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Mineralogical-petrographical observations on metamorphic transformations in the gabbroids from transitional zone of the Iuţi-Tişoviţa-Plavişeviţa ophiolitic complex

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Abstract

On the basis of the mineralogical-petrographical observations performed on some rock samples from transitional unit of the Iuţi-Tisoviţa-Plavişeviţa (ITP) ophiolitic complex in the paper are made some considerations concerning the metamorphic transformations which took place in this region.

The rocks were classified as chlorite-amphibole metagabbros. It has been proposed a possible succession for the identified metamorphic transformations. All these transformations had a strong metasomatic character and were determined by some hydrothermal fluids which removed from the studied rocks especially Ca, Si, and Na.

Key words: *gabbroids, Iuţi-Tişoviţa-Plavişeviţa ophiolitic complex, metamorphic transformations, mineralogical-petrographical observations*

1. Introduction

The paper presents a mineralogical-petrographical investigation performed on some rock samples taken from the transitional unit of the Iuţi-Tisoviţa-Plavişeviţa (ITP) ophiolitic complex. These rock samples have been taken from the left versant of the Danube River, more precisely, from the slope (fig. 1) of the Orşova-Moldova Nouă road (DN57), uphill the bridge over Tişoviţa valley. This road follows the Danube River, through the ITP ophiolitic complex. The studied rock is compact and hard. It has a green color and an inequigranulare, massive isotropic texture.

The ITP ophiolitic (mafic-ultramafic) complex represents an obduction fragment of the oceanic crust, well preserved in the Upper Danubian basement [1, 2], intermediary between lithogroups Drăgşan (dominated by MT-MP metabasites) in superior position and Lainici-Păiuş (dominated by HT-LP metasediments) in inferior position [2, 3, 4, 5]. This relation must interpretation like a suture zone of the Paleozoic age, between Drăgşan and Lainici-Păiuş terranes [4]. The ITP ophiolitic complex is continue in the south in several major ophiolitic massive: Zaglavac and Deli Jovan (north-east Serbia), and Tcherni Vrach (north-west Bulgaria). In Stara Planina, is covered by a Cambrian formation of insular arch, low metamorphosed = Berkovica group [6]. It is assuming [4] to the obduction of the ITP ophiolitic complex over the rocks from Lainici-Păiuş lithogroup have Ordovician age, on the basis of the Brustur Formation age who contains cobbles

of the ITP rock-type. The oceanic crust of the ITP ophilitic complex revealed a classical sequence of the pillow-lave, lamellar dykes, gabbroic cumulate, dunitic cumulate and harzburgitic tectonites [1, 6].

The ITP ophiolitic complex includes two main units which show the ophiolite igneous stratigraphy: a lower unit with upper mantle lithologies and an upper association of plutonic cumulates [1, 2]. The mantle peridotite unit, forming the lower part of the ophiolite igneous stratigraphy, consists mainly of harzburgite with tectonite structure and subordinate dunite, hosting small podiform chromitites. The cumulate sequence includes an ultramafic unit (dominated by layered dunites, which show lens-shaped bodies of plagioclase-bearing dunite, troctolite, olivine gabbro and gabbro), a transitional zone (consists of alternating cumulates, mafic = troctolite, olivine gabbro, gabbro, and ultramafic = dunite, plagioclase dunite, wehrlite, clinopyroxenite) and a layered mafic unit (include gabbro, olivine gabbro and troctolite, forming a rhythmic layered sequence which is cross-cut by isotropic olivine gabbro) [1, 2].

2. Mineralogical-petrographical investigations

2.1. The mineral composition

By the microscopic examination in transmitted polarized light performed on several thin sections it has been found that the rock is composed from primary and secondary minerals. Their relative proportions are variable depending on the sampling location. The primary minerals are igneous and the secondary ones are formed subsolidus. Both categories are presented in table 1.

Table 1. The primary and secondary minerals in the studied rock and their volume proportions.

