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Study of Plagioclasic Metamorphic Rocks from Western Part of Neamţu Crystalline Unit from Valea Satului (Almăj Mountains)

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Abstract

The dioritic igneous intrusion developed between the Corbu phyllites unit and the Neamţu unit outcrops on the slopes of Valea Satului River from Almăj Mountains (Dubova locality, Mehedinţi County). This Intrusion generated, in contact with Neamţu unit, a number of petrologic effects clearly differentiated from the effects of contact with Corbu unit giving rise to plagioclasic metamorphic rocks.

Based on mineralogical-petrographical observations made on several rock samples taken from the area in contact with Neamţu unit, this paper provides some considerations concerning the metamorphic transformations which took place in this region.

Key words: *Southern Carpathians, Danubian Autochthon, plagioclasic metamorphic rocks, mineralogical-petrographical observations*

Introduction

The geologic field study campaign from the summer of 2007 made on the Danube Valley was the starting point for a mineralogical-petrographical study of the magmatic intrusion which outcrops on the slopes from the Valea Satului River (Dubova locality, Mehedinţi County), near DN 57 Orşova - Moldova Nouă. This intrusive body (fig. 1, 2) located between the Neamţu crystalline unit to the East and the Corbu phyllites unit to the West, developed in the shape of a tabular body oriented NNW-SSE, was previously considered relatively homogenous. Thus, in the classical paper it is considered metadioritic [4], granodioritic [10] etc. This intrusive body has a series of interesting features starting from the contact with the Neamţu unit to the Corbu unit. To present all this features in detail, we have taken several samples from the intrusion, from the outcrops on the Valea Satului River.

The Danubian Autochthon represents a major unit of the Southern Carpathians and it is made up of Upper Proterozoic – Upper Ante-Carboniferous crystalline formations and sedimentary formations belonging to the Paleozoic and Mesozoic eras (fig. 3, 4). The crystalline basement of the Danubian area is crossed by important granodioritic bodies and eruptive bodies of basic and ultrabasic rocks. In the studied area, the Danubian domain consists in several metamorphic series named as follows: Poiana Mraconia area, Corbu area, Neamţu area.

The Neamţu crystalline unit occurs east of the Corbu phyllites unit, being continuously present from the Danube River to the eastern area of the Plugova where it winds under some sedimentary rock formations. This unit mainly consists in fine granular biotite-gneisses and amphibolites, the latest being present at the contact with the Ogradena granite. The Neamțu unit is crossed by granodiorites and nepheline sienite in its median area. The fine granular biotite-gneisses have sometimes a massive feature. They are generally intruded by granitic masses, which are either present as intrusions near the Ogradena granite, or produced by the metasomatic growth of the microcline. The amphibolitic rocks alternate very closely with the biotite-gneisses. In this amphibolitic rock group, several types have been distinguished as follows: amphibolites, rubanate amphibole gneisses and metadiorites.

The metadiorites are present as a band at the western limit with the Corbu area and also as a band in the Cozileşte-Mraconia region. Subordinately, quartzites and quartzo-micaschists are present in the Neamțu area. The identification of the initial metamorphic facies is difficult in this area due to granitic injection and granitic metasomatic processes. The 15-20% anorthite content of the plagioclase in the metapelitic rocks, the 35-38% anorthite content in the igneous metabasites and the existence of the common hornblende were considered indicators of the almandine amphibolitic facies, the superior part of the staurolite-quartz subfacies (almandine area). These rocks are mostly retromorphosed, showing a tendency to adapt to the greenschists facies [10].

Fig. 1. Igneous intrusions on the slopes from the Valea Satului River, near DN 57 Orşova-Moldova Nouă (the photo has been taken from the river).

Fig. 2. Igneous intrusions on the slopes from the Valea Satului River, near road DN 57 Orşova-Moldova Nouă (the photo has been taken from the road).

The Neamțu unit is mainly made up of metapelites, paragneisses and granitic bodies forming an important migmatic complex. This unit is affected by a typical amphibolitic-like metamorphism characterized by medium pressure/high temperature [9]. The Neamțu series consists in rocks metamorphosed in the amphibolite facies (the garnet area) and in the greenschists facies. In the corresponding area, the gneisses and amphibolites widely develop. The first have a thin layered texture and they are made up of quartz, plagioclase (20-25% An) and micas. Lenticular intercalations of amphibolites and amphibole schists frequently occur between gneisses.

Mineralogical-petrographical Investigations

Making detailed polarized-light microscopic observations on several thin sections of our samples, it has been found that the rocks are made up of igneous minerals (primary minerals) and metamorphic minerals. The relative proportions of these two categories of minerals depend on the sampling location. After the field sampling and the optical microscopic study made on thin sections we have identified several petrographic types.

