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Metamorphism of garnet amphibolite from the Neldy Formation, Makbal area in the Kyrgyz Northern Tien-Shan, Kyrgyzstan

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The Makbal Complex in the Kyrgyz Northern Tien-Shan is one of several HP/UHP metamorphic complexes in the Tianshan orogenic belt located in the western segment of the CAOB. The metamorphic rocks exposed in the Makbal district are divided into the Akdzhon and the Scharkyrak Groups based on their metamorphic conditions (Tagiri and Bakirov, 1990). The metamorphic sequence of the Akdzhon Group in the Northern Tien-Shan is devided into two contrasting metamorphic formation the structurally lower Makbal Formation and the upper Neldy Formation. The Neldy Formation is mainly composed of pelitic schists (garnet chlorotoid-bearing schist, garnet-phengite schist) and chlorite-carbonate rocks along with minor metaquartzites, marbles and amphibolites. Garnet amphibolites occur in the pelitic schists as lenses or blocks up to 50m across. Eclogites are preserved in the core of the garnet amphibolite bodies (Togonbaeva *et al*., 2010).

The garnet amphibolites are crops out in the Neldy Formation is composed mainly of amphibole (Brs, Mhb, Act, Fprg, Fts, Ts), garnet and chlorite with small amounts of quartz, epidote and albite. Accessory minerals are biotite, paragonite, muscovite, oligioclase, titanite, ilmenite and calcite. A schistosity is defined by preferred orientation of amphibole (Brs, Mhb), chlorite and biotite. The garnets occur as porphyroblasts up to 1.4 mm in diameter, which show distinct compositional zoning, in which X_{Sps} (0.22-0.04) decreases, X_{Alm} (0.34-0.63) and X_{Grs} (0.30-0.64) increase, and slightly increases X_{Prp} (0.01-0.03) from the core to the rim. The core of garnet contains inclusions of epidote, titanite, ilmenite, calcite and quartz. The rim of the garnet contains inclusions of amphibole (Act, Mhb), chlorite (X_{Mg} 0.37-0.42), epidote (X_{Ps} 0.13-0.25), quartz and also contain polyphase inclusions of muscovite + chlorite + epidote and chlorite + paragonite + epidote + olgioclase (An $<$18), although some of them are connected outside with cracks. Box-shaped polyphase inclusions of paragonite+epidote$\pm$chlorite$\pm$muscovite$\pm$oligoclase suggest a possibility of pseudomorphs after lawsonite. Porphyroblastic garnets are sometimes replaced by amphibole (Fprg, Ts), chlorite (X_{Mg} 0.46-0.52) and epidote (X_{Ps} 0.13-0.23) along rim and cracks. Amphiboles in the matrix show a zoning with Mg-hornblende and actinolite (Na_B 0.15-0.48 pfu) core, barroisite (Na_B 0.50-0.63 pfu) mantle, and Mg-hornblende and tschermakite (Na_B 0.18-0.46 pfu) rim. Amphiboles replacing the garnets have a zoning with barroisite (Na_B 0.62-0.65 pfu) core and ferrotschermakite, ferropargasite and Mg-hornblende (Na_B 0.11-0.48 pfu) rim.

Based on the texture and mineral composition, two metamorphic events have been distinguished from the garnet amphibolites. The prograde to peak stage of the first metamorphic event is characterized by core to rim of the porphyroblastic garnets and inclusion minerals therein (i.e. amphibole, epidote, chlorite, biotite, paragonite, titanite, ilmenite, calcite and quartz). The peak metamorphic conditions are probably stable in the epidote-amphibolite facies. The retrograde stage is characterized by chlorite, which replaces the porphyroblastic garnets. The prograde stage of the second metamorphic event is characterized by barroisite core of the amphiboles and epidote replacing the garnets. The peak stage is characterized by fracture connected inclusions of muscovite and oligoclase and tschermakite and ferropargasitic amphibole developed at the rim of the amphiboles replacing the garnets, probably suffered amphibolite facies metamorphic conditions. The retrograde stage is characterized by albite and quartz in the matrix.

The petrological study suggests that the garnet amphibolites probably suffered metamorphism events of (i) high-pressure epidote amphibolite facies and (ii) amphibolite facies. These metamorphic events are related to the tectonics of the oceanic plate subduction and subsequent continental collision.

キーワード: Garnet amphibolite, Makbal Complex, Neldy Formation, amphibolite facies, Kyrgyz Northern Tien-Shan
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