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MANTLE XENOLITHS FROM ÑEMBY, EASTERN PARAGUAY: O-Sr-Nd ISOTOPES AND TRACE ELEMENTS OF HOSTED CLINOPYROXENES

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The Ñemby spinel peridotites (Asunción-Sapucai-Villarrica Graben, Central Eastern Paraguay) are variable in major element compositions, ranging from relatively "fertile" to very depleted in basaltic component. Some of the xenoliths have exceeding high K_2O (HK suite, distinct from the low K_2O, LK-suite) and incompatible element (IE) contents compared with the composition of lherzolites which underwent partial melting during "basalt-extraction" (Fig. 1).

The IE contents of clinopyroxenes encompass world-wide occurrences. This suggests that processes, other than depletion, occurred. Demarchi et al. (1988) have shown that K is mostly partitioned into glassy patches (blebs) in the xenoliths and glassy drops in clinopyroxenes. The blebs have been interpreted as derived from the breakdown of volatile-bearing wet phases, such as amphibole and/or phlogopite, which melted during ascent to the surface; the glassy drops in clinopyroxenes are generally interpreted as products of incongruent partial melting induced by decompression (Comin-Chiaramonti et al., 1986). Both probably represent the remnants of hydrous phases such as micas and/or amphiboles, and/or products induced by the influx of small-volume, volatile-rich melts (Petrini et al., 1994).

In summary, most of the major element chemistry of the Ñemby xenoliths (except for K_2O and to a lesser extent for Na_2O) are consistent with (1) residual compositions after variable degrees of partial melting and (2) metasomatic effects shown by alkali and IE enrichments in both whole rock and in clinopyroxene (Fig. 1).

Clinopyroxenes display variable REE enrichments (Fig. 2), more evident in those crystals characterized by spongy texture and abundance of glassy drops.

A possible explanation for the progressive enrichment of samples characterized by similar HREE and different LREE abundances is different ion-exchange processes (cf. "simple mixing metasomatism model" of Song and Frey, 1989; Sen et al., 1993) due to the passage of LREE-rich chemical front on depleted compositions, both in LK and HK suites.

It is believed that "residual" pyroxenes incorporated REE during later metasomatic events (cf. Chen et al., 1989). The above observation is consistent with the Nd isotope ratios measured on clinopyroxenes, indicating a LREE-depleted source for some samples and supporting the hypothesis that clinopyroxenes from some lherzolites did not crystallize from an original LREE enriched component; other samples approach enriched or undifferentiated compositions.

Alkaline basaltic magmas from deeper, garnet-bearing mantle may be suitable enrichment agents (cf. Comin-Chiaramonti et al, 1997). Moreover, the Ñemby xenoliths were probably involved in carbonatite metasomatism (Comin-Chiaramonti et al., 1991), as possibly indicated by the IE patterns of some clinopyroxenes. The latter are characterized by high LREE and Sr abundances coupled with depletion in Nb, Ti, Zr. Notably, similar behaviour has already been described for clinopyroxenes from peridotite xenoliths hosted in ocean island basalts from Samoa and Tubai, which, according to Hauri et al. (1993), show clear evidence of carbonatitic metasomatism.

Systematic isotope differences between LK and HK xenoliths were not observed, excepting for those related to ? ?^{8}O(Cpx-Ol) (Fig. 1 E-G).