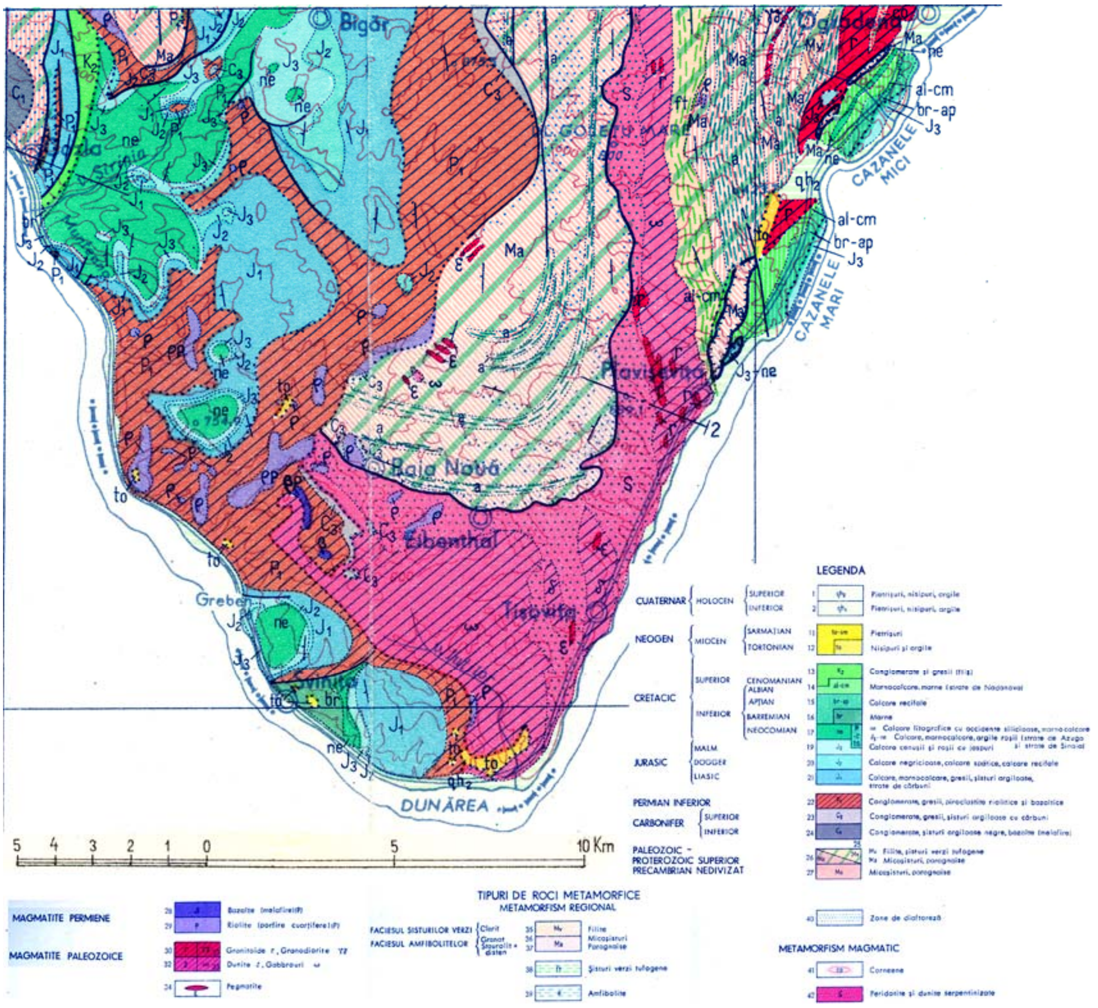

Fig. 3. Geological map fragment in studied area
(after *Geological map of Romania*, scale 1:200.000, Turnu Severin sheet, 1967).

