequilibrium. Disequilibrium is also evident in the elemental geochemistry of the mantle minerals and a general correlation exists between oxygen isotopes and major (Si, Mg, Ca, Fe) and trace elements (Ce, Cr, Zr, Nb, REE). The interpretation that isotopic heterogeneity may relate to melt processes is supported by  $\delta^{18}\text{O}$  zonation in garnets, significant isotopic variation close to secondary veins,  $\delta^{18}\text{O}$  (primary phases)  $>$   $\delta^{18}\text{O}$  (secondary phases) and oxygen isotope disequilibria in many minerals. In addition a positive correlation between  $\delta^{18}\text{O}$  and grain size indicates a role for deformation processes as a result of diffusion reactions perhaps inextricably linked to melt processes. The following conclusions can be reached from the oxygen isotope studies and the investigation of the correlation between the oxygen isotopes and the elemental geochemistry in polymict xenoliths, South Africa:

- (1) All the mineral phases in the polymict xenoliths show a large inter-mineral disequilibrium in oxygen isotope and have low  $\delta^{18}\text{O}$  values relative to equivalent minerals in mantle xenoliths from elsewhere. Some minerals (i.e. garnet, ilmenite, and diopside) still show an intra-mineral  $\delta^{18}\text{O}$  disequilibrium. Normally the reaction rim has a lower  $\delta^{18}\text{O}$  value than the core of the mineral.
- (2) Fluid migration and deformation are the main processes resulting in the inter- and intra-mineral disequilibrium in the minerals and these may have been recently captured

and frozen in time by the entrainment processes.

- (3) Fluid influx was associated with the introduction of low  $\delta^{18}\text{O}$ , and high LREE, CaO,  $\text{TiO}_2$ , and FeO. The positive correlation between  $\delta^{18}\text{O}$  and elemental geochemistry is associated with melt ingress.
- (4) Some minerals have retained information about the precursory lithologies (i.e. lherzolite) that were disrupted during the deformation process.
- (5) Oxygen isotopes in many minerals from the polymict xenoliths straddle a large variety of mantle provenances. Together with the elemental consequences these polymict xenoliths show large mixed provenances of lithospheric peridotites.
- (6) No unequivocal evidence exists for the presence of an eclogite precursor.

We suggest that polymict peridotites formed as a result of movement along mantle shear zones which led to the juxtaposition of minerals of varied provenance. Contemporaneous melt transfer reacted with these mantle breccias and rapid entrainment by "kimberlite" meant that any associated mineral disequilibria was very effectively frozen in time.

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