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GNEISSES OF TEKIJA REGION, NE SERBIA

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ABSTRACT

The paper presents the results of the research of gneisses of the region of Tekija with the objective, to characterize the type of the protoliths and the metamorphic evolution, based on the fabric of rocks and mineral transformations in them.

INTRODUCTION

The investigated gneisses belong to the region of Tekija located in Northeast Serbia, namely the eastern slopes of the mountain Miroč.

The first data on the geological structure of the studied area were given by M. Žujović (1893) and S. Urošević (1908) who mention different sorts of schists in this region. A. Grubić (1962) classified crystalline schists into the amphibolite facies with characteristic minerals: hornblende, muscovite, garnet, staurolite and kyanite. The data on the mineral composition of Tekija, Sip, and Brza Palanka rocks were given by V. Aleksić and M. Kalenić (1977) who claim that mineral associations correspond to the amphibolite facies of the regional thermo-dynamic metamorphism of Barrow type, i.e. the continental metamorphism of kyanite-sillimanite type, of

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medium P - medium T, with superimposed metamorphism of low P-high T. In the short review of the metamorphic processes of Old-Baikal cycle, V. Aleksić and M. Kalenić (1977) report: "Crystalline schists of the Moesian and Kučaj - Homolje metamorphic belt of Old-Baikal cycle originated from shallow-water psammite-pelite sediments deposited in the broad (Pangeosynclinal) area at the southern boundary of the Karelian Europe. Considering the rare occurrence of basic magmatites, we cannot refer with confidence to the type of crust in the base of Old-Baikal products. The processes of kratonization, i.e. sial mobilization, occurred in several phases:

a) in the first phase, Na-Ca mobilization (plagiogranitization) took place in the conditions of kyanite-sillimanite metamorphism, i.e. thermo-dynamic metamorphism Barrow's type. Then the products of amphibolite facies medium P - medium T were created, with the characteristic zones: sillimanite (?) - kyanite-staurolite-garnet-biotite zone;

b) in the second phase, granitization was manifested - the occurrence of augen, amygdaloidal, and other types of migmatite gneisses, as well as the occurrence of granitoids, which in late kinematic events obtain the gneiss-like appearance;

c) in the late kinematics, there occur aplitoid granitoids which in the form of veins cut across the already migmatized rocks."

In the separation of units within Carpato-Balkanides, B.Sikošek and B. Maksimović (1965) consider the Tekija crystalline as Getikum, and M. Andjelković and P. Nikolić (1974) as Djerdap Nappe.

PETROGRAPHY

In the Tekija crystalline there are mica schists, gneiss-mica schists, gneisses, quartzites, amphibolites and amphibolitic schists. As the aim of the study was to characterize the type of the protoliths and the metamorphic evolution in the studied area, based on the fabric of rocks and mineral transformations in them, the paper shows fine augen gneisses, porphyroblastic plagioclase gneisses, augen gneisses and fine-grained mica gneisses with characteristic blasts of plagioclases.

Fine augen gneisses are some of the most interesting rocks of the Tekija crystalline. They occur in the central parts of the complex, and they are characterized by a fine augen texture, relicts of blasto-psammite structure (Fig.2) and by the phenomena of recrystallization.

In fine-augen gneisses, the augen are polymineralic (made of very fine-grained plagioclase and quartz), or monomineralic (quartz or K-feldspar) with dimensions reaching 2.4mm x 2mm. In the interstices of the "eyes" weakly oriented flakes of biotite, needles of sillimanite and a few grains of quartz, garnet, plagioclase, and metallic mineral appear. Together with these minerals sericite, and in some varieties muscovite, appear (whereas sillimanite disappears and sericite is gradually reduced) and rarely, kyanite occurs in addition (in the absence of sillimanite and sericite).

Quartz occurs in the augen in monomineralic aggregates (relicts of quartzite from original sandstones) or aggregates with plagioclase, but in the form of individual grains. When it is in monomineralic aggregates, it very often intergrows mosaically, and its blasts are coarser (ca 0. 2 mm x 0.3 mm) than the blasts of quartz which occurs in augen aggregates with plagioclase, where it is very fine-grained (0.02 mm x 0.02 mm) and allotriomorphic.

