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Metaeclogites from the Sredna Gora terrain – petrological features and P-T path of evolution

Philip Machev[1], Borjana Borisova[1], Lutz Hecht[2]

[1] "St. Kliment Ohridski" University, Sofia; E-mail: machev@gea.uni-sofia.bg; borri@abv.bg
[2] Museum für Naturkunde, Humboldt University, Berlin; E-mail: Lutz.Hecht@museum.hu-berlin.de

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Introduction

One of the main problems in understanding the thermomechanical evolution of mountain belts is to constrain the uplift history of high-pressure metamorphic rocks such as eclogites. Therefore, the study on eclogites from collision zones of fold areas represents one of the main ways of investigating tectonic events in deep settings. In this respect, the area of the Sredna Gora Mountain belongs to the Sredna Gora tectonic zone, a part of the Intermediade Balkanides (Ivanov, 1998). The pre-Mesozoic basement of this zone is built up of high-grade metamorphic rocks — migmatites of mainly granitic origin, ortho- and paraamphibolites, metapelites. Rare lenses of serpentinized ultramaphic rocks are observed, too. Large bodies of undeformed granitoids are intruded in these rocks and thus crosscut the metamorphic fabrics. The age of the protolithes of the high-grade metamorphites is 616-595 Ma (Carrigan et al., 2006) as they were metamorphosed under high-temperature amphibolite facies conditions 336-305 Ma ago (Velichkova et al., 2001; Carrigan et al., 2006). The mentioned granitic rocks have relatively younger but close ages: 303.5±3.3 Ma for the Hisar pluton; 312.0±5.4 Ma for the Koprivstiza pluton; 289.5±7.8 Ma for the Strelcha pluton and 304.1±5.5 Ma for the Smilovene pluton (Carrigan et al., 2005). According to Velichkova et al. (2001), the rocks from the pre-Mesozoic basement of the Sredna Gora zone underwent retrograde metamorphic changes before 120-78 Ma.

Petrology

The metaeclogites from the Sredna Gora tectonic zone (Ihtiman tectonic Unit in the sense of Ivanov, 1998) were described for the thirst time by Dimitrova and Belmustakova (1982). Since then they have remained somewhat aside of the attention of geologists. The aim of this study is to present new data about the petrology, geochemistry and P-T evolution of these rocks. The metaeclogites crop out in the northern slope of the peak of Eledjik and they occur as small isolated bodies enclosed in amphibolites, two-mica schists, migmatized gneisses and small serpentinized ultramafic bodies associated with them. The petrological investigations enable to distinguish two equilibrium mineral associations in the metaeclogites — high-pressure (HP) association: (Grt+CPx(Omp)+Zo+Rt) and middle pressure - middle temperature association (MP/MT) presented by Amp+Pl+Qzt+Ep+Ilm+Ti.

Garnet commonly forms idioblastic porphyroblasts (0.5-2.3 mm in diameter) and sometimes comprises up to 40 % of the rock volume. The cores of the porphyroblasts are usually rich in inclusions (rutile and amphibole). In the partly replaced metaeclogites the garnet porphyroblasts are surrounded by thin halo of blue-green amphibole (fig. 1). The extended retrograde changes caused total replacement of the garnet by fine-grained aggregates of Amp+Ep+Qtz+Pl. The garnets from the studied metaeclogites show typically prograde zonation (Pyr

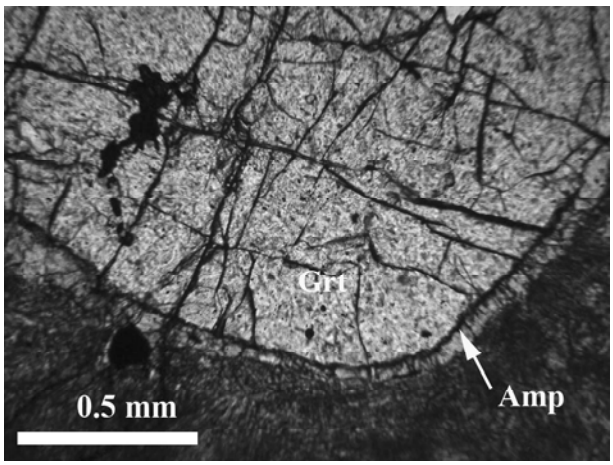

Fig. 1. Garnet porphyroblast (Grt) surrounded by a thin halo of blue-green amphibole (Amp)