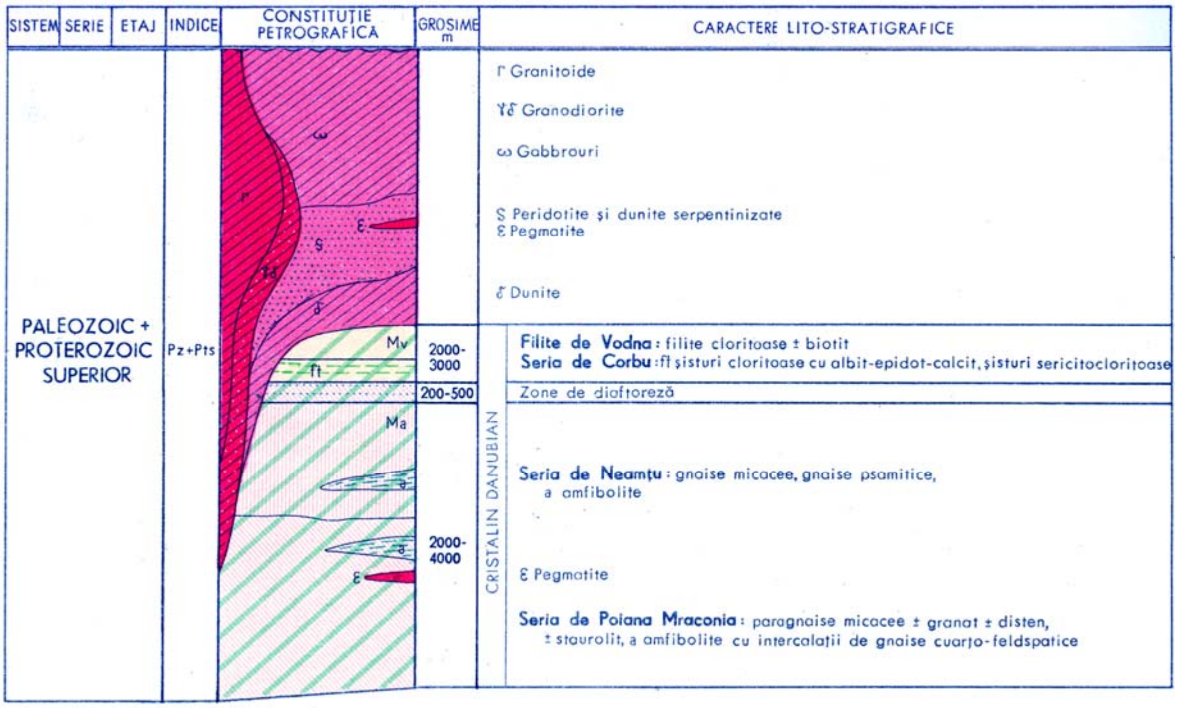

Fig. 4. Lithostratigraphical column fragment of crystalline formations in studied area
(after *Geological map of Romania*, scale 1:200.000, Turnu Severin sheet, 1967).

Type 1

The actual mineralogical composition is: oligoclase, sericite, chlorite, quartz, calcite, and hematite. The texture is non-oriented micro to mediogranulare. The mineral ratios are as follows: oligoclase + sericite 85-90%, chlorite 4-7%, quartz 2-4%, calcite 1-2%, hematite < 1%. The oligoclase is present frequently as anhedrale twins and rarely as subhedrale twins. These twins are partially substituted by sericite. The oligoclase is the dominant mineral (fig. 5). The dimensions of the twins are in the range of 0.90-1.10mm. The sericite is also present as intergrowths with the chlorite and hematite. These intergrowths are the result of several substitution processes (fig. 6). The quartz is a minor mineral which is present exclusively in the intergranular space (in between the oligoclase grains) (fig. 8). The chlorite is present or independent or grouped with hematite, or in some mineral polycrystalline aggregates, it consist in chlorite, sericite and hematite (fig. 6) with dimensions in the range of 0.25-0.40mm. The presence of sagenitic microtextures in the chlorite crystals (fig. 7) suggests that the chlorite is formed by substitution of the biotite. The calcite is present exclusively in thin joints with some hematite. The hematite is present in two contexts: (1) in distinct polycrystalline groups with chlorite and sericite, and (2) in joints with calcite (the microscopic aspect of these crystals suggests that the hematite is formed by substitution of a sulphide mineral predecessor, probably pyrite).

The primary minerals were: oligoclase, biotite, quartz. The secondary minerals are: chlorite, sericite, hematite, and calcite, the last one being present only in the joints.

Type 2

The actual mineralogical composition is: oligoclase, calcite, quartz, sericite, chlorite, and muscovite. The rock texture is cataclastic. The oligoclase is present as twin clasts with variable dimensions (the dimensions observed in our thin sections are in the range 0.75-2.50mm). All the oligoclase clasts have rounded quartz inclusions with dimensions ranging from 0.10-0.20mm. They are partially substituted by sericite (fig. 9). Between the oligoclase cataclasts, rather thin carbonatic domains are present. Near the carbonatice areas the oligoclase cataclasts have albite borders in which the continuity of the twins can be observed (fig. 10). In these albite borders there is no sericite present. The chlorite is a secondary mineral with strong pleochroism and an anomalous birefringence colours. It is present as small polycrystalline groups associated with the interclastic calcite (fig. 11). The muscovite is present in small proportion in the microcrystalline chloritic groups from the intraclastic spaces (fig. 12). The primary minerals were: oligoclase, quartz.