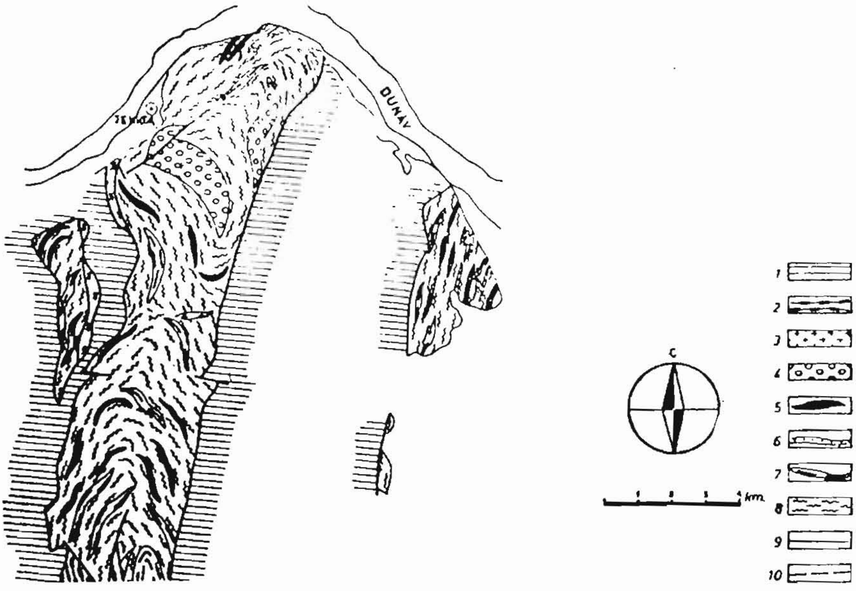

Figure 1.

Geologic map of schists of Tekija and Sip (B.Marković et al., 1973/74; and P.Bogdanović, 1973; composed by M.Kalenić and V. Aleksić). Legend: 1.Mesozoic sediments;2.Chlorite schists, phyllites and metasandstones;3.Granites.4.Migmatite gneisses; 5.Amphybolites and amphybolite schists;6.Quartzites;7.Mica-schists;8.Plagioclase gneisses and gneiss-micaschists; 9.Fault;10.Supposed fault.

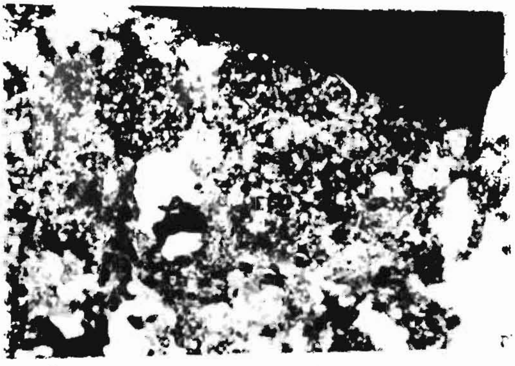

Figure 2.

Photomicrograph of relicts of blastopsammite structure. a.Quartz-feldspar aggregates. b.Quartz aggregates.Crossed polarizers.Magnified 25 x.

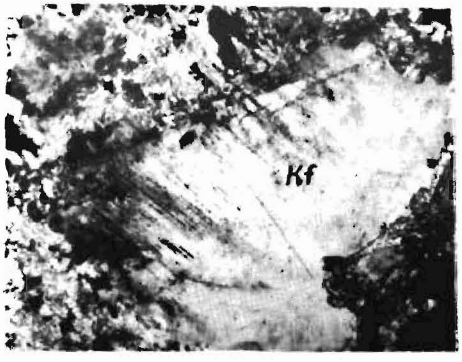

Figure 3.

Photomicrograph of K-feldspar porphyroblasts (fine-grained gneiss) Crossed polarizers.Magnified 25 x.

