

# Chemical zoning of garnets in peridotites and diamonds

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Chemical characteristics of mineral inclusions in diamonds provide unique information about geochemistry of materials and processes in the continental upper mantle. Garnet is one of the common silicate mineral species with measurable trace element abundances and has attracted much attention of petrologists and geochemists (e.g., Sobolev, 1977; Gurney *et al.*, 1979; Richardson *et al.*, 1984; Shimizu and Richardson; Griffin *et al.*, 1992; 1993).

Diamond inclusion garnets of the 'peridotitic' affinity are refractory in major element chemistry (i.e., typically sub-calcic, magnesian and high-Cr), but they display enrichment in LREE relative to HREE (e.g., Shimizu and Richardson, 1987), unusually high Sr (e.g., Griffin *et al.*, 1992; 1993), trace element variabilities among specimens collected within individual kimberlite pipes are very large, and are difficult to reconcile with simple mantle-melt relationships.

The purpose of this paper is to report major and trace element data of zoned garnets from

garnet harzburgite and dunite which show progressive chemical changes from diamond inclusion-like characteristics in the core to 'normal' lherzolitic traits in the rim, and to compare them with chemically zoned diamond inclusion garnets. It is an attempt to put diamond inclusion garnets into a 'geochemical context' and to discuss implications of the observations for nature and age of geochemical processes in the mantle.

Major element data were obtained with a JEOL 733 at MIT and a JEOL JXA-8600 at Geophysical Laboratory, and trace elements were determined with a Cameca IMS 3f at WHOI.

Garnet crystals in garnet dunite (PHN 5600 from Jagersfontein, South Africa) and garnet harzburgite (Uv 4/76 from Udachnaya, Siberia) both have sub-calcic core (CaO = 0.9 % and 1.8 %, respectively), and as CaO increases steeply toward rim, Ti, Zr, *M*-HREE (Sm ~ Yb) follow suit (Fig. 1A). The low-Ca cores are characterized by high (up to 8 ppm) and highly variable (by a

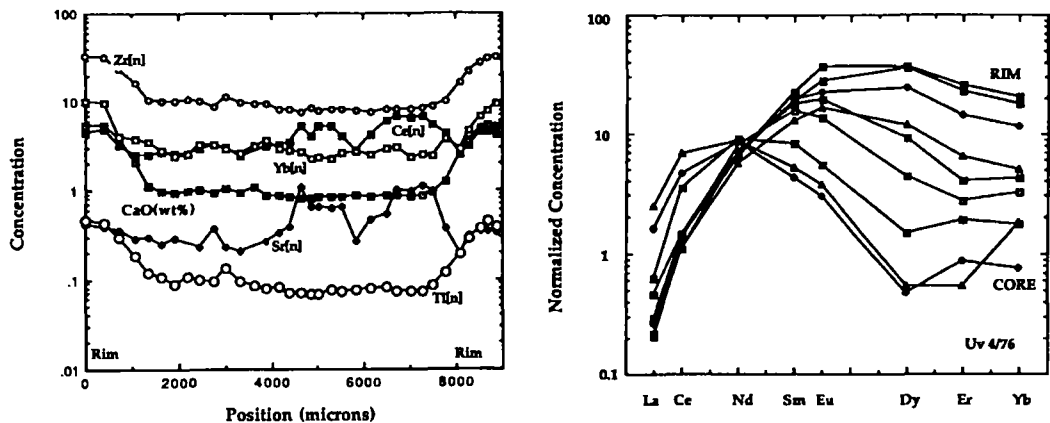


FIG. 1. A: Zoning patterns of selected elements of garnet in dunite (PHN 5600). CaO in wt%, trace element contents in chondrite-normalized values. B: Chondrite-normalized REE patterns of selected positions in garnet in harzburgite (Uv 4/76).

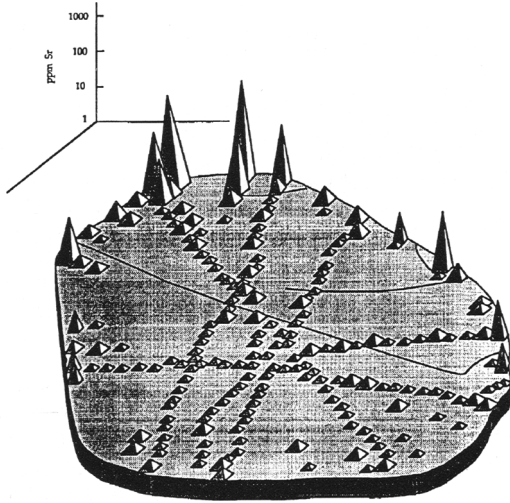


FIG. 2. Bird's eye view of the distribution of Sr in a polished section of a diamond inclusion garnet (MR 129/15) from Mir. Note that Sr contents (log scale) are expressed as height of the data point.

factor of 5) Sr. Chondrite-normalized *REE* patterns in the low-Ca cores are highly 'sinuous' and as *M*~*HREE* increase rimward, patterns change continuously toward those of normal lherzolitic garnets (Fig. 1B).

The observed trace element zoning and associated variations in *REE* patterns can be explained by continuous growth of garnet under changing conditions; core was formed under highly disequilibrium conditions and equilibrium was approached toward rim.

Discrete garnet inclusions from single diamonds display variable *REE* patterns reminiscent of various parts of the zoned garnets, suggesting that growth of diamond inclusion

garnets may have occurred under similarly changing conditions. Indeed, a large (~200 microns across) unfragmented garnet inclusion from a Mir diamond (MR 129/15) was found to be zoned as illustrated in Fig. 2. In the high-Sr corner (maximum Sr is 530 ppm) and in areas where Sr is anomalously high, *LREE* are also high and *REE* patterns are quite unusual, whereas low-Sr areas display sinuous *REE* patterns typical of low-Ca diamond inclusion garnets and cores of zoned garnets in peridotites.

The observed Sr (and *LREE*) variations in the low-Ca cores in the peridotite garnets, zoning of the diamond inclusion garnets, and consideration of diffusion kinetics strongly suggest that the growth of these garnets and diamonds took place shortly before incorporation in the host kimberlite.

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