Graphite formation from CO_2-rich fluid in metasomatized mantle

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Garnets in ultrahigh-pressure (~4 GPa/1100°C) peridotites and pyroxenites of the Saxothuringian basement in the northwestern Bohemian Massif, enclose multiphase solid inclusions (MSI) which provide evidence for a widespread cryptic metasomatism by silicate-carbonate liquids (Kotková *et al.*, 2021). Mineral assemblages in MSI are dominated by silicates and carbonates and (re)crystallized during exhumation at c. 2 GPa and 1000°C (Haifler *et al.*, this volume). Only about 30% of MSI show decrepitation features, *i.e.*, offshoots and rare haloes of small fluid inclusions. Graphite occurs within the MSI as well as in the offshoots and haloes. Relatively common tiny rounded grains of graphite formed from residual CO_2-rich fluids after crystallization of major phases in MSI (Fig. 1a). Rare, thin graphite films along grain boundaries between pargasite/Ba-mica and carbonate documented by FIB-TEM can be explained by CO_2 reduction at contemporaneous Fe oxidation in the silicate (Fig. 1c). Graphite occurring in offshoots and fluid inclusion haloes in association with magnesite and Ba-mica indicates escape of CO_2-rich fluids from MSI during decrepitation (Fig. 1b). Raman spectroscopy and FIB-TEM study show that the crystallinity of the rounded graphite grains within MSI is generally higher compared with the other two textural types of graphite. Raman spectroscopy-based thermometry (Aoya *et al.*, 2010) for these graphite grains yielded temperatures ranging from 450 to 650°C depending on the sample. On the contrary, graphite in offshoots shows variable degree of crystallinity as well as temperatures (~ 270-550°C). Presence of graphite as well as Raman spectra of Ba-mica and pargasite in MSI with very weak OH bands reflect high CO_2/H_2O ratio in metasomatizing liquid trapped in MSI. Highly refractory graphite enables to retain carbon in the mantle by contrast to carbonates, which easily decompose and liberate CO_2 during exhumation.

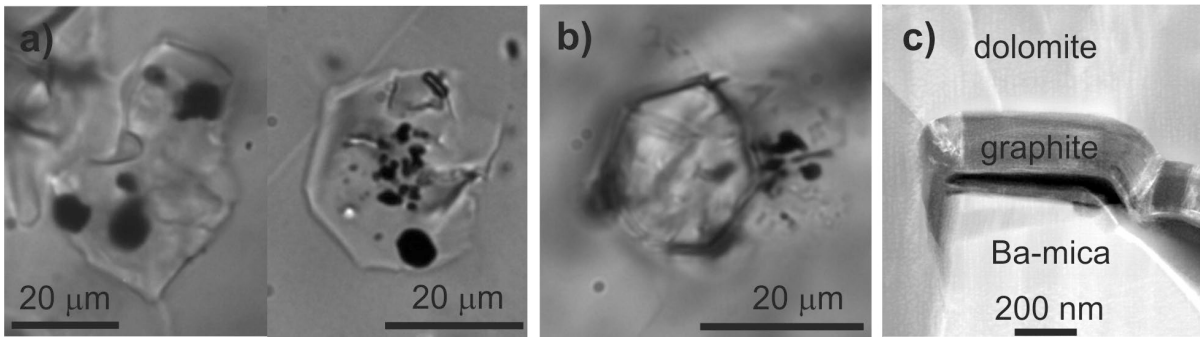

Figure 1- Graphite inclusions in MSI (a) and in decrepitation products (b) under optical microscope and graphite along grain boundary in FIB-TEM (c).

Aoya, M., Kouketsu, Y., Endo, S., Shimizu, H., Mizukami, T., Nakamura, D., Wallis, S., 2010. Extending the applicability of the Raman carbonaceous-material geothermometer using data from contact metamorphic rocks. *J. Metamorphic Geol.* 28, 895-914.

Kotková, J., Čopjaková, R., Škoda, R., 2021. Multiphase solid inclusions reveal the origin and fate of carbonate-silicate melts in metasomatised peridotite. *Lithos* 398, 106309.