K-feldspar occurs in various amounts (frequently it is absent or reduced to a minimum), as homogeneous or partly homogeneous grains of different size. Coarser grains are ca 2 mm x 1.2 mm. According to optical measurements, the angle of optical axes ranges from -71° to -80°. Very rarely in sericite aggregates which occur locally in K-feldspar(Fig.3), fine needles of sillimanite also appear.

In the river Kosovica the distribution of fine-augen gneisses is small, and they are characterized by a considerable content of younger K-feldspar, which are vein type. As for the variety occurring in the watershed of the Veliki Potok, the primary K-feldspar is often absent (due to intense alteration).

Plagioclase occurs in augen together with quartz (rock relicts from sandstones). It forms quite fine (0.02 mm x 0.02 mm), allotriomorphic blasts which are clear and untwinned.

It was observed that crystallinity gradually increases in some varieties of these rocks, namely the size of quartz blasts and of feldspar in quartz-feldspar augen (Fig.4) increases. Simultaneously, sillimanite disappeared and fine folia of muscovite appeared.

In recrystallized augen, plagioclases and quartz range in dimensions to 0.15 mm x 0.15 mm, although in different varieties of these rocks there are all the grades in grain sizes between 0.02 mm x 0.02 mm and 0.15 mm x 0.15 mm. It is important to note that each rock variety is always distinguished by uniform sizes of quartz and plagioclase blasts in the augen.

Optical characteristics indicate that in the recrystallized augen, the acid plagioclase contains up to An_{15}.

In the varieties of fine-augen gneisses with intensively recrystallized quartz - feldspar augen, partial cumulative

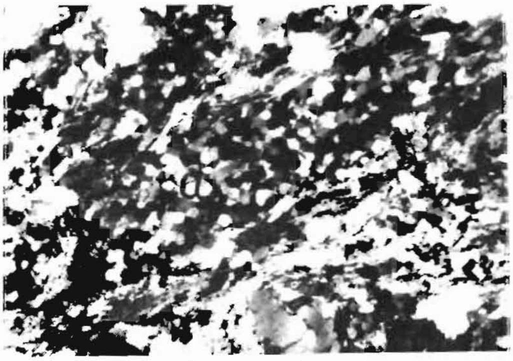

Figure 1.

Photomicrograph of increased crystallinity of quartz and feldspar in augen. a.Fine-augen gneiss. Crossed polarizers. Magnified 25 x.

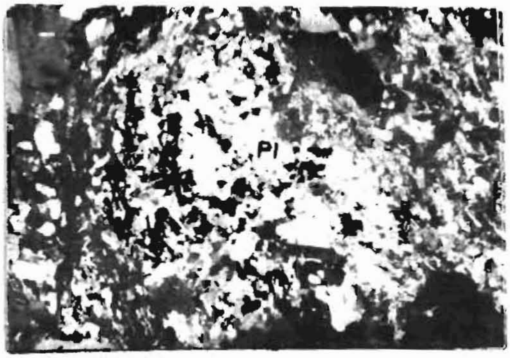

Figure 5.

Photomicrograph of the initial phase of plagioclase porphyro- blasts creation (Pl). Fine-augen gneiss. Crossed polarizers. Magnified 25 x.

Figure 6.

Photomicrograph of plagioclase porphyroblasts (detail). Augen gneiss. Crossed polarizers. Magnified 25 x.

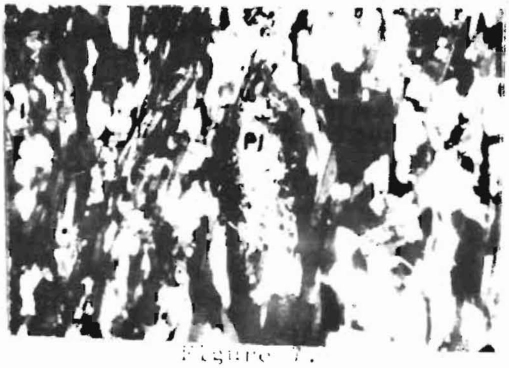

Figure 7.