Type 3

This rock has a porphyroclastic texture and a well developed schistosity. The porphyroclasts proportion is in the range of 55-60%. There are two types of porphyroclasts: (1) porphyroclasts at intermediary plagioclase. This type is the prevailing one. They are relatively rounded. Their dimensions are in the range of 0.50-0.90mm (fig. 13). They are partially sericitized. (2) porphyroclasts represented by completely pseudomorphosed fragments made up of chlorite and muscovite. In these pseudomorphs the chlorite/muscovite ratio is highly variable (fig. 14, 15). These porphyroclasts have dimensions in the range of 0.80-1.00mm. The muscovite/chlorite ratio varies from 6:1 to 1:8. These porphyroclasts have resulted from previous mafic minerals, mostly probably from pyroxene. In some cataclasts, apatite inclusions are present. The rock matrix mainly consists in chlorite and muscovite and subordinate of opaque minerals and plagioclase. This matrix has been formed by intense deformation and by identity losing of the chlorite-muscovite pseudomorphs.

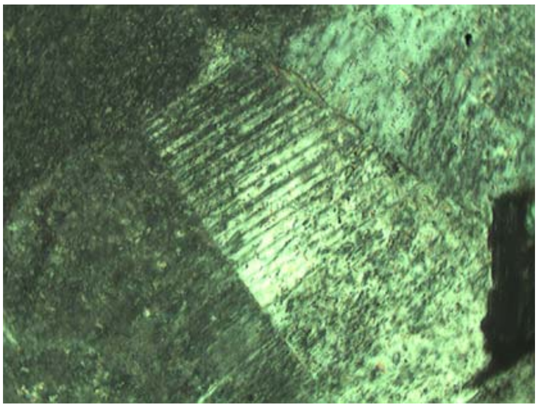

Fig. 5. Anhedrale twins of plagioclase partially substituted by sericite (N+, 100x)

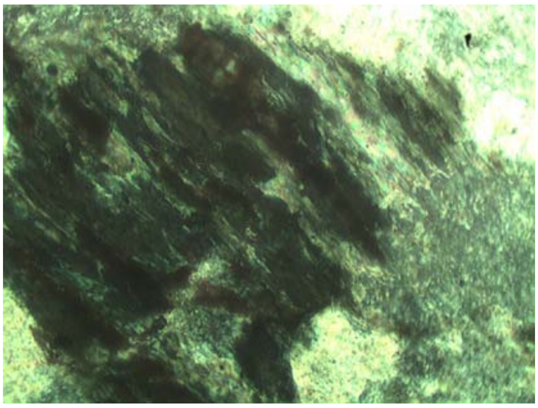

Fig. 6. Sericite-chlorite-hematite group (N+, 100x)

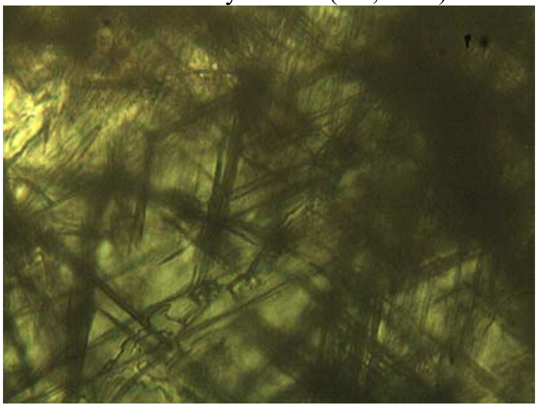

Fig. 7. Relict sagenitic microtexture in chlorite (N+, 630x).

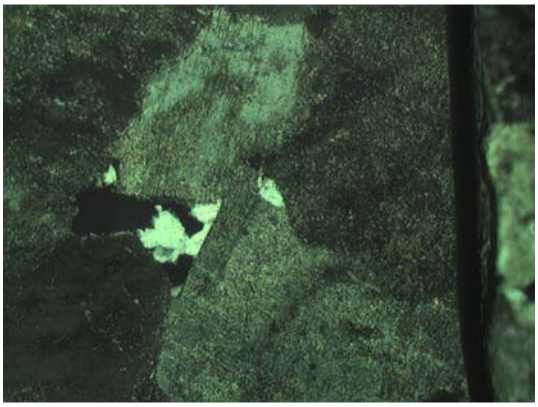

Fig. 8. Tiny quartz crystals in the intergranulare spaces (N+, 40x).

