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Most Cr-diopside spinel lherzolite xenoliths from Bullenmerri and Gnotuk maars, western Victoria, show modal metasomatism, involving introduction of amphibole \pm mica \pm apatite(Cl-CO₂) at the expense of pyroxenes + spinel (Griffin et al. 1984). The microstructural situation of the volatile-bearing phases ranges from obvious replacement rims on spinel, to apparent equilibrium mosaics with olivine + clinopyroxene + orthopyroxene \pm spinel. Similar effects are common in lherzolites from other Victorian localities. The metasomatism is attributed to infiltration of CO₂-rich fluids, which are observed in fluid inclusions (Andersen et al. 1985). Most of the fluid was probably introduced during the intrusion and crystallization of basaltic magmas, now represented by veins of pyroxenite.

Major element compositions of the lherzolites are little affected by the metasomatism, except for the introduction of Fe. Mg/(Mg+Fe) drops markedly (from >90 to <80) while Cr/(Cr+Al) is unaffected; these two "indices of refractoriness" are therefore not correlated, and neither is clearly related to a partial melting event. Na, Ca, Cr and Al contents are essentially controlled by premetasomatic pyroxene/olivine/spinel ratios; Ca may have been introduced in some apatite-rich (ca. 5%) lherzolites.

REE patterns of anhydrous lherzolites range from LREE-depleted ((La/Yb)_N = 0.4) to LREE-enriched ((La/Yb)_N = 30), all at low EREE. These rocks show an inverse correlation of (Nd/Sm) with CaO, and separated clinopyroxenes show a correlation of (Nd/Sm)_N with Nd. This can be modelled as uptake by clinopyroxene of the REE from an infiltrating fluid with (La/Yb)_N > 50. The clinopyroxene-rich rocks are thus less "contaminated" with the LREE-enriched component. Amphibole-rich peridotites are enriched in REE (with (La/Yb)_N = 10), Zr and Ta, with high K/Rb. Mica-rich rocks are enriched in K, Rb, Ba, Ta and Ti, with low K/Rb. Introduction of apatite leads to high EREE (with (La/Yb)_N = 30-50), Sr, U and Th contents. The distribution of trace elements in the peridotites is thus controlled by the crystal chemistry of the metasomatic phases (Fig. 1). The variable distribution of these phases in space and time results in a decoupling of major, minor and trace elements during metasomatism, related mainly to crystal/fluid partitioning. Models involving a "KREEP" or "infiltrating melt" component are clearly oversimplified.

Examination of >2000 lherzolite xenoliths from Bullenmerri and Gnotuk shows that amphibole lherzolite is the most common type; micaceous ones are least common, and "dry" ones are rare. This may reflect their distribution in the mantle, with micaceous selvages on abundant metasomatic veins and pyroxenite dikes, and small relict volumes of "dry" lherzolites, showing various degrees of cryptic metasomatism, within a "matrix" of amphibole lherzolite. The sporadic distribution of apatite in these rock types, and in clinopyroxene+apatite veins, suggests that the introduction of apatite may be independent of the formation of mica and amphibole.

The overall pattern of trace element enrichment in Victorian lherzolites (Fig. 2) reflects the volumetric distribution of the different types of metasomatism. Ni, Cr, V, Sc, Y and Na values are similar to those in depleted mantle xenoliths and the source regions of N-type MORB. Median concentrations of Ba, Th, U, Ta, Nb and LREE range from 2-10x primordial values. The low median values of K and Ti reflect "dumping" of these components in micaceous rocks of limited volumetric abundance. The resulting mantle signature resembles that of calculated source regions for intraplate undersaturated magmas like the Honolulu Series. Similar patterns are seen in other continental and oceanic suites of metasomatized mantle xenoliths

(Dreiser Weiher, Zabargad,, St. Paul's Rocks, Nunivak Is.) where data bases are large enough.

Abundant xenoliths of garnet- and spinel-pyroxenites are products of an older magmatic episode; igneous-textured wehrlite series xenoliths represent a younger (recent?) episode. Both types have metasomatically modified their wall rocks (Griffin et al. 1984; Irving 1980).

The Sr-Nd isotopic compositions of the lherzolites (Fig. 3) spread into the "enriched mantle" field. T_{DM} model ages cluster at 600 ± 120 Ma. At 700 Ma $>1/3$ of the lherzolites have $\epsilon Nd > Dm$; this represents a maximum age for the LREE-enrichment "event". Several of the garnet- and spinel pyroxenites have $\epsilon Sr \approx 150$ and $\epsilon Nd \approx -9$; the rest scatter toward the field occupied by the lherzolites (Fig. 4). This is interpreted as the effect of wall-rock reaction, leading to isotopic equilibration between the small dikes of pyroxenite and the surrounding reservoir of lherzolite. At 300-500 Ma the pyroxenites define a good mixing hyperbola with the lherzolites, most of which have $\epsilon Sr > 0$ at this time (Fig. 4).