Photomicrograph of characteristic plagioclase blast (Pl). Mica gneiss with characteristic plagioclase blasts.Crossed polarizers. Magnified 25 x.

crystallization in the augen occurs very rarely which represents the initial phase in the formation of future porphyroblastic plagioclase gneisses (Fig. 5).

Biotite occurs in the form of fine flakes sized 0.3 mm x 0.1 mm. It is weakly oriented and (together with sillimanite, quartz and garnet) it fills the interstices of the augen. It was observed very rarely also in recrystallized quartz feldspar augen or in sericitic aggregates.

It is characteristic that biotite reaches its quantitative maximum in the varieties of fine-augen gneisses in which quartz and plagioclase blasts in quartz-feldspar augen are the smallest and where the participation of sillimanite is the greatest.

Sillimanite shows positive elongation and occurs:

- in the form of smaller, fine-acicular, monomineralic aggregates;
- together with sericite in K-feldspar;
- in the central parts of sericite aggregates which resemble the coarser grains of K-feldspar; and
- in aggregates with biotite and garnet between the augen.

Garnet occurs in the form of quite small blasts together with biotite.

Sericite is concentrated in aggregates (where it is sometimes with relict sillimanite, or very rarely with biotite) occurring in the rock mass between the augen, or they occur locally in K-feldspar.

By the extinction of sillimanite and by the increase of blast sizes in quartz-feldspar augen, sericite grades into fine-foliated muscovite, which is evidently the consequence of a new, prograde phase of metamorphism.

Muscovite occurs in fine-augen gneisses with recrystallized quartz-feldspar augen. It occurs in nodular, fine-plated aggregates (in which also fine kyanite is rarely observed), rarely in fine folia in recrystallized quartz-feldspar augen and, finally, with biotite in the interstices of the augen.

Kyanite occurs in those varieties of fine augen gneisses where muscovite appears instead of sericite. It occurs in fine blasts with the angle of optical axes $2V = -81^\circ$ and the angle of darkening $Ng:c = 5^\circ$.

Based on the successive occurrences of different varieties of these rocks which represent evolutionary stages of their transformation, and on account of the relicts of blasto - psamm i te structure and mineral transformations, it can be concluded that they derived by the metamorphism of graywackes and conglomeratic sandstones, and that they were subjected to polymetamorphism.

Original sandstones contained fragments of rocks (which were transformed by metamorphism into quartz and quartz-feldspar augen), K-feldspar, and quartz and they were bonded by clayey cementing material. At places where K-feldspar was kaolinized in the original sandstones, and where the potassium component was leached, at high temperatures and pressures, fine acicular sillimanite was formed. During in the subsequent retrograde changes, sillimanite was replaced by sericite, so that today primary sillimanite needles are rarely observed in sericite aggregates which occur locally in K-feldspar. In the new prograde stage of metamorphism, sillimanite disappears, sericite is replaced by muscovite, kyanite appears and also cumulative crystallization in quartz-feldspar augen which represents the initial phase in the formation of porphyroblastic plagioclase gneisses.

Porphyroblastic plagioclase gneisses have schistose texture and porphyroblastic structure. They are characterized by the association: quartz-plagioclase±microcline-biotite-muscovite-garnet and, in the form of porphyroblasts, plagioclase from An_9 to An_{18} reaching ca 2 mm x 3 mm in size, and quartz..

Augen gneisses are of augen texture and porphyroblastic structure. The augen are with dimensions reaching 1.2 cm x 1.2 cm and are made of coarse porphyroblasts of plagioclase from An_{10} to An_{20} (Fig.6) and quartz. They consist of plagioclases, quartz, sometimes microcline, muscovite, biotite and garnet which are sometimes accompanied by kyanite or staurolite.

