Fluid enhanced metamorphic transformations of granitoid rocks into orthoschists, East Rhodopes

Превръщане на гранитоиди в ортошисти при метаморфизъм, благоприятстван от флуиди (Източни Родопи)

Lyubomira Macheva, Valentin Ganev
Любомира Мачева, Валентин Ганев

Institute of of Mineralogy and Crystallography, Bulgarian Academy of Science, 1113 Sofia, Acad. G. Bonchev Str., Bl. 107;
E-mail: lu_macheva@dir.bg; valganev@dir.bg

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Introduction

The circulation of fluids through shear zones is an important factor influencing both the deformation and the associated changes in rock chemistry. Shear zones characterized by intense fluid-rock interaction typically show significant variations in mineral composition and intense chemical transformations of the whole-rock chemistry, which could be compared with those in metasomatic processes. On the contrary, Kerrich et al. (1980) noted the fact, that in the absence of substantial involvement of fluid transport in the system during metamorphism, the deformation could be considered as an isocheimal process and may be accompanied by minor changes in the chemistry of the rock.

This study focuses on the integrated field, microstructural, and geochemical peculiarities of the deformation of metagranitoids within a middle-crustal shear zone in East Rhodopes and their transformation into aluminous schists.

Geological setting and field observations

The studied rocks, cropping out in the most southeastern part of Bulgaria are referred to the lowermost tectonic unit of the metamorphic complex in East Rhodopes – the Byala Reka Tectonic Unit. Hercynian in age metaaluminous to peraluminous porphyritic and equigranular metagranitoids constitute the main part of the unit. These rocks have undergone complicated metamorphic history changing from HP/LT to MP/MT, and finally to LP/LT conditions accompanied by heterogeneous deformation preserving lenses of weakly deformed metagranitoids within more widely distributed mylonitised varieties. In the southern and central part of the unit metagranitoids form a huge body, and in the northern part, between the villages of Konnitsi and Popsko, they are observed as numerous lenticular bodies situated within garnet-bearing two mica schists and gneiss-schists. Mylonite and ultramylonite bands lying parallel to the regional foliation are common in metagranitoids from this area. The relationships between the metagranitoids and two mica gneiss-schists are highly varied, with numerous repeated alternations strongly resembling parametamorphic or volcanogenic-sedimentary terrain. This gave the basis of all previous authors to assume their metasedimentary origin. Our field and mainly microscopic investigations allow us to consider these rocks as orthoschists, which were derived at the expense of fluid-assisted transformation of metagranitoids in an open system, causing total recrystallization and deep change in the rock chemistry on wide areas. Field evidence for this assumption are: 1) the existence of numerous inclusions of these rocks in the metagranitoids and vice versa; 2) the recognition of gradational transitions between metagranitoids and mica schists occurring within narrow shear zones; 3) the existence of numerous deformed pegmatite and aplite veins within the schists; 4) the existence of microgranular melanonocratic enclaves in gneiss-schists strongly resembling enclaves found in metagranitoids. Nevertheless, the main arguments about orthometamorphic origin of these schists and gneiss-schists come from microstructural investigations.

Microstructural and mineralogical features of orthoschists

Typically, orthoschists are coarse grained mica-rich meso- to melanocratic gneisses to gneiss-schists composed of white mica, biotite, plagioclase (An_{5-20}) porphyroblasts, garnet porphyroblasts reaching up to 1 cm, quartz, and staurolite. Accessory minerals are zircon, apatite, rutile, and ilmenite. The texture of the rocks is blastomylonitic to mylonitic. Microscopically, between metagranitoids and orthoschists was observed a great variety of microstructural transitions which, according to their increasing degree of transformation could be denoted respectively as protoblastomylonites, blastomylonites, and ultrablastomylonites. The first ones contain relict potassium feldspar porphyroclasts side by side with garnet porphyroblasts and increasing quantity of phyllosilicates. In the blastomylonites all potassium feldspar porphyroclasts are completely obliterated and replaced by white mica and clear albite porphyroblasts, which, however, preserve inherited deformation-induced myrmekite intergrowths, developed at the most strained sites of the former potassium feldspar. Albite porphyroblasts are full of small, worm-like quartz rods, which according to Ashworth (1986) could be formed by retrograde metamorphism at the expense of former more basic plagioclase. Staurolite and tourmaline porphyroblasts are also present.

Ultrablastomylonites (true orthoschists) show a thin banded texture and are composed mainly of phyllosilicates, garnet, and quartz, while feldspars are rare. Hence, the formation of aligned mica-defined foliation weakens the tectonites and further promotes their transformation.

Whole-rock chemistry

Major and trace element compositions of whole-rock samples were analyzed on fusion glass tablets by XRF with a SIEMENS SRS at the Müseum für Naturkunde, Berlin and by LA-ICP-MS technique on the PE ELAN DRC-e quadrupole mass spectrometer at the Geological Institute of the BAS, Sofia.

Mass, volume, and compositional changes accompanying deformation were evaluated using the isocon method of Grant (1986). In all isocon plots of the studied rocks Al, Ti, Mg, Zr, and Hf, show a coherent behavior. These elements are considered to be almost immobile in the present case. A significant volume change during alteration has caused relative enrichment of rare earth elements, Sc, Cr, V, Ni, Zn, Cu, Nd, and Yb. There is depletion on K_2O, Th, Rb, Ba, and Sr, which is in accordance with the breakdown of feldspars and its release.

In addition, the zircon morphology from the schists studied strongly resembles that of the zircons from the neighboring metagranitoids. Zircons with a well-preserved crystal forms, identical with that of zircons from metagranitoids, are common.

Summary and conclusions

Our investigations show that the studied schist and gneiss-schists are derived at the expense of ductile heterogenous deformation of granitoid rocks. The deformation promote considerable mobility of the fluid phase favoring recrystallization accompanied by deep transformation of the rock chemistry as well as material transport to a great distances. Thereby, the process could lead to completely recrystallized rocks, mesoscopically with appearance typical for the mica schists and passing gradually into augen gneisses. The metamorphic differentiation in many cases is so intense that the rocks acquire the appearance of banded migmatites and the concentration of some inert components such as Al, Ti, Fe, and Mg leads to the formation of aluminum-rich micaceous rocks. Changes of the rocks are carried out in a ductile shear zone under conditions of decreasing temperature and hydration.

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