P-T EVOLUTION OF THE METAPELITES FROM THE WESTERN SLOPE OF THE PIRIN MOUNTAIN

Philip Machev[1], Lutz Hecht[2], Laslo Klain[1], Vladimir Atanasov[1]

[1] Faculty of Geology & Geography, "St. Kliment Ohridski" University; e-mail: machev@gea.uni-sofia.bg
[2] Museum für Naturkunde, Humboldt University, Berlin; e-mail: Lutz.Hecht@museum.hu-berlin.de

Key words: metapelites, Rhodope massif, P-T evolution, zoned garnets

Introduction

The metamorphic rocks from the western slope of the Pirin Mountain are traditionally interpreted as a part of the metamorphic rocks from the Rhodope massif (Zagorchev et. al., 1971; Zidarov et. al., 1971; Zagorchev, Dinkova, 1991 etc.). They were considered as high-grade rocks of Precambrian age and were subdivided into lithostratigraphic units identical with those from the Central Rhodopes (Zagorchev, Dinkova, 1991 etc.). The high-grade metamorphic rocks from the western side of the Strymon valley are traditionally assigned either to the Serbo-Macedonian Massif (Kockel, Walther, 1965; Bonchev, 1971 etc.), or to the Rhodope massif (Ograzdenian Supergroup; Zagorchev, Dinkova, 1991). The new data show that the Rhodope and Serbo-Macedonian provinces of southern Bulgaria and northeastern Greece comprise a structurally complicated domain of tectonically intercalated high- and low-grade metamorphic rocks and igneous bodies. The two parts of this domain (Rhodope and Serbo-Macedonian) are separated by a brittle low-angle southwest dipping thrust fault, called the "Strimonüberschiebung" (Kockel, Walther, 1965). A recent geological mapping has established that the "Strimonüberschiebung" is not a thrust, but a major Neogene low-angle normal fault, called the Strymon Valley detachment fault. It accommodates the unroofing of the Rhodope core complex and eventually its subaerial exposure between the Strymon and Nestos rivers (Dinter, Royden, 1993; Burg et al., 1996; Ivanov, 1998). According to this concept, the rocks of the Serbo-Macedonian massif build up the hanging wall of the fault. They were separated as Upper terrain by Burg et al. (1996). Ivanov (1998) and Machev & Veit (2001) presented evidence that parts of the hanging wall of the Strymon detachment cover the metamorphic rocks on the western slope of the Pirin Mountain. The aim of this study is to compare the P-T evolution of the metapelites from the hanging wall with the ones from the underlying metamorphic rocks in the Pirin Mountain. Attention is also focused on the zoned garnet porphyroblasts.

Petrology of the metapelites from the hanging wall of the Strymon detachment fault (HWMP)

These rocks crop out in the valley of Sandanska Bistritza River, east of the town of Sandanski. Together with different type of gneisses, rare marble layers and lenses of ultramafic rocks they present the host rocks of large metagabbro bodies (Machev, Veit, 2001). Two equilibrium assemblages can be distinguished in these metapelites – I –garnet + staurolite + kyanite + quartz and II – biotite + white mica (muscovite) + andalusite + chlorite + quartz. All minerals from the first assemblage are resorbed and replaced by "secondary" minerals: the coarse garnet porphyroblasts - mainly by biotite or by chlorite + white mica (sericite) aggregates (Fig. 1); kyanite - by undistinguishable under polarized microscope fine-grained aggregates and staurolite - by sericite. Typical for the HWMP are biotite + fibrolite intergrowths and fibrolite formation around the andalusite porphyroblasts. These fabrics are observed only in strongly deformed parts of the metapelites.