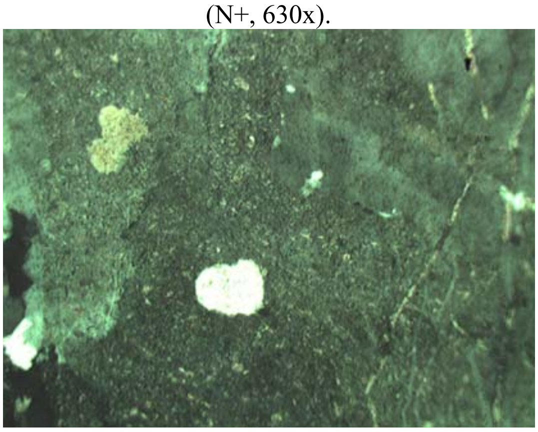

Fig. 9. Oligoclase cataclasts partially replaced by sericite (N+, 40x)

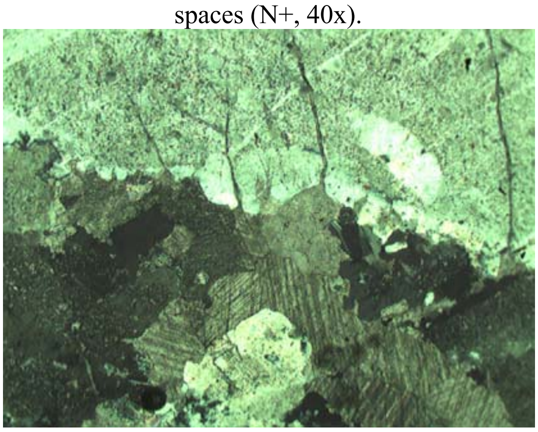

Fig. 10. Albite border at the edge of an oligoclase clast towards the carbonatic domain (N+, 40x)

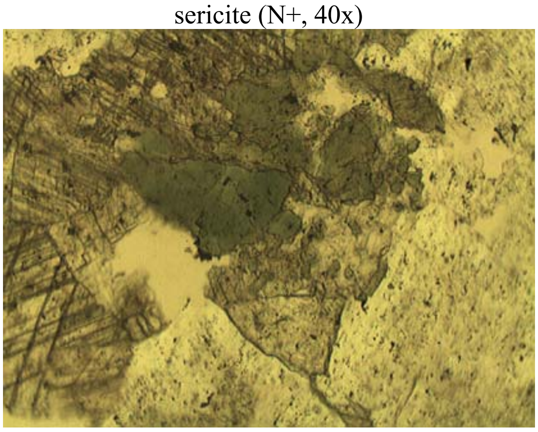

Fig. 11. Chlorite spatially associated with calcite in the intraclastic space (N||, 40x).

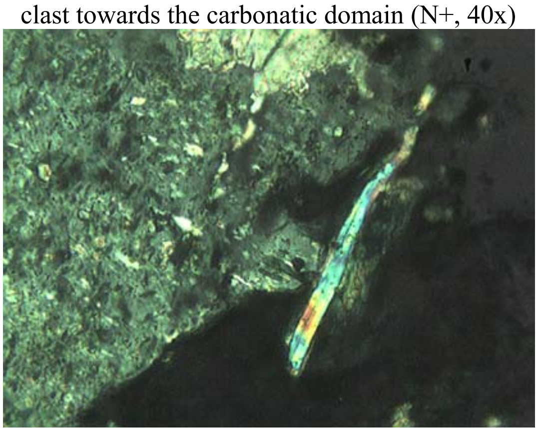

Fig. 12. Muscovite spatially associated with chlorite in the intraclastic space (N+, 250x).

Type 4

The mineralogical composition (in a decreasing order of mineral proportions) is: plagioclase, muscovite, chlorite, opaque mineral, calcite, quartz, Fe-hydroxide. The mineral proportions are as follows: plagioclase 45-50%, chlorite + muscovite 40-45%, opaque mineral 5-6%, calcite 2-3%, quartz 2-3%, Fe-hydroxide < 1%. The structure is schistose, lepido-microporphyroclastic. The plagioclase is an oligoclase present as derived twin-shape microporphyroclasts or non-twinned crystals with dimensions ranging from 0.08 to 0.14 mm. Most of the microporphyroclasts are partially muscovitized (sericitized) (fig. 16). Locally these microporphyroclasts are replaced by calcite (fig. 17).