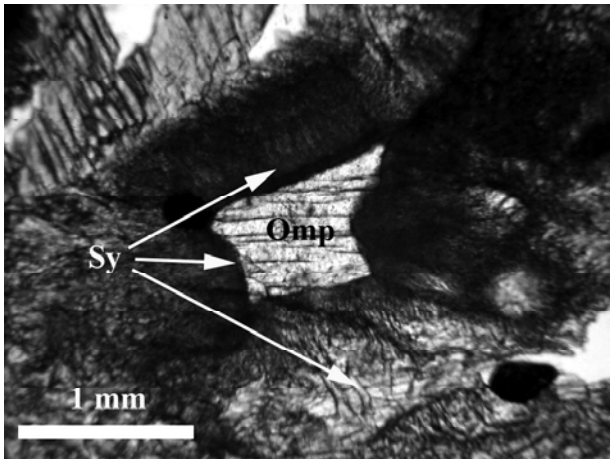

Fig.2. Relics of omphacite (Omp) replaced by pyroxene+plagioclase symplectites (Sy)

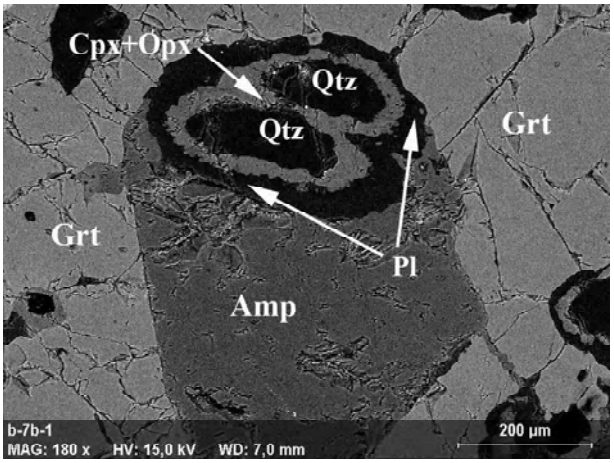

Fig. 3. BSE image of Amp+Pl+Opx+Cpx+Pl inclusion in garnet (Grt) porphyroblast

increases, Grs and Spes decrease from core to rim). The Fe content is relatively constant or shows poorly developed prograde zonation. Mn enrichment in the rim areas is observed, too.

Clinopyroxene (Omp) is observed in the matrix of the rocks being partly or comletely replaced by symplectitic intergrowths of clinopyroxene+plagioclase (fig. 2). Microprobe analyses yield omphacites with jadeite contents ranging from 20.88-51.89 mole %. There are two morphological types of symplectites around the omphacite crystals. The first type is represented by fine-grained thin symplectite, developed immediately along the border of the omphacite crystal. Further away from the crystal rim the symplectite becomes coarser making the second type. We suggest that the symplectite formation took place after the model proposed by Joanny et al. (1999) and is related to temperature and pressure decreasing. The pyroxene in the symplectites is enriched in Jd (14.68-29.31%) as a result from omphacite breakdown under relatively high pressure. There are no compositional diferenses between the pyroxenes from the fine-grained and the coarser symplectites.

Rutile is observed as inclusions in the garnet porphyroblasts or as fragments that are partly replaced by ilmenite and titanite.

The retrograde mineral assemblage is represented by amphibole, plagioclase, quartz and epidote.

The amphibole content increases proportionally to the degree of retrograde changes in the metaeclogites. This mineral forms a thin halo (blue-green in color and with pargasitic composition) around the garnet porphyroblasts (fig.1) or comprises more that 50 % of the rock in the completely retrograde replaced metaeclogites. In the second case the amphibole forms large porphyroblasts with symplectitic intergrowths with plagioclase and has composition of edenite-magnesiohornblende with transition to actinolite. Occasionally the central parts of these crystals are brownish in color (ferropargasite) and the rims are blue-green. The amphibole inclusions in the garnet porphyroblasts are pargasite but they have the highest $Mg/(Mg+Fe^{2+})$ ratio (0.74-0.86). In this case they are associated with Pl (albite-oligoclase) + Qtz + Cpx (diopside-augite) + Opx (clinoenstatite) (fig. 3). We interpret this association as breakdown product from the former magmatic assemblage of the rocks.

Minerals of the epidote group. Zoisite from the HP assemblage forms porphyroblasts with X_{Czo}= 0.903-0.983. The retrograde minerals of the epidote group are observed only in the completely amphibolized metaeclogites and are represented by two different morphological types. The first one is found as large resorbed porphyroblasts (X_{Ep}=0.37-0.36) surrounded by amphibole. The second type is represented by small idioblastic porphyroblasts (X_{Ep}=0.27-0.36) filled with xenoblasic inclusions of plagioclase, which look like symplectitic intergrowths. In this case the adjacent plagioclase grains are filled with quartz inclusions, too.