Fine-grained mica gneisses with characteristic blasts of plagioclases were not distinguished as a special type of gneisses based on common petrologic criteria. The following criteria were taken into consideration for their distinction: the characteristic blasts of plagioclases (Fig.7) showing all the features of plagioclase porphyroblasts of the previously described rocks. Their texture is schistose and the dominant structure is lepidoblastic. They are characterized by the association quartz - plagioclase (An_9 to An_{15}) - biotite-muscovite -garnet±microcline.

CHARACTERISTICS OF AUGEN GNEISSES, PORPHYROBLASTIC PLAGIOCLASE GNEISSES AND FINE-GRAINED MICA GNEISSES WITH CHARACTERISTIC BLASTS OF PLAGIOCLASE

Starting from the augen gneisses and porphyroblastic plagioclase gneisses, to fine-grained mica gneisses with characteristic blasts of plagioclases, it can be observed:

- that porphyroblasts and characteristic blasts of plagioclases are untwinned or polysynthetically twinned and that they contain numerous inclusions of fine grains of quartz and sometimes garnet and fine flakes of muscovite and biotite, so that at places it appears also as diablastic intergrowth;

- that microcline is formed after the phase of cataclasis of these rocks and that it occurs only locally /according to M. Kalenić and V. Aleksić (1977) "microclinization accompanied by the processes of granitization is a subsequent process"/;

- that microcline is concentrated in the veinlets or that it occurs as "patches" in the porphyroblasts of plagioclases (metasomatic replacement);

- that microcline of the gneisses at the northern part of the studied area has mainly the grid twinning, whereas the microcline observed in the southern part of the terrain is always homogeneous, which can be an indication of two-stage formation of microcline;

- that biotite usually predominates over muscovite and that it occurs (usually together with muscovite) in bands alternating with quartz-feldspar, or as aureoles around porphyroblasts and blasts of plagioclases;

- that muscovite often occurs in the form of mono-mineral aggregates which look like transformed K-feldspars from original sedimentary rocks;

-that staurolite is present only in some varieties of augen-gneisses and that it occurs in the form of porphyroblasts of characteristic pleochroism in honey-yellow shades (optic axial angle $2V = +82^0$);

-that kyanite occurs rarely in some augen-gneisses and that it occurs in the form of blasts, with the optic axial angle $2V = -82^0$ and the angle of darkening $Ng:c = 6^o$.

- locally the rocks are cataclased and retrogradely metamorphosed, with chlorite, sericite and minerals from epidote group as retrograde products.

CHARACTER OF PROTOLITHS

Augen-gneisses, porphyroblastic plagioclase gneisses, fine augen-gneisses and fine-grained mica gneisses with characteristic blasts of plagioclases must be genetically associated, as in the field (going from the southern towards the northern part), there is a good succession of these rocks, as well as the absence of indications of the introduction of components in the phase of their creation. Based on the field and microscopic investigations, it can be concluded that augen gneisses probably represent the final products of metamorphism of original conglomerates, the porphyroblastic plagioclase gneisses are the products of the metamorphism of conglomeratic sandstones, fine-augen gneisses are the products of the metamorphism of conglomeratic sandstones and graywackes, and the fine-grained gneisses with characteristic blasts of plagioclases are the products of metamorphism of fine-grained sandstones with the presence of rock fragments.

METAMORPHIC EPISODES

Burial of this sedimentary succession into deeper parts of the earth's crust under medium pressure and high temperature conditions, augen-gneisses with sillimanite were formed (and with the mineral association quartz-plagioclase- K-feldspar-biotite-sillimanite-garnet) which today represent metastable relicts in the investigated crystalline.

The absence of the coexistence of muscovite and quartz, the presence of sillimanite (instead of kyanite and muscovite) and biotite indicate that the primary prograde metamorphism must have taken place under high temperatures and medium pressures, namely in the conditions of lower-temperature part of the sillimanite-almandine-orthoclase subfacies of the almandine-amphibolite facies of Barrow type metamorphism (Winkler, 1967). This means that the temperature must have been 650° C, and the pressure higher than 6 kbar, accompanied by a relatively dry system, because in the opposite case, with a small quantity of water, metamorphism would proceed under lower temperatures.