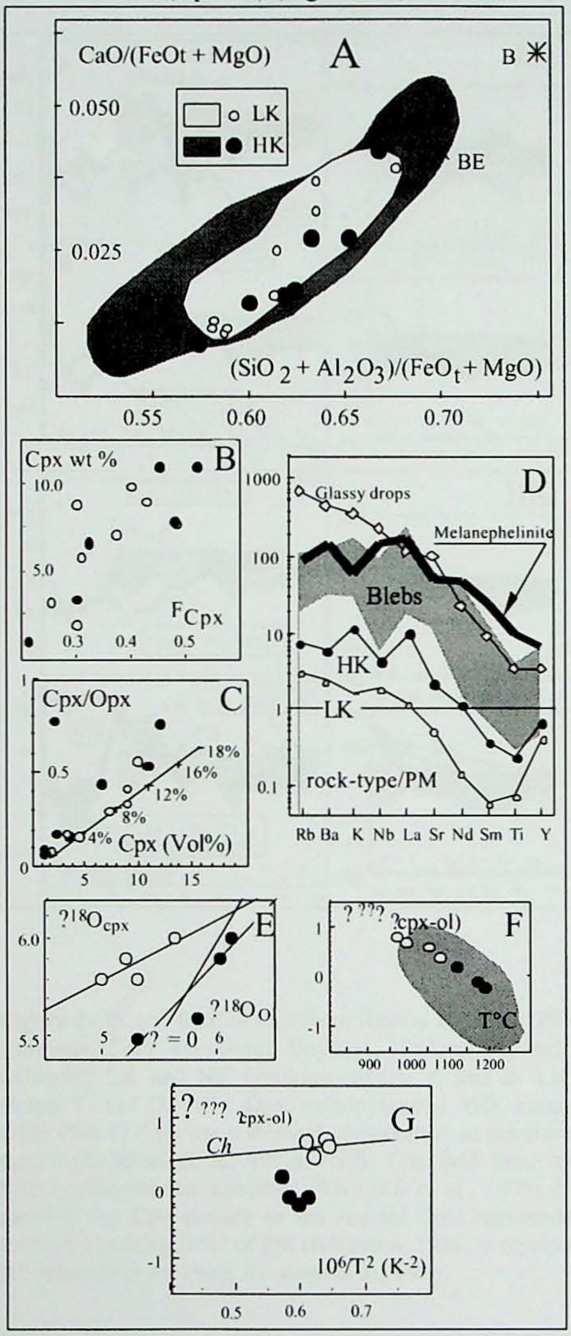

Figure 1. **A**: Molar ratios for bulk-rock compositions, LK and HK suites, respectively. Stars B and BE: pyrolite composition (Bristow, 1984) and Bulk Earth (McKenzie and O'Nions, 1991), respectively. Outlined fields from Demarchi et al. (1988). **B**: F (F_{Cpx} = (Al+Fe+Na+Ti)/(Mg+Cr) atoms) vs Cpx (vol%) of xenoliths. **C**: modal Cpx vs Cpx/Opx ratio. Line indicates model variation trends induced by 0-18% non-modal fractionation melting in a primitive mantle composition at 4% melting intervals. **D**: Primitive Mantle, PM (Sun and McDonough, 1989) - normalized diagrams for IE of xenoliths (LK and HK), lavas, and glassy drops (av. compositions) and blebs (field of the representative compositions). **E**: ?$^{18}O_{Cpx}$ vs ?$^{18}O_{Ol}$ with regression lines, LK and HK, and ? ?= 0, respectively. **F**: ? $^{18}O_{Cpx-Ol}$ vs isotopic equilibration temperatures, T°C (Kyser et al., 1981); field: Cpx-Ol pairs from South America mantle xenoliths (Kyser, 1990). **G**: Cpx-Ol fractionation as a function of clinopyroxene intracrystalline temperatures (Mercier, 1980); *Ch:* fractionation line (*Ch*) from Chiba et al. (1989).

This suggests a buffering dominated by olivine in the upper mantle, where the equilibration is supported by coherence between observed O-isotope fractionation and clinopyroxene temperatures.

The observed radiogenic isotope trend (Bulk Earth vs Depleted Mantle) is not consistent with major element refractory parameters. A mixing between depleted and enriched components is suggested by isotope records both in clinopyroxenes and on a whole-rock scale (Fig. 3A). The enriched components were mostly trapped in some clinopyroxenes, which had previously crystallized from depleted to quasi-chondritic mantle sources.

On the whole, the isotopic data seem to indicate that the lithospheric mantle prior to the enrichment event(s) was dominated by a depleted component, isotopically resembling MORB sources (cf. Song and Frey, 1989; Comin-Chiaramonti et al., 1997) or even more depleted, probably related to the occurrence of residua which differentiated from ancient events of partial melting.

The Nd-T_{DM} (model ages referred to depleted mantle) of clinopyroxenes and host rocks record, to some extent, earlier fluid-infiltration events. These appear defined between 135 and 1065 Ma (Table 3), with more than 50% model ages spanning the Brasiliano cycle (i.e. 1000-450 Ma, cf. Almeida and Hasui, 1984).

Considering that in the Asunción-Sapucai-Villarrica area the magmatism (Early Cretaceous: tholeiitic and K-alkaline-carbonatitic rocks; Late Cretaceous to Tertiary: Na-alkaline rocks) demands that their parental magmas derived from an heterogeneous subcontinental mantle (garnet peridotite; Comin-Chiaramonti et al., 1997), significant fluids are expected to modify the isotope ratios of the overlaying spinel peridodites.

On this respect, the younger Nd-T_{DM} and the Rb-Sr systematics may reflect the main melting episodes occurring in the mantle regions during the different phases of lithospheric thinning (cf. Comin-Chiaramonti and Gomes, 1996) and repeated interactions between fluids and overlaying peridotites.