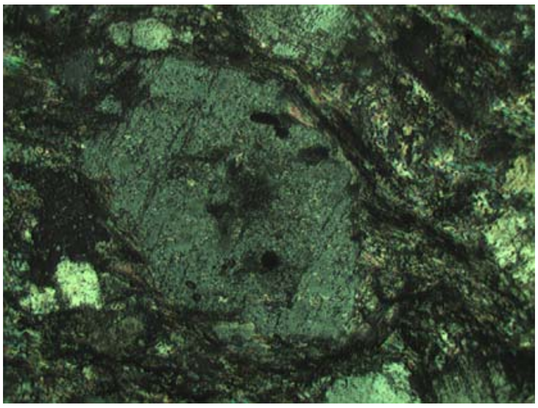

Fig. 13. Neutral plagioclase porphyroclasts (N+, 40x)

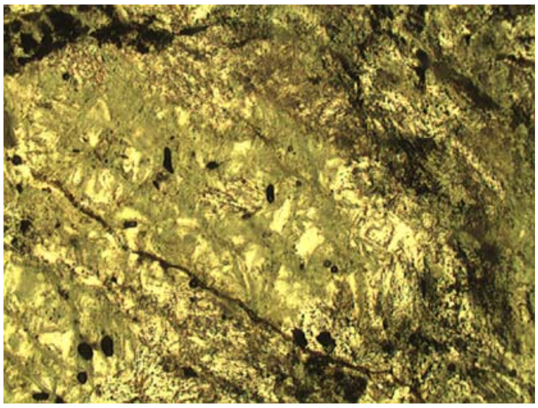

Fig. 14. Chlorite-muscovite porphyroclast (N||, 40x).

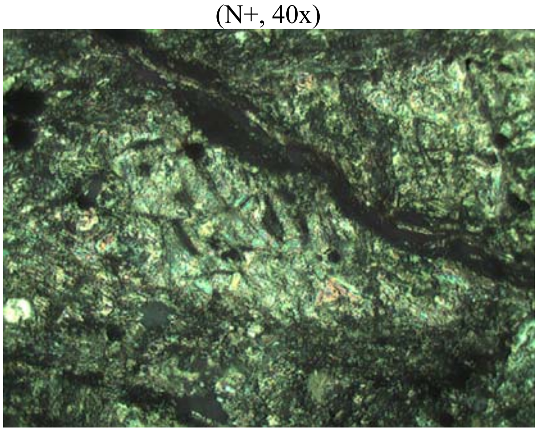

Fig. 15. Chlorite-muscovite porphyroclast (N+, 40x).

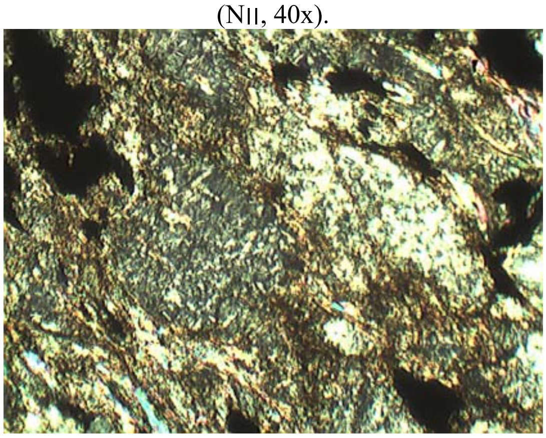

Fig. 16. Muscovitized plagioclase microporphyroclasts (N+, 100x)

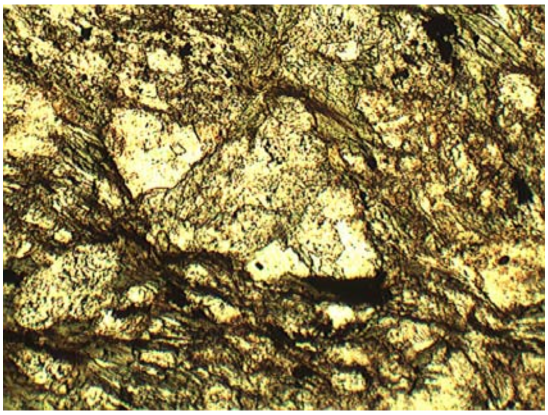

Fig. 17. Plagioclase microporphyroclast replaced by calcite (N||, 100x).

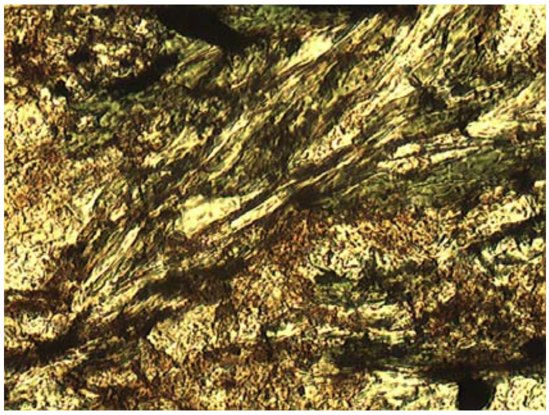

Fig. 18. Muscovite-chlorite intergrowth in the milonite matrix (N||, 250x).