Genetic type	Mineral	Volume proportion, %
Primary minerals (igneous)	Plagioclase	35–45
	Clinopyroxene	0–5
	Magnetite	< 1
Secondary minerals (subsolidus)	Tremolite	15–30
	Actinolite	5–12
	Brown hornblende	0–2
	Chlorite	18–23
	Epidote	0–1
	Zoisite	0–1
	Calcite	0–3
	Zeolite	

The plagioclase is a labradorite and it is found as polysintetically twinned crystals with relict features. The majority of these relics are surrounded or traversed by chlorite with or without fragments of amphibole (fig. 2). The plagioclase relics have dimensions ranging from 0,6 to 3,2mm.

The amphibole is found only as pseudomorph crystals after some older crystals of clinopyroxene. These pseudomorphs are either complete ones either partial ones (fig. 3). They present a particular zonation: in the central zones the amphibole is a tremolite (colorless amphibole) and in the peripheral zones it is an actinolite (green and colorless amphibole). The transition between these two types of amphiboles is often a sharp one and seldom is gradually (fig. 4). These relations show that they are formed one on the other. Locally the actinolite is transformed in a brown amphibole by an oxidation process.

Fig. 1. Outcrop in the igneous rocks from slope of the Orşova-Moldova Nouă road = DN57 (uphill the bridge over Tişoviţa valley).

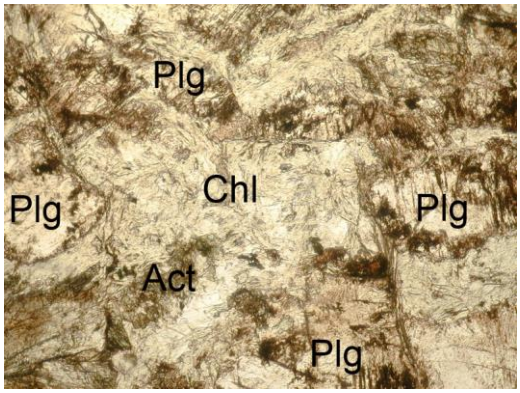

Fig. 2. Plagioclase relics surrounded by magnesian chlorite (N|| 40x).

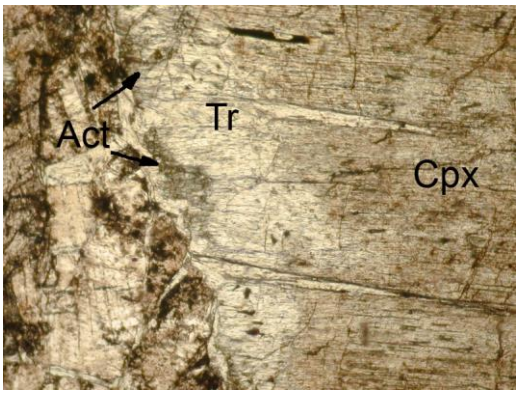

Fig. 3. Partial amphibole pseudomorph on clinopyroxene: actinolite at the margin; clinopyroxene in the center; tremolite between the actinolite and the clinopyroxene zones (N|| 40x).

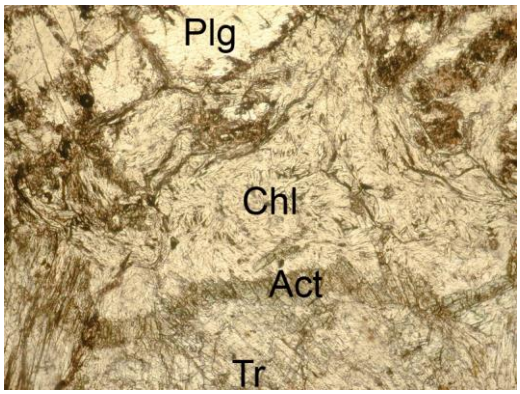

Fig. 4. Tremolite actinolization at the previous tremolite-plagioclase boundary (N|| 40x).