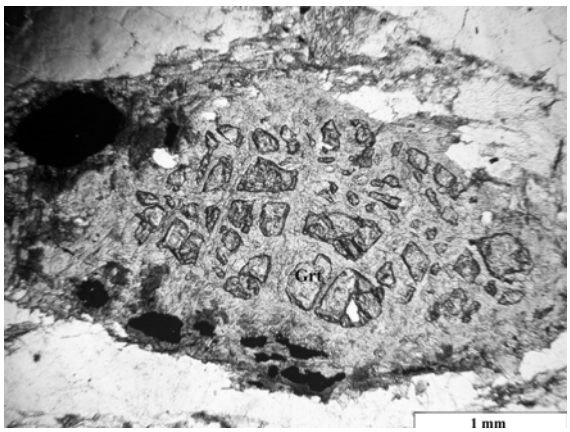

Fig. 1. Garnet porphyroblast replaced by chlorite and sericite in the HWMP.

The aim of this study is to examine the type of zoning in the fine (<1 mm) garnet porphyroblasts. The reason for studying zoned crystals is that they presumably hold the key to understand the chemical reaction history of a rock and hence its P-T evolution. All investigated grains have retrograde type of zoning (Alm, Sps and Fe/Fe+Mg) ratio increase from core to rim and Pyr decrease in this direction) (Fig. 2a). We interpret this fact as typical diffusion, retrograde zoning. It is well known (Spear, 1993) that diffusion by cooling and exhumation of rocks could affect and change the garnet composition in very narrow zones (≈1 mm). Because the investigated garnets are smaller their cores were affected by diffusion, too.

Petrology of metapelites from the Pirin Mountain (PMMP)

These metapelites crop out as layers in association with different types of gneisses, marbles and amphibolites. The equilibrium assemblage is represented by garnet + biotite + white mica (muscovite) + staurolite + kyanite + quartz ± plagioclase ± fibrolite. Only chlorite is observed as replacement product after biotite. The garnets from the PMMP (independent of grain size) have typical prograde diffusion zoning (Fig. 2b). They have flat pattern of homogeneous garnet with reverse zoning only in the outermost rim. In this area the Sps and Alm increase, whereas the Pyr decrease as a result of cooling by the rock exhumation. This type of zoning is common for garnets of high-grade metamorphic rocks (amphibolite facies). The established zoning of the garnets from PMMP contradicts the zoning of garnets from the Lower Tectonic Unit in Greece (Mposkos, Liati, 1993), which show a distinctly pronounced increase of Alm and Pyr, and decrease of Sps and Gros from core to rim. The investigated garnets from PMMP are similar to the ones from the Upper Tectonic Unit in Northern Greece. The biotites in the rock matrix have X_{Fe} = 0.47-0.50 and the biotite inclusions in garnet have 0.31-0.39 (hence, they are richer in Mg). The composition of biotite inclusions may be a result from exchange reactions between garnet and biotite, or it reflects the biotite composition at the temperature peak of metamorphism.

Conclusion

It is very difficult to determine the P-T conditions of the metamorphism of the HWMP, because the conventional geothermo-barometers are inapplicable (most minerals are in disequilibrium). Therefore, we used the X_{Fe} isopleths on the P-T grid of Spear (1993) (only data from the core composition of small garners were used). The estimated P-T values (650°C and 10 kbars) are the lowest for the formation of the first equilibrium assemblage. For the PMMP we obtained 610-640° C by 6 kbar (Grt-Bt thermometer of Ferry & Spear, 1978). We believe that this temperature is close to the temperature peak of metamorphism of PMMP. Prior to the metamorphism of PMMP, the HWMP and associated rocks were thrusted over the Pirin Mountain during the collisional stage of evolution of the Rhodope massif, i.e. they were earlier metamorphosed. The prograde Alpine metamorphism of PMMP was retrograde for the HWMP. It caused retrograde replacement of the minerals from the first equilibrium assemblage and retrograde diffusion zoning in the small garnets. Because the HWMP overlie the PMMP, the pressure of the retrograde metamorphism was lower (in the stability field of andalusite).