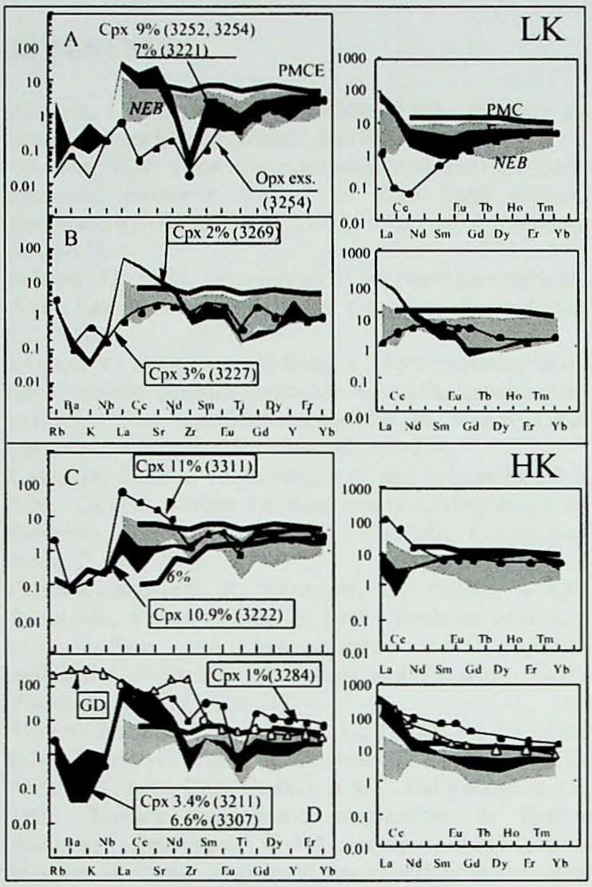

Figure 2. IE and REE of Cpx from Ñemby xenoliths (PM, Hofmann, 1988; chondrites, Boynton, 1984, normalized), following LK and HK typology (panels A and B: LK; panels C and D: HK). Opx, orthopyroxene, GD, glassy drop; PMCE: Cpx trace element composition in primitive mantle (Rivalenti et al., 1996); NEB: Cpx field from NE Brazil protogranular xenoliths (Rivalenti et al., 2000). In panel C the Cpx pattern in the residue from non-modal fractional melting (6%) of PM (Hofmann, 1988) is reported (cf. Johnson et al., 1990; Rivalenti et al., 1996).

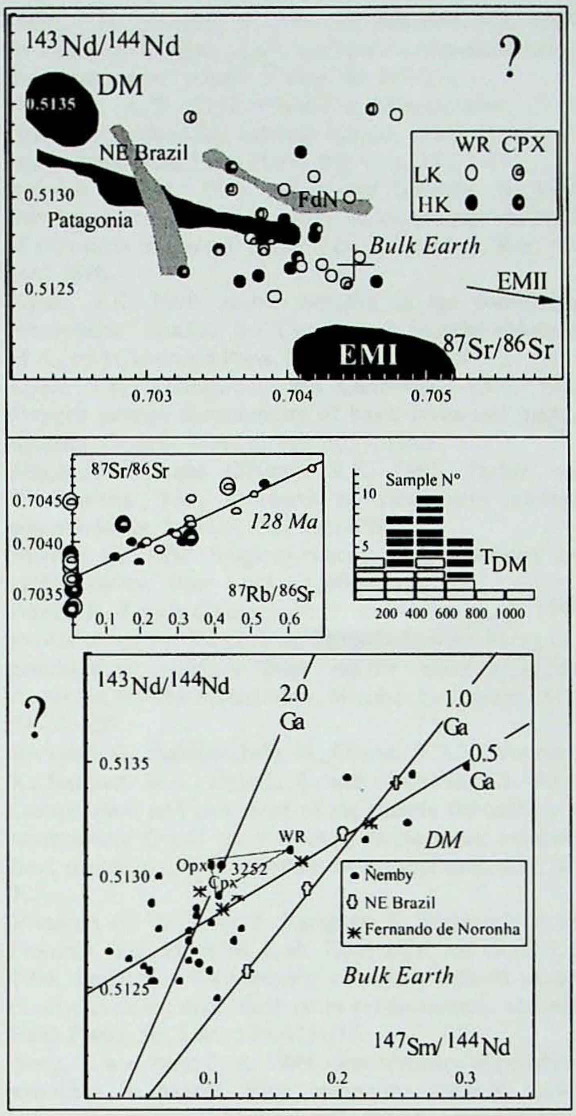

Figure 3. A: $^{87}Sr/^{86}Sr$ vs $^{143}Nd/^{144}Nd$ plot for Ñemby Cpx and host xenoliths; for comparison the compositions of the Cpx from NE Brazil and Fernando de Noronha (Rivalenti et al., 2000), Patagonia (Stern et al., 1989) are also plotted. **B** : $^{147}Sm/^{144}Nd$ vs $^{143}Nd/^{144}Nd$ plot for Ñemby Cpx and xenoliths, 0.5 — 2.0 Ga reference lines, along with NE Brazil and Fernando de Noronha Cpx plots; insets: $^{87}Rb/^{86}Sr$ vs $^{87}Sr/^{86}Sr$ plot and 128 Ma reference line, and T_{DM} model ages.

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