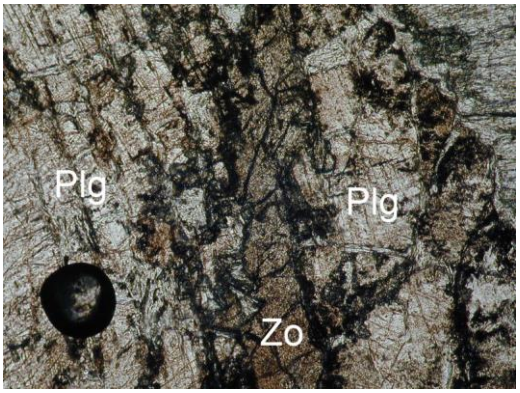

Fig. 5. Zoizite found in the fractures in the plagioclase (N|| 40x).

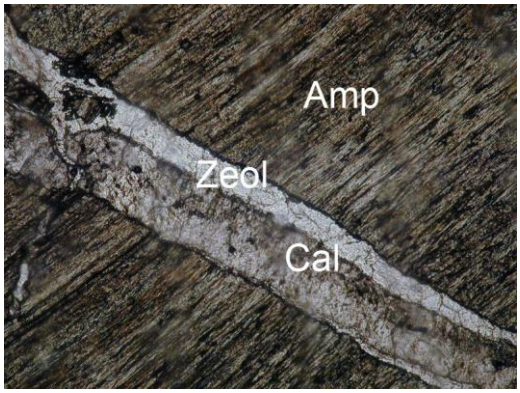

Fig. 6. Zoned joint filled with zeolite and calcite (N|| 40x).

The clinopyroxene is found as relict nuclei surrounded through substitution by the above mentioned amphiboles. Often in these nuclei are found numerous tremolite crystals with slight discordant optical orientations giving to these pyroxene relics a perthitic aspect. In contrast with the tremolite, the clinopyroxene has a pale brown tint and numerous fine opaque inclusions.

The chlorite is a colorless magnesian variety. It is present as tabular crystals having dimensions of the order of 0,08–0,18mm. These crystals have random orientations. It has normal gray-white

first-order birefringence colors. Most of it is found around the plagioclase relics or in the joints which cross the plagioclase.

The epidote is seldom found as anhedral crystals preferentially formed in the plagioclase relics.

The zoisite is seldom found on the fractures which cross the plagioclase relics (fig. 5). The zoisite crystals have a columnar habit. There are not direct spatial relations between zoisite and epidote in these rocks for a relative age determination to be possible.

The calcite and zeolite are found filling the joints which cross both the plagioclase relics and the mafic minerals. In the analyzed thin sections these joint have thicknesses of the order of 0,1–0,2mm. Often the deposition of these minerals is zoned with the zeolite to the margins and calcite in the center (fig. 6).

The magnetite is present in small proportion always as subhedral crystals included in the mafic silicates. Seldom are these crystals surrounded by a thin limonitic coating.

2.2. Textural features

Although the substitution degree of the primary minerals is high, it is still possible to microscopically recognize the dimensions and the even the older forms of the primary crystals. Based on this kind of observations it can be deduced that the initial rock had a phaneritic structure which is specific for the plutonic rocks. A low intensity brittle deformation process led to the local fragmentation of some plagioclase and clinopyroxene crystals. The few clasts formed are also pseudomorphozed by a chloritic or amphibolic aggregate depending on the mineral nature.

3. Genetical remarks

The type of the primary minerals and the phaneritic structure led us to the conclusion that the rock was a gabbro sensu stricto. The first observed transformation that took place in subsolidus conditions was a brittle deformation. This has allowed the circulation of some hydrothermal which determined the chemical disequilibrium of the primary minerals and thus all the metamorphic transformations with a strong metasomatic character. Taking into account that the nature of the initial rock can still be identified, the fact that the transformations are metamorphic and the nature of the prevalent secondary minerals, the correct name for the studied rock is **chlorite-amphibole metagabbro**.

