Unique phlogopite and amphibole-bearing fluid inclusions in upper mantle xenoliths from Cameroon Volcanic Line

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Introduction

Phlogopite and amphibole play great role in understanding the role of H_2O-bearing CO_2-rich fluids/melts in the lithospheric upper mantle (e.g. Sato et al., 1997). The presence of the H_2O in mantle fluid inclusions (Berkesi et al., 2009) as well as amphibole-and/or phlogopite-bearing ultramafic xenoliths (e.g. Szabó et al., 2009) shed lighten on the importance of understanding the fluid properties in the mantle. We have studied fluid inclusions hosted in upper mantle xenoliths from alkali basalts outcropped at Nyos and Barombi Lakes, which are situated at the Cameroon Volcanic Line (CVL). We found both phlogopite and amphibole (pargasite) within the fluid inclusion, beside the C-O-H-S system providing an insight into the fluid/peridotite reaction.

Ultramafic xenoliths

The studied amphibole-bearing peridotite xenoliths are spinel lherzolites with protogranular and porphyroclastic texture showing lithologies and mineral chemistries similar to the other xenoliths from the continental sector (Lee et al., 1996; Dautria and Girod, 1986) along the CVL, and also to the average sub-continental lithospheric mantle (Downes, 2001).

Petrography of fluid inclusions

Based on fluid inclusion petrography, two main generations of fluid inclusions can be distinguished in the xenoliths as Type 1 and 2 (Fig. 1). Type 1 fluid inclusions can be seen randomly in olivine and orthopyroxene in Nyos peridotites. These fluid inclusions have negative crystal shape with an average size of 50 µm, and they are partially or completely decrepitated. This population of fluid inclusions is considered as older generation fluid inclusions relative to the Type 2 ones, which occur in all the mantle silicates, (including clinopyroxene, orthopyroxene and olivine) in both Barombi and Nyos xenoliths. These inclusions are trapped along healed fractures in sizes of 8 - 30 µm. In the Nyos peridotites, however, they can also be found in neighbourhood of the older decrepitated inclusions. This population of fluid inclusions is considered as younger generation fluid inclusions. They can be divided into two subgroups: generation 2A fluid inclusions showing negative crystal or spherical shapes, and generation 2B fluid inclusions which have irregular, oval or vermicular shape. Solid phases in the younger generation (2A) fluid inclusions were identified under polarized microscope.

Microthermometry and Raman analyses

Microthermometric measurements were carried out only on generation 2A fluid inclusions because they show textural equilibrium with the host silicates in mantle xenoliths. In the generation 2A fluid inclusions for both Barombi and Nyos peridotites similar last melting temperatures were observed. In the Barombi xenoliths melting temperature shows a very narrow range between -57.9 and -56.6 °C, and in the Nyos samples the range is between -58.1 and -56.6 °C. The homogenization temperatures are between -48.2 and -27.8 °C in the Barombi xenoliths and between -50.9 and -30.1 °C in the Nyos xenoliths. Based on the density of CO_2-rich inclusions in ortho- and clinopyroxenes (1.12 - 1.03 g/cm^3), the estimated minimum trapping pressure conditions correspond to a range between 8.4 and 11 kbar (Holloway & Blank, 1981).

Raman analyses were conducted at room and elevated temperatures (+150 °C) after Berkesi et al. (2009). At room temperatures the CO_2, H_2S and small peak of H_2O as a dissolved component in CO_2 were detected, whereas at elevated temperatures, beside the Fermi-diad of CO_2, the peaks of H_2O dissolved in CO_2 were also observed in higher ratio than at room temperature. Presence of H_2S is in good accordance with the distribution of the observed CO_2 melting temperatures. With Raman spectroscopy solid phases were also detectable, which show magnesitic composition (Type 2A).

SR-FTIR on the fluid inclusions

The main advantage of the use of the Fourier Transform Infrared Spectroscopy coupled with Synchrotron Radiation (SR-FTIR) is twofold: 1) enables high resolution (5x5 microns aperture size) mapping of the phases in the mantle fluid inclusions and 2) able to detect OH-bearing, microns sized, solid phases easily. By the use of SR-FTIR we detected and mapped fluid inclusion compositions, especially H_2O next to the major CO_2 (Fig.1). Solid phases were also identified inside the fluid inclusion. Their absorbance characteristics are a combination of both pargasite and phlogopite (Green et al., 2010) in the OH stretching range (Fig.1). It is important to mention that by the use of Raman spectroscopy, the identification of these latter phases is more ambiguous.

Conclusion

Our results suggest that the CO_2-rich fluid inclusions, occurring in both Barombi and Nyos upper mantle xenoliths, trapped at lithospheric mantle condition in the mantle silicates. The application of the infrared spectroscopy coupled to synchrotron radiation is confirmed to be a great tool for mapping the fluid phases and identify OH-bearing solid phases (phlogopite and amphibole), that play a great role in the metasomatized upper mantle.

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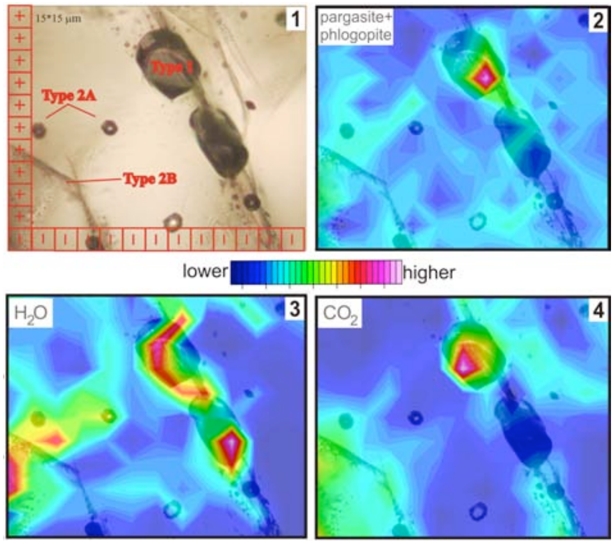

Fig. 1. Orthopyroxene-hosted fluid inclusions (Type 1, 2A and 2B) (1) and the distribution of OH-bearing solid phases (2), H_2O (3) and CO_2 (4) inside the fluid inclusions.

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