The plagioclase from both the matrix and the plagioclase-amphibole intergrowths is relatively enriched in An (An_{27-40}) compared with those from the symplectites (An_{6-32}).

The metaeclogites from the Ihtiman Sredna Gora have mainly basaltic composition. There are no significant differences in the chemical composition between the metaeclogites with symplectites and the completely amphibolized rocks. Only the K_2O+Na_2O contents are relatively lower in the latter. The studied rocks have distinct tholeiitic composition (fig.4) with the completely amphibolized metaeclogites being relatively enriched on MgO. On the Ti_2O-Zr discriminant diagram (Pearce, 1982) they plot in the field of the MOR basalts.

The estimated P-T conditions of HP metamorphism are in the range 16.25-20.2 kbar (using the

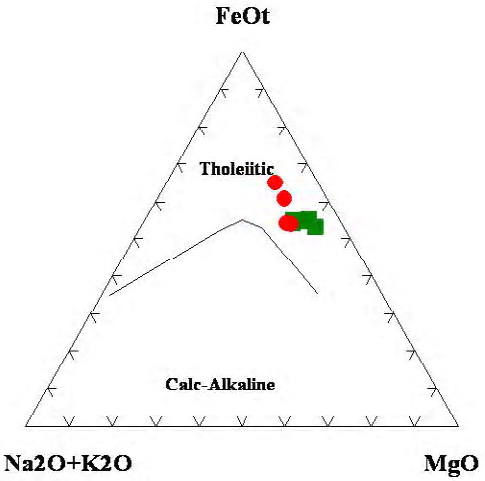

Fig. 4. Tholeiitic vs. Ca-alcaline series discrimination diagram (Irvine and Baragar, 1971). Filled circles — completely amphibolized metaeclogites without omphacite; Filled squares — metaeclogites with omphacite and symplectites.

geobarometer of Holland (1983). The P values are determined for the 650-750 °C temperature interval, because the pyroxene-plagioclase symplectite (omphacite breakdown) forms above 550±50 °C (Joanny et al., 1991), i.e. the temperature of the eclogite facies was higher. The temperature of the HP metamorphism is 650-690 °C (Grt-Px thermometer of Ellis and Green (1979). This range is obtained by using garnet rim-omphacite pairs. By using garnet core-omphacite pairs the obtained temperature is lower - 560-580 °C. Our data are comparable to these of Mukasa et al. (2003) which point to 630 °C. The P-T conditions of the retrograde amphibolite facies metamorphism are in the range 620-650 °C (Amp-Pl thermometer of Blundy and Holland, 1990) and 6-8 kbar (Al-barometer of Johnson and Rutherford, 1989).

The estimated P-T conditions of the metamorphis, together with the type of the metamorphism of the host rocks, allow suggesting that the metaeclogites from the Ihtiman Sredna Gora belong to the low-temperature type of eclogites in the sense of Bucher and Frey (1994). The HP metamorphism was followed by nearly isothermal decompression and metamorphism under amphibolite facies conditions. The omphacite breakdown occurred at relatively high pressure (11-14 kbar, calculated on the basis of high Na content in the symplectitic pyroxenes).

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Метаеклогити от Средна гора – петроложки особености и P-T ход на еволюция

Филип Мачев, Боряна Борисова, Лутц Хехт

Резюме. Амфиболитизираните в различна степен метаеклогити в Ихтиманска Средна гора са установени за първи път от Димитрова и Белмустакова (1982). Предмет на насоящето изследване са метеклогитите, разкриващи се под формата на малки изолирани тела сред амфиболити, биотитови и двуслюдени шисти, мигматизирани гнайси и асоцииращи с тях серпентинизирани ултрамафити по северния склон на вр. Еледжик в района на х. Шиндар.

Установени са два равновесни минерални състава:

1) Високобаричен (HP) — гранат (често с корона от синьозелен амфибол)+омфацит (винаги със симплектитова обвивка от моноклинен пироксен и плагиоклаз)+цоизит+рутил и

2) Умеренобаричен (MT/MP) — амфибол+плагиоклаз+епидот-клиноцоизит+кварц+илменит +титанит.

Протолитите на метаеклогитите са субалкални базични магматични скали с подчертан толеитов тренд на диференциация. Геохимичните им особености показват сродство с базалтите от СОХ (MORB) и островно-дъговите толеити. P-T условията на метаморфизма в еклогитов фациес са в рамките на 650—670°C и P 16—20 kbar. По своите характеристики метаеклогитите от Ихтиманска Средна гора може да бъдат отнесени към нискотемпературните еклогити в мисъла на Bucher & Frey (1994).