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Origin of vesuvianite-garnet veins in calc-silicate rocks from part of the Chotanagpur Granite Gneiss Complex, East Indian Shield: The quantitative P-T-X_{CO_2} topology in parts of the system CaO-MgO-Al_2O_3-SiO_2-H_2O-CO_2 (+Fe_2O_3, F)

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ABSTRACT

A calc-silicate rock from part of the Chotanagpur Granite Gneiss Complex, East India, develops veins and patches of vesuvianite (F: 2.3–3.9 apfu, Fe^{3+}: 1.7–2.1 apfu) and garnet ($Gr_{71-80}Alm_{12-17}Adr_{1-9}$) proximal to amphibole-bearing quartzo-feldspathic pegmatitic veins. The host calc-silicate rock exhibits a prominent gneissic banding that is defined by alternate clinopyroxene- and plagioclase-rich layers. The vesuvianite-garnet veins are both parallel and cross-cutting the gneissic banding of the host calc-silicate rock. Two contrasting mineralogical domains that are rich in garnet and vesuvianite, respectively, develop within the vesuvianite-garnet veins. Textural studies support the view that the garnet- and vesuvianite-rich domains preferentially develop in the clinopyroxene- and plagioclase-rich layers of the host calc-silicate rocks, respectively. Some of the vesuvianite-rich domains of the veins develop the assemblage vesuvianite + quartz + calcite + anorthite (as a result of the reaction diopside + quartz + calcite + anorthite = vesuvianite) that was deemed metastable in the commonly used qualitative isobaric T-X_{CO_2} topology in the system CaO-MgO-Al_2O_3-SiO_2-H_2O-CO_2 (CMASV).

Using an internally consistent thermodynamic database, quantitative petrogenetic grids in the P-T and isobaric T-X_{CO_2} spaces have been computed in the CMASV system. The influence of the non-CMASV components (e.g., Na, Fe^{3+}, F) on the CMASV topologies have been discussed using the published a-X relations of the minerals. Our study shows topological inversion in the isobaric T-X_{CO_2} space that primarily depends upon the composition of the vesuvianite. The quantitative CMASV topologies presented in this study successfully explain the stabilities of the natural vesuvianite-bearing assemblages including the paradoxical assemblage vesuvianite + quartz + calcite + anorthite.

Application of the activity-corrected CMASV topology suggests that infiltration of F-bearing oxidizing aqueous fluids into the calc-silicate rocks develop the vesuvianite-garnet veins in the studied area. A genetic link between quartzo-feldspathic pegmatites and the vesuvianite-garnet veins seems plausible.

This study demonstrates controls of topological inversion in the complex natural system, owing to which certain mineral assemblages develop in nature that are otherwise deemed metastable in one set of reaction geometry.

Keywords: Calc-silicate rocks, vesuvianite, CMASV petrogenetic grid, fluorine infiltration, topological inversion