Characterization of the metasomatizing agent in the upper mantle beneath the northern Pannonian Basin based on Raman imaging, FIB-SEM, and LA-ICP-MS analyses of silicate melt inclusions in spinel peridotite

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Abstract

Silicate melt inclusions (SMI) containing several daughter minerals, residual glass, and a CO₂ bubble were analyzed to constrain the composition and evolution of the metasomatic melt present in the upper mantle beneath the Nógrád-Gömör Volcanic Field (NGVF), northern Hungary to southern Slovakia. The SMI were analyzed with a combination of Raman spectroscopy, FIB-SEM, and LA-ICP-MS to identify phases and obtain their volume proportions and major- and trace-element geochemistry. Slicing through the entire volume of the inclusions and collecting geochemical information at each slice with FIB-SEM allowed us to model the 3D appearance of the phases within the SMI and to use this information to calculate bulk major-element compositions.

The partially crystallized SMI are hosted in clinopyroxene in a lherzolite xenolith that shows evidence of a metasomatic event that altered the lherzolites to produce wehrlites. Based on bulk compositions, the SMI trapped the metasomatic melt linked to wehrlite formation in the NGVF. The melt is enriched in Fe and has an OIB-like trace-element pattern, which suggests an intraplate mafic melt similar to the host basalt, but with slightly different chemistry. Pre-entrapment evolution and reaction with the lherzolite wallrock produced an intermediate melt composition. Petrogenetic modeling indicates that the melt was generated as a result of a very small degree of partial melting of a garnet lherzolite source. Following entrapment, a volatile bubble exsolved from the residual melt during ascent to shallow depths as suggested by consistent densities of CO₂ in vapor bubbles. Small crystals, including sulfates and mica, that formed at the boundary of the bubble and the glass indicate that the exsolved fluid originally contained S and H₂O, in addition to CO₂.

Keywords: Silicate melt inclusions, Raman spectroscopy, FIB-SEM, lithospheric mantle, metasomatism, Pannonian Basin; Applications of Fluid, Mineral, and Melt Inclusions

Introduction

Primary silicate melt inclusions (SMI) hosted by upper mantle minerals have been commonly used to characterize the melts that infiltrate and react with the mantle phases (e.g., Schiano et al. 1992, 2000; Szabó et al. 1996, 2009; Zajacz et al. 2007; Hidas et al. 2010; Duan et al. 2014). The SMI are considered to represent the original melt composition at the time of entrapment at mantle conditions (Schiano et al. 1992, 2000; Frezzotti 2001). The trapped melt droplet remains isolated, i.e., behaves as a closed system and evolves independently from the host (e.g., Roedder 1984) because of the high-elastic modulus of the host minerals that prevent decompression and volumetric changes during and after ascent to the surface (Schiano and Bourdon 1999). However, diffusion into or out of the SMI may still occur to different extents for different elements, depending on the concentrations and diffusion coefficients of the given element in the host mineral. Therefore, in general, the elements most likely to retain their original concentrations in the SMI are those that are least compatible with the host (Qin et al. 1992). Consequently, melt inclusions, if present in great abundance, can be a significant reservoir for incompatible trace elements and volatiles that tend to partition in the melt.

Fluid and silicate melt inclusions are common in peridotite xenoliths of the Carpathian-Pannonian region (CPR) and have been the subject of numerous studies, especially from the Bakony-Balaton Highland (e.g., Török 1995; Szabó et al. 2009; Hidas et al. 2010; Berkesi et al. 2012). The melt inclusions have been interpreted to represent a mafic melt of asthenospheric