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Petrological Signs of the Fluid Flow in Metamorphic Rocks of the Northern Karelian Greenstone Belt (Eastern Fennoscandia)

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Metasomatic rocks are resulted from the alteration of primary rocks by infiltrating fluid. They can be used for the reconstruction of conditions and features of fluid flow. Such reconstruction should be based on the detailed petrological study of metasomatites.

The Northern Karelian Greenstone Belt (NKGB) is located at western part of the Belomorian Mobile Belt (eastern part of the Fennoscandian Shield). It composed of metavolcanic gneisses and amphibolites. Metasomatites and altered rocks occur there as numerous bodies and zones (width up to 300-400 m). We can divide two main groups of metasomatites: silicificated and basificated rocks. All metasomatite bodies demonstrate distinct mineral zoning. Silicification led to forming aluminous quartzites with kyanite, magnesian staurolite, garnet, and muscovite. These rocks contain assemblages as Qtz+Ky+Grt, Qtz+St(+Ky), Qtz+St+Ts(+Ky), Qtz+St+Ms(+Grt). Silificated rocks, located among gneisses and amphibolites, were formed owing to acid leaching of the host rocks. Basification zones are composed of quartz-free aluminous amphibolites (anthophyllite-tschermakite rocks with staurolite and spinel) and garnet-cummingtonite rocks. Metasomatic bodies have lenticular, sheet, vein, and massive shape. Silification is controlled by vertical shear zones whereas basification zones are located along thrust faults. Metasomatic bodies are situated along the fold axis planes. Veins cut earlier schistosity. Metasomatic rocks have typically porphyroblastic, spotted, cellular, veiny structures which differ strongly from wall rock structures. The intermediate metasomatic zones reveal corrosive relations between minerals, reaction rims and other disequilibrium textures as well as disequilibrium mineral assemblages.

Structural and space features of metasomatites as well as textural evidences indicate that metasomatites formed during the metamorphism (not under pre-metamorphic alteration). Thermobarometry and mineral assemblages display that fluid flow was under near-peak (600-650 C and 7.5-8 kbar) and post-peak conditions. The element mobility during metasomatism can be concluded from the metasomatic zone sequence. During silification Na, Ca and Mg were mobile and removed from altered rocks. Fe and K were partly mobile and then precipitated in late zones. Al and Ti were immobile and accumulated in the internal metasomatic zones. Basification appeared as loss of Si, Na, partly Ca, influx of Mg/Fe, and accumulation of Al and Ti. Analysing the morphology and anatomy of mineral crystals in metasomatic sequence we reveal the evolution of crystallization kinetics. Internal metasomatic zones display advective mass transport the high disequilibrium between parent rock and fluid and. At the same time external zones display a strong diffusional contribution to the mass transport.

The clear structural control of the metasomatism and constitution of mineral crystals display that shear zones and thrusts were good channels for metamorphic fluid. Most intensive fluid flows happened at near-peak conditions. Initial fluids were far from equilibrium that resulted in essential alteration and change of rock composition (especially at silicification).

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