Plots of $^{143}Nd/^{144}Nd$ vs. Nd and $^{87}Sr/^{86}Sr$ vs. Sr support this mixing model, and define a second trend for the apatite-bearing lherzolites. The apatite component has a present-day ϵSr and $\epsilon Nd \approx 0$. The isotopic systematics of the lherzolites and pyroxenites suggest at least three "events": (1) intrusion of basaltic magmas 300-500 Ma ago, leading to cryptic and patent metasomatism of the lherzolite wall rocks, and changing their isotopic compositions as well as Rb/Sr and Sm/Nd ratios; (2) introduction of the apatite component with "bulk-earth" isotopic ratios; (3) intrusion of basaltic magmas (parental to the wehrlite series) with $\epsilon Sr = -10$, $\epsilon Nd = 2-5$, leading to some of the scatter around the mixing line resulting from (1) and (2).

The least-modified magmas of (1) have very unradiogenic Nd and unsupported radiogenic Sr. They thus contain a large component from an older, undepleted reservoir. This may be either a deeper primitive mantle, or recycled crustal material. The relatively radiogenic Sr of the lherzolites suggests a similar effect. We suggest that the pyroxenite-forming magmas and their associated fluids may have been derived from the material of a subduction zone during the Paleozoic crustal-accretion event in this region. The apatite component (2) may have a similar origin, but cannot be clearly explained with the present data. Event (3) is probably sub-recent, related to the same general episode of basanitic magmatism which resulted in the Newer Volcanics.

The major metasomatic effects observed in lherzolite xenoliths from Victoria may thus reflect modification of a mantle wedge by fluids (largely sea water?) and melts derived from a subducted plate. Fragments of such a plate may be represented by some compositionally and isotopically unusual xenoliths, such as those found at Delegate.

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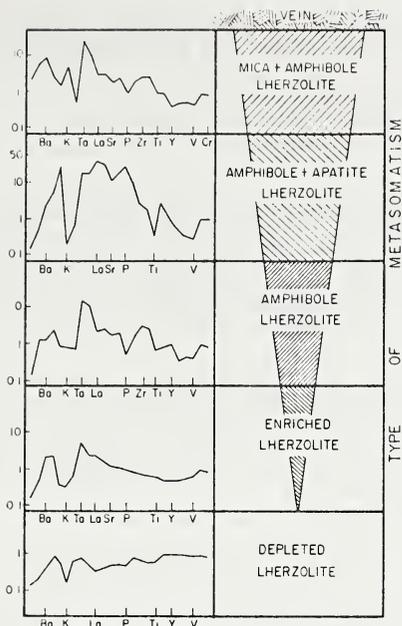


Fig. 1. Correlation of key minor and trace element abundances (normalised to primordial mantle) with type of metasomatism.

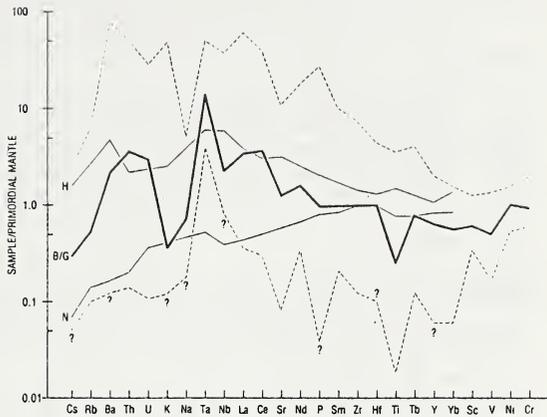


Fig. 2. Dark line: median of minor/trace element abundances in Victorian lherzolites. Stippled field covers range of analyses (n=12-65). H: calculated source region for Honolulu Series magmas. N: calculated source region for N-type MORB.

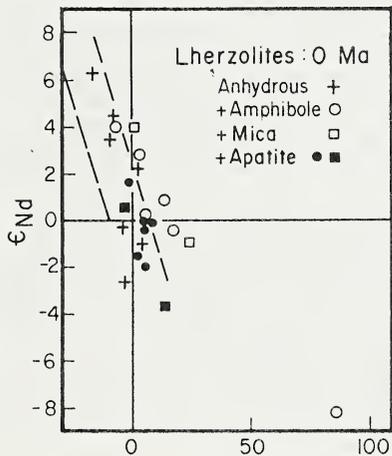


Fig. 3. Sr/Nd isotopic compositions of lherzolites from Bullenmerri/Gnotuk.

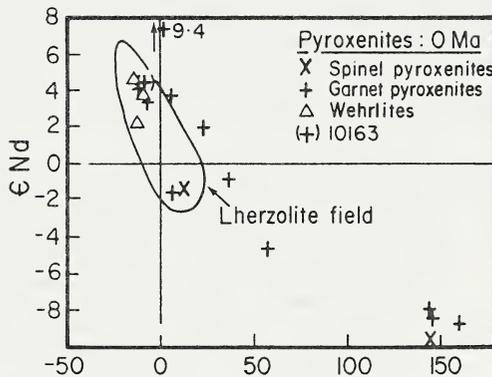


Fig. 4. Sr/Nd isotopic compositions of spinel- and garnet pyroxenite xenoliths from Bullenmerri/Gnotuk. Lherzolite field encloses main cluster of lherzolite values.