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Submicron scale 3D investigation of kelyphyites after garnet: thermodynamics, crystallographic orientation, microstructure evolution and fluid-rock interactions

Júlia Dégi (1), Kálmán Török (1), Bianca Németh (1), Dieter Rhede (2), Ágnes Takács (3), Gerlinde Habler (4), and Rainer Abart (4)

(1) Geological and Geophysical Institute of Hungary, Budapest, Hungary (julia.degi@gmail.com), (2) Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Potsdam, Germany, (3) Eötvös Loránd University of Sciences, Budapest, Hungary, (4) University of Vienna, Vienna, Austria

Complex kelyphitic rims after garnet were studied in a lower crustal mafic granulite xenolith from the Bakony–Balaton Highland Volcanic Field, W-Hungary. The xenolith is dominated by a garnet granulite mineral assemblage equilibrated at 900 ˚C, 1.4 GPa within the overthickened orogenic root of the Alps. Garnet breakdown was initiated during the extension of the Pannonian Basin and remained continuous until the xenoliths reached the surface. This resulted in the formation of various microstructural domains within the kelyphitic rims which were distinguished to three main types: fine-grained symplectites, recrystallized symplectites and cyrstallized melts. Fine-grained symplectites are the products of isochemical breakdown of garnet to pure anorthite, Al-orthopyroxene and hercynitic spinel. Nanoscale topography built up by curved chains of humps on the garnet surface showing regular spatial distribution is observed at the reaction front in 3D reconstructions. These patterns follow the contours of anorthites nucleating at the reaction front. This suggests that diffusion-controlled material transfer in solid state together with surface energy minimization determines symplectite microstructure. The latter leads to continuous isochemical coarsening getting further from the reaction front.

Slight increase of Na and Ti-content in fine-grained symplectites is associated with sudden changes in 3D microstructure reflecting the effect of aquaeous fluids infiltrating to the reaction rim. A similar aquaeous fluid may have induced the formation of nearly isochemical melting and in situ recrystallization of the symplectites to form recrystallized symplectites. Some of these remained pristine, while some experienced ductile deformation and remelting due to a reaction with an external melt in the lower crust. Well-crystallized melt pockets consisting of complexly zoned pyroxene, spinel and plagioclase grains were formed around 1000 ˚C in this stage.

Following this, interaction with the host basalt took place and resulted in chemical modification of recrystallized symplectites and melt pockets as well and the formation of melt channels at the kelyphite boundaries partly penetrating into the reaction rim. Although orthopyroxene should form during garnet breakdown, according to our EBSD studies, all pyroxenes in the kelyphite have clinoenstatite microstructure. This is explained by the transition of orthopyroxene to protopyroxene above 1100 ˚C due to the heating effect of the host magma, which was followed by protopyroxene to clinopyroxene transition during quenching.