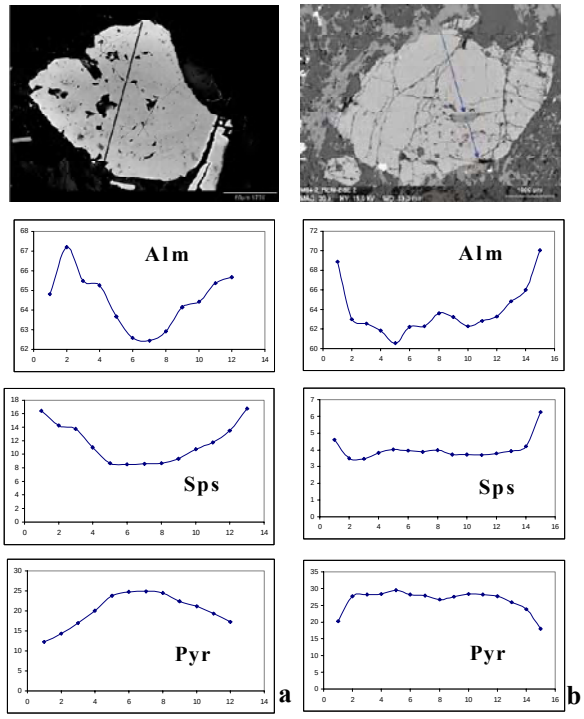

Fig. 2. (a)BSE image of small garnet porphyroblast from the HWMP and Alm, Sps and Pyr distribution along the traverse line; b) the same in garnet porphyroblast from the PMMP.

The obtained results show that the rocks east of the town of Sandanski have not been a part of the Rhodope massif. They have undergone different P-T evolution and we agree with the opinion of Ivanov (1998), that the rocks from the hanging wall of the Strymon detachment fault (Serbo-Macedonian massif or Upper terrain after Burg et. al., 1996) are part from the Sredna Gora metamorphic rocks (Paleozoic age of metamorphism).

References

Bonchev, Ek. 1971. *Problems of Tectonics of Bulgaria*. Sofia, Technika, 203 p. (In Bulgarian).

Burg, J.-P., Z. Ivanov, L. Ricou, D. Dimov, L. Klain. 1996. Synmetamorphic nappe complex in the Rhodope massif: structure and kinematics. – *Terra Nova, 8*, 6-15.

Dinter, D. A., L. Royden. 1993. Late Cenozoic extension in northeastern Greece: Strymon Valley detachment and Rhodope metamorphic core complex. – *Geology, 21*, 45-48.

Ferry, J., F. Spear. 1978. Experimental calibration of the partitioning of Fe and g between biotite and garnet. – *Contr. Mineral., Petrol., 66*, 113-117.

Ivanov. Z. 1998. (in press) *Tectonic of Bulgaria*. Sofia, Ed. Sofia Univ., 634 p., (in Bulgarian).

Kockel, F., H. W. Walther. 1965. Die Strimonlinie als Grenze zwischen Serbo-Mazedonischen und Rila-Rhodope-Massiv in Ost-Mazedonien. – *Geol. Jahrb., 83*, 575-602.

Machev, Ph., B, Veit. 2001. Metamorphosed basic rocks from the Western slope of Pirin Mountain (Serbo-Mazedonian massif) – tectonic setting and metamorphic history. – *Ann.Univ. Sofia, Fac. Geol. -Geogr., 94*, vol. 1- geol., 135-153.

Mposkos, E., A. Liati. 1993. Metamorphic evolution of metapelites in the high-pressure terrane of the Rhodope zone, Northern Greece. – *Can. Mineral., 31*, 401-424.

Spear., F. 1993. *Metamorphic Phase Equlibria and Pressure-temperature-time Path*. Mineral. Soc. of Amer., Monograph, 799 p.

