Preliminary EBSD analysis and interpretation of Spinel-Olivine-Plagioclase pseudomorphs in skarnoid xenoliths from Southern Slovakia

L. Reato[1], M. Huraiová[1], T. Griffiths[2], G. Habler[2], R. Abart[2], V. Hurai[3], P. Konečný[4]

[1]*Comenius University, Faculty of Natural Sciences, Department of Mineralogy, Petrology and Economic Geology, Ilkovičova 6, 842 15 Bratislava, Slovakia*
[2]*University of Vienna, Department of Lithospheric Research, Josef-Holaubek-Platz 2, 1090, Vienna*
[3]*Slovak Academy of Sciences, Institute of Earth Sciences, Dúbravská Cesta 9, 840 05 Bratislava, Slovakia*
[4]*State Geological Institute of Dionýz Štúr, Department of Special Laboratories, Mlynská Dolina 1,817 04 Bratislava, Slovakia*
e-mail: reato1@uniba.sk

Calc-silicate skarnoid xenoliths, with dimensions of up to 20 cm in diameter, were collected from Pleistocene alkali basalts of Southern Slovakia. Their general mineralogy and petrology have been described in Reato et al. (2022). They are composed of layers of relict augitic diopside, skeletal olivine and interstitial ternary feldspar (An_{57-86}), alternating with layers of anorthite (An_{95-100}) ± high Al, Fe^{3+} clinopyroxenes [$Ca(Al,Fe^{3+})AlSiO_6$] ± melilite inclusions. Such a mineral assemblage is indicative of thermal metamorphism in a high fO_2 environment and can be found in skarn or paralava (Foit et al. 1987; Pascal et al., 2005). Occasional pockets and veins of calcite ± aragonite can be present in both layers. Most of the xenoliths contain pseudomorphs comprising olivine (Ol), spinel (Spl), and ternary feldspar with an integrated average composition resembling tschermakitic amphibole. The pseudomorphs are characterised by very fine grained (1-100 μm^2) skeletal to dendritic olivine and spinel, surrounded by interstitial ternary feldspar. The interstitial ternary feldspar within the pseudomorphs (An_{53-96}) has compositions similar to the one in the diopside + olivine layer (An_{57-86}). A sharp chemical boundary between the pseudomorphs and the anorthite layer is present. The olivine within the pseudomorphs is richer in Mg and has a more restricted composition (Fo_{85-88}) compared to olivine outside the pseudomorphs (Fo_{66-88}), which is characterised by much bigger (>100 μm) crystals, growing perpendicular to the elongation direction of the pseudomorphs.

The sample's lineation and foliation were determined by X-ray micro-computed tomography using an industrial v|tome|x L 240 tomograph from the Institute of Earth Sciences - SAS in Banská Bystrica, and thin sections were cut parallel to the lineation and perpendicular to the foliation. Locations with interesting micro-structural features were selected through transmitted light microscopy. The mineralogy of the selected areas was quantified through EMPA at the State Geological Survey of Slovakia in Bratislava, using a CAMECA SX-100 electron microprobe. EBSD analysis, together with EDS maps, were produced at the Laboratory for Field-Emission Scanning Electron Microscopy and Focused Ion Beam Applications at the University of Vienna, using the FEI QuantaTM 3D FEG instrument. After this, data were re-indexed and processed using EDAX OIM Analysis™ at the University of Vienna, and the Matlab™ toolbox MTEX (Bachmann et al. 2010).

A region containing a pseudomorph at the contact between the anorthite layer and the diopside + olivine layer was selected to determine the microstructural characteristics of the three different domains and their interactions. Both anorthite and ternary feldspar outside the pseudomorph keep the same crystal orientation inside the pseudomorph, despite their change in composition. The grain boundary misorientation angle distribution between olivine and spinel inside the pseudomorph shows a peak at 56°. When only the Spl-Ol boundary segments in the range 55°-57° misorientation angle are considered, a very strong misorientation axis peak, suggestive of a near-specific crystallographic orientation relationship (COR), was observed. This was confirmed by plotting Spl directions with respect to Ol for the selected boundaries, revealing alignment of one of the {111}Spl planes with the (100)Ol plane and one of the {110}Spl planes with (001)Ol, with minor dispersion (generally <5°) around the perfect relationship.

The observed COR between spinel and olivine implies an interaction between the two lattices, most likely during simultaneous growth. Similar plane relationships have been found in experimental petrology studies and were related to the exsolution of spinel from olivine occurring in the mantle transition zone (Hamaya & Akimoto 1982; Green, 1984). However, the xenoliths' protolith was formed and transformed within the crust (Reato et al. 2022), implying a different simultaneous growth process is responsible for the COR in this case. Concerning the behaviour of plagioclase within the pseudomorph, we can conclude that it has likely grown after olivine and spinel, using the plagioclase crystals from outside the pseudomorphs as a template for its growth within them, analogous to the formation of myrmekites (Phillips and Evans, 1980; Yuguchi & Nishiyama 2008). This feature is typical of rapid cooling systems, which is in accordance with the geological context and history of the xenoliths, which are thought to have undergone high-T thermal metamorphism before being collected by the host alkali basalt (Reato et al. 2022).

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