The most probable succession of the metamorphic transformations is:

The pyroxene tremolitization was a process that involves the introduction of water and partial elimination of Ca^{2+}. The reaction is:

$$5CaMgSi_2O_6 + H_2O \rightarrow Ca_2Mg_5Si_8O_{22}(OH)_2 + 3Ca + 2Si + 7O \quad (1)$$

(*diopside from clinopyroxene*) (*tremolite*)

In this tremolitization process the amphibole had a multiple nucleation on the pyroxenic paleosome. Most of the nuclei are grown epitaxial so that they the tremolite crystals have the same reticular orientation as the paleosome.

The tremolite actinolization is a process that consisted in cation exchange reaction between the tremolite and the metasomatic fluid. The exchange cations were: $Fe^{2+} \leftrightarrow Mg^{2+}$.

The reaction is:

$$Ca_2Mg_5Si_8O_{22}(OH)_2 + Fe^{2+} \rightarrow Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2 + Mg^{2+} \quad (2)$$

(*tremolite*) (*from fluid*) (*actinolite*) (*in the fluid*)

This process was minor and it took place especially at the tremolite-plagioclase interface (fig.4).

The plagioclase chloritization is a process that involved the introduction of Mg^{2+} in the rock and the elimination of: Na^+, Ca^{2+} and Si^{+4}. The reaction one of the following type:

$$[2(Ca,Na)_2Al_2Si_2O_8]+6Mg+4H_2O \rightarrow 1.5Mg_4Al_2Si_3O_{10}(OH)_8+2.5Si+4Ca+1.5O_2+Na \quad (3)$$

(*basic plagioclase*) (*chlorite*)

Unlike the above mentioned metasomatic processes the epidote and zoisite formation was a subordinate process. It is very likely that the epidote and zoisite were formed only through the plagioclase transformation at constant Al with the elimination of Na^+.

In the last evolution stage the joints which are presently filled with were formed. Their morphology suggests an extensive nature. The filling with the calcite and zeolite was synchronic with the joints extension opening. In accordance with the joints zoning, the zeolite was first deposited near the walls and then the calcite in the center.

Taking into account that the present rock is a metagabbro which was subjected to metasomatic processes we conclude that its global chemical composition can not be used to determine the geochemical features of the initially igneous rock and to determine the geotectonic context of the magma formation. We can claim that unlike the well known Iuţi unaltered gabbros, the protolitic gabbros for these studied rocks did not contain olivine. The metamorphism that transformed these rocks was a static metasomatism.

4. Conclusions

The mineralogical-petrographical study of the rock samples from transitional zone of Iuţi-Tişoviţa-Plavişeviţa ophiolitic complex reveals the presence of some metasomatic metamorphic transformations on the basic igneous plutonic rocks. The metamorphosed rocks were classified as chlorite-amphibole metagabbros.

The metasomatic reaction which implied the plagioclase in the studied rocks is distinct from the reaction which determined the plagioclase saussuritization previous described in the same region by several other authors [1, 7, 8].

It has been proposed a possible succession for the identified metamorphic transformations. All these transformations had a strong metasomatic character and were determined by some hydrothermal fluids which removed from the studied rocks especially Ca, Si, and Na.

The most secondary metamorphic minerals are hydrous phases and their proportion relative to the primary igneous minerals is related with the degree of initial brittle deformation.

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Observaţii mineralogo-petrografice asupra transformărilor metamorfice suferite de gabbroidele din zona de tranziţie a complexului ofiolitic Iuţi-Tişoviţa-Plavişeviţa

Rezumat

Pe baza observaţiilor mineralogo-petrografice efectuate asupra unor probe de roci prelevate din zona de tranziţie a complexului ofiolitic Iuţi-Tisoviţa-Plavişeviţa în lucrare se fac consideraţii genetice referitoare la transformările metamorfice suferite de rocile din zona studiată.

Rocile studiate au fost clasificate ca metagabbrouri cu clorit şi amfibol. A fost propusă o succesiune posibilă pentru transformările metamorfice identificate. Toate aceste transformări au un puternic caracter metasomatic şi au fost determinate de fluide hidrotermale care au luat în soluţie din rocile studiate în special Ca, Si, şi Na.