Fine-augen gneisses with sillimanite occur at places in the central part of the complex, where also high-temperature amphibolites appear, but such a high degree of metamorphism should characterize the whole complex.

After this metamorphic stage, a phase of retrograde metamorphism followed which is recorded in fine -augen gneisses with sillimanite. In this stage of metamorphism (which must have been short, as it did not succeed to overprint completely the primary assemblages) under conditions of lower temperatures and pressures and the action of solutions (primarily water), the existing mineral paragenesis became unstable and was replaced by new minerals. Sillimanite graded into sericite, and then, in the following phase of the prograde metamorphism, sericite graded into muscovite and feldspar-quartz augen were transformed into porphyroblasts of acid plagioclases, and quartz augen into quartz porphyroblasts. In the third phase of metamorphism, augen-porphyroblastic plagioclase gneisses and fine-grained mica gneisses with characteristic blasts of plagioclases were developed as the metamorphic products of augen sillimanite gneisses (which do not exist nowadays, but whose augen, by their fabric and composition, must have been similar to the augen of fine-augen gneisses), fine-augen gneisses and fine-grained sillimanite gneisses in which there must have existed the aggregates of fine-grained feldspar and quartz.

Inte r pre t ation of the fabric of augen and porphyroblastic plagioclase gneisses, as well as fine-grained mica gneisses with characteristic blasts of plagioclases indicate preexistence of the primary sedimentary series to form these rocks, i.e. in the composition and fabric of the conglomerates, conglomeratic sandstones, graywackes and fine-grained sandstones in which, by the processes of polymetamorphism, some fragments of rocks, by their transformation "in situ", developed into augen, porphyroblasts and blasts.

In the third phase of metamorphism, the diagnostic minerals are staurolite, kyanite and almandine. Such a metamorphosed series corresponds to the medium stage of metamorphism (Winkler,1976), i.e. to the temperature and pressure which were lower than the temperature and pressure in the sillimanite-almandine - orthoclase subfacies of the almandine - amphibolite facies of Barrow type metamorphism (Winkler, 1967).

The ivestigated rocks belong to Carpato-Balkanides, i.e. the metamorphic belt continuing through Romania, but not in Greece, still they represent the wider Aegean area. Polymetamorphism is possible almost in all old metamorphic areas, so this paper is a contribution to the solution of this problem, especially in the metamorphic areas of Southern Carpathians.

CONCLUSION

The paper presents the results of the research of the gneisses of Tekija region in the aim to characterize the type of protoliths and the metamorphic evolution, based on the composition and fabric of the rocks, as well as on the mineral relationships.Based on the results of the research of gneisses, it can be concluded that they developed by polymetamorphism probably of conglomerates, conglomeratic sandstones, graywackes and fine-grained sandstones in which there still existed some fine fragments of rocks. The interpretation of the fabric of augen and porphyroblastic plagioclase gneisses, as well as fine-grained mica gneisses with characteristic blasts of plagioclases, indicates also the preexistence of a sedimentary series which formed these rocks, i.e. the fabric and composition of conglomerates, conglomeratic sandstones, graywackes and fine-grained sandstones in which, by processes of polymorphism, the fragments of rocks, by their transformation "in situ" developed into augen, porphyroblasts and blasts. The first stage of metamorphism took place under conditions of the sillimanite-almandine-orthoclase subfacies of the almandine-amphibolite facies of Barrow type metamorphism (Winkler, 1967); the second phase was of retrograde character (occurrence of sericite and disappearance of sillimanite) and it must have been short, because it did not obliterate completely the differences in the degree of metamorphism, whereas the third phase (occurrence of staurolite and kyanite) corresponds to the conditions of the medium pressure and temperature of metamorphism (Winkler, 1976), i.e. the temperature and pressure were lower than the temperature and pressure in the conditions of sillimanite - almandine - orthoclase subfacies of the almandine - amphibolite facies of Barrow type metamorphism (Winkler,1967).

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