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Metasomatism induced by alkaline magma on upper mantle of the Northern Victoria Land (Antarctica): an experimental approach

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Cenozoic alkali-basaltic volcanics of Mt. Melbourne Volcanic Province (Northern Victoria Land, Antarctica) include mantle xenoliths represented by depleted spinel lherzolites, cumulitic pyroxenites and scarce composite xenoliths. Spinel peridotites and cumulitic pyroxenites often reveal cryptic and modal metasomatism. This is evidenced by pirometamorphic textures of pyroxenes and by the occurrence of pargasitic to kaersutitic amphibole. Chemical and textural features of the xenoliths indicate metasomatic reaction between the mantle rocks and an undersaturated alkaline melt. According to the model proposed by Coltorti et al. (2004) and Perinelli et al. (submitted), the composition of the metasomatic agent closely resemble to rare nephelinitic lavas outcropping in the Mt. Melbourne Volcanic Province.

Based on textural relationships and on the P-T conditions under which metasomatism may have occurred (Perinelli and Armienti, 2002), a number of high P- high T experiments have been programmed in order to understand the mechanisms involved in the metasomatic process. Thus, in the experimental charges a layer of nephelinite was placed in close contact with peridotite or pyroxenite. The experiments were performed in a piston-cylinder apparatus using the graphite-Pt double capsule technique at P=1.0-2.0 GPa and T=1150-1300˚C.

The nephelinite/lherzolite experimental products reveal that nephelinite melted almost completely at P=1.5 GPa (at 1250-1300˚C) whereas lherzolite suffered small degrees of partial melting. In the lherzolitic part of the charges, clinopyroxene (Cpx) increases

its mg# (from 16-17 to 18-26 wt.%), Na_2O (from 0.4-0.7 to 0.8-1.5 wt.%) and Cr_2O_3 (from 0.3-0.8 to 0.9-1.8 wt.%) contents while decreases its CaO content (from 22-23 to 10-17 wt.%) with respect to the original phases. Furthermore, in the experiment performed at P=2.0 GPa the TiO_2 content of Cpx increases from $<$0.1 to 0.4-1.4 wt.%. As regards spinels, their Cr# increase from 0.22-0.30 to 0.52-0.59. These features can be interpreted as the effects of metasomatic reactions occurring between nephelinite-generated melt and the lherzolite. This hypothesis is supported by the presence of melt pockets in lherzolite having chemical composition compatible with their generation for metasomatism caused by Na-alkaline silicate melts.

Concerning the nephelinite/pyroxenite experiments, the P=1.0 GPa and T=1250˚C run shows that the clinopyroxenite undergoes partial melting. At the interface, Cpx is completely exhausted, whereas olivine (Ol) is reabsorbing. Far from the interface, partial melting of clinopyroxenite produces interstitial melt pockets in which secondary Cpx crystallized. These crystals are enriched in TiO_2 (from 0.46-0.67 to 1.3-1.5 wt.%), Al_2O_3 (from 3.9-4.2 to 5.2-7.3 wt.%), FeO (from 5.9-6.0 to 10.0-10.4 wt.%) and Na_2O (from 0.37-0.72 to 1.2-1.6 wt.%) respect to the original Cpx. In the experiments performed at lower T (1150-1200˚C), the reaction between nephelinite and pyroxenite occur in a 200 micron wide region where Cpx from pyroxenite have rims enriched in TiO_2 (up to 2 wt.%), Al_2O_3 (up to 6.9 wt.%), FeO (up to 7.5 wt.%) and Na_2O (1.6 wt.%). Furthermore, Ol displays a decrease of forsterite component (from 81 to 77) at the rims.

In conclusion, data obtaneid from both experimental assemblages display that Cpx is the phase that presents the widest compositional variation. In agreement with the results of Coltorti et al., (2004) the compositional variation of Cpx, as triggered by metasomatic reaction, can be a precursor of amphibole crystallization (in our experiments anyway, amphibole was never found because the high T utilized.).

Coltorti et al., (2004): Lithos,75,115-139.

Perinelli & Armienti, (2002): Workshop “Scienze della Terra in Antartide”, Siena.

Perinelli et al., (2005): submitted to Contrib Mineral Petrol.