Muscovite and chlorite – the preferred orientation of the crystals of these two phyllosilicates located outside the plagioclase microporphyroclasts gives the schistosity of the rock. A part of the muscovite crystals is included in the plagioclase microporphyroclasts, especially as a secondary sericite, and another part is located outside the porphyroclasts where they are generally larger. Nevertheless, the presence of an almost continuous range of dimensions for the muscovite crystals suggests that all the muscovite is formed in the same stage by the same type of metamorphic reaction which implied plagioclase as a reactant. In the matrix, the two phyllosilicates – the chlorite and the muscovite – are found in parallel intergrowths (fig. 18). A part of the chlorite crystals are present in the rock joints. They are developed especially at the joints intersections (fig. 19).

Calcite is present in the microscopic joints (fig. 20) or in microlenses oriented parallel with the rock foliation (fig. 21). The quartz is present mainly in microlenses parallel with the foliation and secondarily in the microjoints. It has a distinguishable undulatory extinction. The opaque mineral is present as euhedrale crystals and also as anhedrale ones, the latest being relatively uniformly disseminated in the entire examined sample. Its spatial relation with some of the plagioclase microporphyroclasts suggests that it was formed later from the solutions that moved through the interclastic space (fig. 22). The Fe-hydroxide is present especially in the microjoints that cross the rock, along with the later formed chlorite.

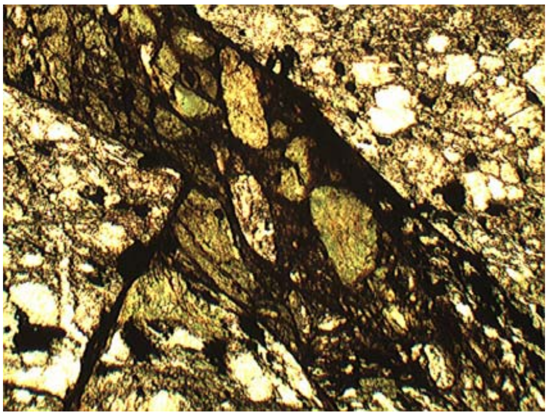

Fig. 19. Chlorite formed in the intersection zone of the microjoints (N||, 40x).

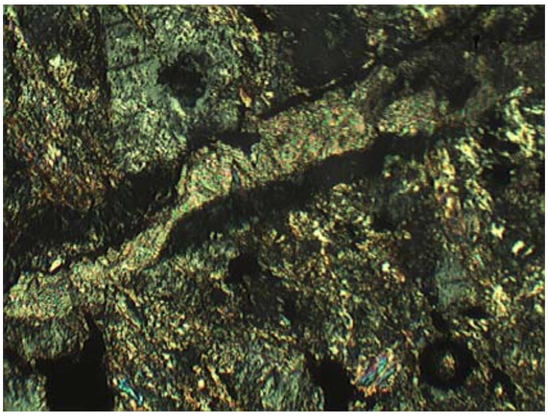

Fig. 20. Calcite-chlorite microjoints (N+, 100x)

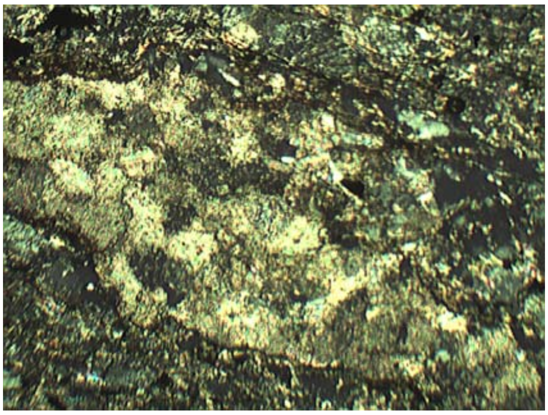

Fig. 21. Calcite microlens parallel with the foliation (N+, 40x).

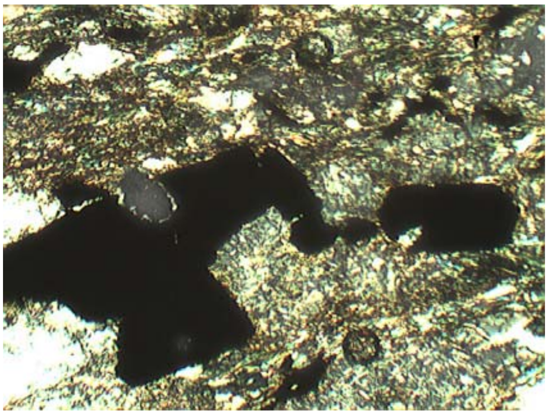

Fig. 22. Plagioclase microporphyroclasts partially surrounded by opaque crystals (N+, 100x)

Genetic Considerations

Type 1 – The primary mineral association and the mineral proportions show that this rock is a ***chlorite oligoclasite***. The protolith of this type is most probably an anortosite.