Zagorchev, I., J. Dinkova. 1991. *Geological Map of Bulgaria*, 1:100 000 (Petrich, Strumiza, Gevgeli, Siderokastron) (in Bulgarian).

Zagorchev, I., N. Zidarov, Il. Iliev, Iv. Slavov, Ior. Sabatov. 1971. On the tectonics of the Pirin horst. – *Jhb. Staat. Wirtschaftsvereinigung "Geol, Erkun."*, *20*, 227-260. (in Bulgarian).

Zidarov, N., I. Zagorchev, Iv. Slavov, I. Sabatov, St. Nedjalkova, V. Toprakcieva, L. Katseva, J. Vodenicarov, J. Geceva, A. Simeonov. 1971. Notes on the metamorphic rocks of Pirin Mountain. – *Jhb. Staat. Wirtschaftsvereinigung "Geol. Erkun.", 20*, 261-278 (in Bulgarian).

P-T ЕВОЛЮЦИЯ НА МЕТАПЕЛИТИТЕ ОТ ЗАПАДНИЯ СКЛОН НА ПИРИН

Филип Мачев[1], Луц Хехт[2], Ласло Клайн[1], Владимир Атанасов[1]

Метаморфните скали от западния склон на Пирин винаги са били сравнявани с разреза на метаморфитите в Централните Родопи и към тях е прилагана същата схема за литостратиграфска подялба. Получените през последните десетина години нови данни показаха, че една част от тези скали имат алхтонно положение т.е. те са част от висящото крило на Струмския разлом на отделяне. В традиционните схващанаия те са отнасяни към т.н. Сръбско-Македонски масив или към Огражденската супергрупа на Родопския масив.

Обект на настоящото изследване са метапелитите от висящото крило на Струмския разлом на отделяне (HWMP) и лежащото му крило (PMMP). За първите са установени два равновесни състава – I –транат + ставролит + кианит + кварц и II – биотит + бяла слюда (мусковит) + андалузит + хлорит + кварц. Всички минерали от първата асоциация са интензивно променени и заместени от тези от втората. Характерна особеност на тези метапелити е фибролитизацията на биотита и образуването на фибролит около андалузитовите порфиробласти. Тъй като едрите гранатови порфиробласти са интензивно резорбирани вниманието бе насочено към дребните (< 1 mm в диаметър). Те показват типична регресивна дифузионна зоналност – намаляване на Pyr компонент от центъра към периферията и увеличаване на Alm и Sps компоненти в същата посока. В PMMP е установен само един равновесен състав – гранат + битит + бяла слюда (мусковит) + ставролит + кианит + каварц ± плагиоклаз ± фибролит. Гранатите от тези скали (без значение на големината им) показват типична проградна дифузионна зоналност (платовидно разпределение на Alm, Pyr и Sps в централните части на кристала и увеличение на Alm и Sps е нямяляване на Pyr в най-външните зони). Такъв тип зоналност се образува при ексхумацията и охлаждането на метаморфозирани при сравнително висока температура (амфиболитов фациес) скали.

Минималната температура, при която е образувана първата равновесна асоциация ва HWMP приемаме 650°C и 10 kbar налягане, определени по X_{Fe} изоплетите на петрогенетичната мрежа за метапелити. За PMMP е получена минимална температура 610-640°C при 6 kbar налягане.

Получените резултати ни дават основание да заключим че HWMP и асоцииращите с тях скали са били навлечени върху Пирин по време на колизионния етап от развитие на Родопския масив като вече метаморфозирани скали. Проградният метаморфизъм на PMMP се е явил ретрограден за тях и тъй като те са лежали по-високо в разреза, измененията в тях са се осъществявали в полето на стабилност на андалузита. Нашите изследвания подкрепят идеята на Ivanov (1998), че скалите от висящото крило на Струмския разлом на отделяне (Сръбско-Македонски масив) са част от Средногорските метаморфити (с палеозойска възраст на метаморфизма), навлечени върху Родопския масив.