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CO_2-rich fluid inclusion study in upper mantle peridotites (Pannonian Basin, western Hungary)

M. Berkesi, K. Hidas, Cs. Szabó

Lithosphere Fluid Research Group, Institute of Geography and Earth Sciences, Eötvös University, Budapest, Hungary (marta.berkesi@gmail.com / Fax: +361 3812212 / Phone: +3612090555ext.8353)

Detailed fluid inclusion study hosted in upper mantle peridotite xenoliths is here presented. The Tihany Maar Complex is the oldest volcano (K/Ar ages: 7.92±0.22 Ma, Balogh & Németh, 2005) of the Bakony-Balaton Highland Volcanic Field (BBHVF) in the central part of the Pannonian Basin (western Hungary). The xenoliths have been brought to surface by Plio-Pleistocene post-extension-related alkali basaltic volcanism, representing the subcontinental lithospheric mantle (Szabó et al., 2004). Peridotites are mostly orthopyroxene-rich harzburgites with poikilitic texture. The modal composition, textural features and major element composition of the silicate minerals suggest that these orthopyroxene-rich rocks were formed through an interaction of SiO_2-rich silicate melt and peridotite wall-rock (Hidas, 2006).

In previously study, using geothermometer based on the orthopyroxene/clinopyroxene equilibrium in the host xenoliths by Brey and Köhler (1990), two domains in the mantle lithosphere beneath Tihany have been distinguished (Hidas, 2006). We applied the given temperature values to be able to estimate pressure, whilst the individual CO_2-rich fluid inclusions, occurring particularly in orthopyroxene and clinopyroxene, have preserved their high density representing minimum trapping conditions in the upper mantle. This is because the fluid inclusions, in equilibrium with their host minerals, can be defined by the intersection of the geotherm with the density of the trapped fluid. Since a precise geobarometer for the spinel peridotites is not available yet, the minimum trapping pressure estimation from CO_2 fluid inclusion densities provides the best method available for pressure estimation for these mantle rocks.

The Tihany orthopyroxene-rich spinel peridotite xenoliths (lherzolites and harzburgites) contain abundant CO_2-rich inclusions. The inclusions are mostly hosted in orthopyroxenes showing two well-defined types: type-1 orthopyroxene-hosted negative crystal shaped inclusions with size up to 70 μm containing one phase (liquid) at ambient conditions, and type-2: orthopyroxene- and olivine-hosted elongated or irregular shaped inclusions with a size varying between 5 and 20 μm. Latter ones contain one (liquid) or two (liquid and vapor) phases at ambient conditions.

The CO_2 fluid inclusions have been studied using heating and cooling stage and Raman microspectroscopy. The microthermometric data suggests that in most cases the fluid phase of the inclusions is pure CO_2 (melting temperature /Tm/ = -56,6 - -56,9 ^oC). Furthermore, type-1 inclusions have higher densities (0.89-1.12 g/cm^3) than type-2 ones (0.5-0.9 g/cm^3) in all xenoliths. Results from microthermometry suggest presence of further fluid phase(s) in those xenoliths, which show values of Tm lower than pure CO_2 ($<$-56,9 ^oC). Raman microspectroscopy confirms that these fluid inclusions also contain H_2S besides CO_2.

For multi-element analysis in situ LA-ICP-MS was used to identify elements associated with the CO_2, fluid inclusions in orthopyroxene. LIL elements such as K, Ba and Rb which are incompatible to the host orthopyroxene were found to be concentrated at the CO_2 inclusions. These results also suggest that the CO_2-rich superdense fluids are important agents for transporting incompatible trace elements in the lithospheric mantle.

References:

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