Regarding the distinct crystal group of chlorite, hematite and sericite, we consider that they are end result of two replacement stages. Thus in the first stage the biotite was replaced by chlorite, and in the second stage the biotite relics were replaced by sericite and hematite.

Type 2 – The only primary minerals in the rock are the quartz and the plagioclase. They locally formed intergrowths. The optical microscopic study has revealed that many of the cataclasts derived from one single primary twin. This fact shows that the primary plagioclase crystals were big. Most probably the protolith was an oligoclase pegmatite.

There are two ways in which we can explain the albite borders formation: (1) the deposition after the clastesis stage of some albite borders from high-temperature solutions which passed through the intraclastic space; (2) the peripheric albitization of the oligoclase clasts by the fluids which brought Na and Si and levigated Ca and Al. The second version is supported by the rare occurrence in the oligoclase clasts of some albitic gulfs that locally extend laterally from some calcite microjoints.

The diagnosis of this kind of rocks is ***oligoclase pegmatite cataclasite***.

Type 3 – The diagnosis for the rock is ***diorite milonite***. In the case of these rocks, the milonitization process was accompanied or most probably preceded by a metasomatic metamorphism which affected the mafic minerals. This metasomatic process has implied a significant contribution of K.

Type 4 – The textural features of the rock (the schistosity and the microporphyroclasts presence) indicate the textural type of ***milonite***. As the mineral nature of the cataclasts shows, the protolith of this milonite was a rock rich in plagioclase (probably a plagioclase). In the milonitization process, muscovite was formed on the clastic plagioclase. This fact shows that during the deformation stage, K bearing fluids penetrated the rock.

The metasomatic reaction whereby muscovite was formed was one of the following:

$$\underbrace{(4NaAlSi_3O_8 + CaAl_2Si_2O_8)}_{\text{initial plagioclase}} + 2H_2O + K_2O \rightarrow \underbrace{2KAl_3Si_3O_{10}(OH)_2}_{\text{muscovite}} + 2Na_2O + CaO + 8SiO_2$$

According to this reaction we can accept that the anorthite content in the plagioclase decreased during the milonitisation stage. Thus, the primary plagioclase was not an acid type.

The chlorite origin is debatable. Hereunder, we consider the following assumptions for its genesis: (1) chlorite was formed from a mafic mineral which existed in the protolith and was depleted by mineral reactions with the fluid during the milonitisation process; (2) chlorite derived from the fluid – plagioclase reaction, which is similar to the muscovite genesis. This is a more probable assumption because it is supported by the presence of the parallel intergrowths of the two phyllosilicates.

The small proportions of quartz and carbonates can be linked with the aforementioned reaction which produces SiO_2 and CaO. Thus, the quartz microlenses could be interpreted as having resulted from the crystallization of the silica, which was metasomatically produced. We suppose here, that at least a part of the chlorite was recrystallized, this fact being supported by the presence of chlorite joints which cross the rock foliation.

Conclusions

The granitoidic intrusions from the Danubian Autochthon were generated by a pre-Carboniferous sinorogenic igneous activity. The analysed intrusion represents most probably an apophyses of the Ogradena granite intruded on the border area between the Corbu phyllites unit and the Neamţu crystalline unit. The initial granitic composition went through granodioritic and even dioritic by the assimilation reaction with the intruded rocks. This assimilation had different features in contact with these two rock units because of their different composition.

The study of the rocks from the contact of the igneous body on the Valea Satului River with the Neamţu crystalline unit shows the presence of the plagioclasic metamorphic rocks (chlorite oligoclasites, oligoclase pegmatite cataclasite, and plagioclase milonite) which are in contrast with the metagranodiorites present at the contact with the Corbu phyllites unit.

The cataclasite and milonite presence suggests a more intense dynamic metamorphism at the igneous intrusion to the contact with the Neamţu crystalline unit.

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Studiul metamorfitelor plagioclazice din partea vestică a zonei cristalinului de Neamțu de pe Valea Satului (Muntii Almăjului)

Rezumat

Intruziunea magmatică de tip dioritic dezvoltată între unitatea filitelor de Corbu şi unitatea cristalinului de Neamțu apare bine deschisă la zi în versanții pârâului Valea Satului (comuna Dubova, jud. Mehedinți) din Munții Almăjului. Intruziunea a determinat la contactul cu unitatea de Neamțu o serie de efecte net diferențiate față de cele de la contactul cu unitatea filitelor de Corbu dând naştere unor metamorfite plagioclazice.

Pe baza observațiilor mineralogo-petrografice efectuate asupra probelor de roci prelevate din zona de la contactul cu unitatea de Neamțu, în lucrare se fac considerații referitoare la transformările metamorfice suferite de rocile din zona studiată.