EGU General Assembly 2023

EGU23-9403, updated on 26 Apr 2024
https://doi.org/10.5194/egusphere-egu23-9403
EGU General Assembly 2023

Corona texture: a complex interplay of evolving P-T conditions, equilibration volume and chemical potential landscape

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‘Equilibration volume’ (EV) is the part of a rock volume over which the chemical potential of its components is spatially equivalent and thus the minerals present within that rock volume is presumed to be in equilibrium with each other. With metamorphism, the size of the EV for each component changes spatially and temporally as a function of a number of parameters (e.g. diffusivity of components, temperature, time, presence/absence of fluid/melt, grain size etc.) leading to a continuous evolution of the chemical potential landscape (CPL). The micro-textures present in a metamorphic rock bear the first-hand testimonies of its CPL evolving through time and space. Thus, unless the dynamic evolution of the EV with changing P-T path is taken into account, complete understanding on the generation and preservation of many mineral textures, like corona, may remain elusive.

Here we study a suite of Mg-Al rich ortho-amphibole-cordierite gneiss from the Cauvery Shear System in the Granulitic Terrane of South India. The rock features aluminosilicate porphyroblasts successively surrounded by an inner symplectic corona of sapphirine + cordierite, and an outer mono-mineralic corona of cordierite. Locally, corundum + cordierite grow along the interface of aluminosilicate and the inner symplectic corona. This double corona separates the aluminosilicate grains from a matrix of ortho-amphibole ± quartz. Based on detailed petrography and composition of individual minerals, the following corona-forming reactions were identified:

R1: Ortho-amphibole + aluminosilicate + quartz = cordierite

R2: Ortho-amphibole + aluminosilicate = sapphirine + cordierite

R3: Sapphirine + aluminosilicate = corundum + cordierite

We calculated quantitative petrogenetic grids within the $MgO-Al_2O_3-SiO_2-H_2O$ (MASH) system taking pressure (P), temperature (T), and chemical potential (μ) of multiple diffusive components as variables to constrain the physico-chemical conditions of the corona formation. The results show that the formation of the corona-bearing assemblage in the studied rock occurred in response to decompression (at lower granulite facies conditions) and continuously changing μ_{MgO}-μ_{SiO2} gradients around the primary aluminosilicate crystals. The calculated grid quantitatively

models the evolution path of the CPL for the corona-bearing micro-domain in the P-μ_{MgO}-μ_{SiO2} (isothermal) space. The path demonstrates that during retrogression, a sequential change of equilibrium mineral assemblage occurred through a series of reactions (R1-R3) in response to the continuously changing μ_{MgO}- μ_{SiO2} gradients around the primary aluminosilicate crystals. Those equilibrium assemblages were preserved in typical spatial arrangement in the form of multiple layers of corona due to the progressively shrinking EV around the central aluminosilicate. The path quantifies the formation of corona-bearing assemblage and their typical spatial arrangement as a function of decompression and decreasing mobility of diffusing elements during retrogression.