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Mineral indicators of high-grade Alpine metamorphism in Mesta and Slashten lithotectonic units, Western Rhodopes

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Introduction

Equilibrium mineral assemblages of metacarbonates and amphibolites from two lithotectonic units in the Western Rhodopes are defined to obtain data about the P-T metamorphic conditions. This study emphasizes the role of coexisting metamorphic minerals as an useful criteria for P-T determination for terrains, where no geothermobarometric data exists.

Geological setting

Three lithotectonic units in a superposition build up the metamorphic section in the Western Rhodopes (Sarov et al., 2008), divided by shear zones as a result of Late Alpine synmetamorphic thrusting. Mesta lithotectonic unit (MLU) is considered as the lowermost part of the section. Metamorphic rocks are dominated by biotite or two-mica orthogneisses and marbles. Carbonate-silicate schists and amphibolites are scarce. The rocks of the unit are strongly mylonitized, concordantly intruded by granite sills of Dolno Dryanovo pluton. Mesta shear zone restricts the unit with the upper Slashten unit (SLU) that consists of parametamorphic rocks (marbles, carbonate-silicate rocks, gneisses, kyanite- and garnet-bearing schists), orthoamphibolites, associating with small lenticular ultramafic bodies and orthogneisses. Sarnitsa lithotectonic unit is the uppermost in the metamorphic section in Western Rhodopes. All three units are attached to the regional-scale Sideronero-Mesta unit (Georgiev et al., 2010).

Field relationships and petrography

Investigated area covers rocks from MLU and north outcrops of SLU, exposed as a thin sheet to the north of Gotse Delchev–Satovcha road. Thin sections of amphibolites and metacarbonates have been chosen for this study, because they are more sensitive to the metamorphic changes than the wide spread quartz-feldspar orthogneisses.

Amphibolites are widespread in SLU, where a big massive metaophiolitic body is exposed. Thin layered amphibolites and Bt-Hb schists alternate together with felsic and metacarbonate rocks in the northern part of the unit, while only separate bands and lenses in MLU are observed. Despite their disposition, rocks of both units show similarity. Amphibolites from the metaophiolitic body are bended and strongly mylonitizated in the Mesta shear zone. Typically these rocks display granoblastic to nemato-granoblastic fabrics, layered in dark bands of hornblende and thinner and lighter bands, composed of plagioclase, epidote, quartz and hornblende. Apatite, rutile, opaques, titanite and zircon are observed as accessories. Plagioclase (oligoclase–andesine) forms small mosaic grains or poikiloblasts with elongate to the main foliation inclusions or even micro-sized bends of fine epidote and hornblende. Intergrowth with quartz relicts of previous plagioclase is common. The amount of epidote shows significant variations. Chlorite and fine grained quartz fill later fractures.

Thin layered amphibolites from other localities differ in their composition and rock-forming mineral proportions. Generally amphibolites are well foliated, fine grained, dark, free of felsic bands, and dominated by needle shaped hornblende. Plagioclase decreases, but preserved the same characteristics as mentioned above. Epidote is rare or absent. Titanite is well presented, while rutile is scarce. Biotite and potassium feldspar also could appear.

Metacarbonates from the MLU and SLU vary from pure marbles to carbonate-silicates schists with less than 50% of calcite. In the northern part of SLU these rocks alternate with two-mica gneisses, schists and amphibolites. Carbonate-silicate rocks are characterized by a weakly foliated granoblastic fabric, which is dominated by coarse grained clinopyroxene (pale green diopside), followed in modal abundance by amphibole (hornblende and/or actinolite) and anomalous blue epidote group minerals (including zoisite). This mineral assemblage coexists with irregular amounts of calcite, quartz, plagioclase, microcline, titanite ±biotite, ±phlogopite(?). Dynamically recrystallized quartz often forms ribbons, parallel to the main foliation. Pure marbles are mid- to coarse grained with isolated lenses of polygonal high limpid calcite and minor mica (phlogopite?). Low-temperature mylonites of impure marbles contain small rounded clasts of quartz, epidote, microcline, tremolite and hornblende, floating in a fine grained calcite matrix.

Pure white marbles, containing also minor graphite, quartz, phlogopite(?) and diopside are dominant metacarbonates in MLU. Grain size depends on strain rates, so calcite is mostly slightly elongated, with irregular boundaries. Direct contacts with granites from Dolno Dryanovo pluton caused growing in calcite size. Silicate minerals from impure marbles and carbonate-silicate schists are presented by hypidioblastic diopside, plagioclase, quartz, microcline, titanite, ±mica, ±tremolite, ±zoisite. Well marked foliation is defined by elongate mineral phases and quartz ribbons. Vesuvianite is rare and elongated to the foliation, while scapolite grows in thin mylonite zones probably caused by fluid infiltration. Relicts of previous plagioclase-quartz intergrowths are observed too. Well marked foliation is defined by elongate mineral phases and quartz ribbons. Diopside is partially overgrown by tremolite or altered by fine sheet silicates and calcite.

Discussion and conclusions

The equilibrium mineral composition, determined for amphibolites from both lithotectonic units is Hb + Pl + Qtz ± Ep. Mineral assamblage represents a prograde regional metamorphic event in the field where epidote is still stable (up to 600 °C). Kyanite bearing schists from the southern part of SLU predict prograde path of metamorphism in the Ky stability field (P≥4.5 kbar).

Mineral paragenesis in metacarbonates reflects differences at initial rock compositions within the both units and presumes metasomatic reactions, caused by unsteady fluid rock infiltration, connected with open paths for fluids after mylonitization, followed by concordant intrusion of granites. Mineral equilibrium for SLU is defined by Cal + Di + Hb + Qtz + Pl + Ep + Tit. For MLU Cal + Di + Qtz + Pl + Tit ± Ep ± Tr represent a stable mineral assemblage. Few points are significant for determination of metamorphic conditions. Dol + Cal + Di ± Fo paragenesis is typical for the middle-temperature part of amphibolite facies. Higher-temperature phases as wollastonite (Wo) or forsterite (Fo) were not identified in the investigated rocks. If the system is low-magnesium (CAFSCH) and Fo do not appear, the T peak of metamorphic conditions is limited by Wo-producing reactions in the diopside stability field. The presence of zoisite is an indicator for a H_2O-rich fluid composition during metamorphism (Storre, Nitsch, 1972). Hydrous phases (amphibole and epidote) are stable at temperatures lower than 600 °C if H_2O is introduced in the system (Rios et al., 2008), which corresponds to the above information.

According to obtained data we suggest a single clockwise metamorphic event in the low-temperature part of amphibolite facies for metacarbonates and amphibolites from MLU and SLU. Mineral assemblages restrict the metamorphic peak conditions between 550–600 °C in the stability field of kyanite.

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