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MINERALOGICAL STUDY OF THE CRYSTALLINE SCHISTS OF LEAOTA MASIFF, SOUTHERN CARPATHIANS, ROMANIA

Magdalin Leonard Dorobăț [1], Codruța Mihaela Dobrescu [1,]*

[1] University of Pitești, Faculty of Science, Physical Education and Informatics, Department of Natural Sciences, Târgu din Vale Street, No. 1, 110040, Pitesti, Romania

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Abstract
This paper presents the results of the mineralogical and chemical analysis made on crystalline schist that covers most of Leaota Mountains. The relief developed on schist substratum must be specific to those mountains, covering, by far, approximately three quarters of their surface. Our studies on the mineralogical composition of crystalline schist are part of a research complex whose main objective is the mesovoid shallow substratum (MSS) or shallow subterranean habitats (SSHs) hosted by the scree that covers some slopes of Leaota Mountains. In fact, the scree, through interclastic porosity, through the micro-climate particularities, represents a very interesting and individualized living environment which has an essential ecologic role (Nitzu et al, 2010; Nitzu et al, 2014, Mammola et al, 2017). The microfauna elements, temporarily or permanently hosted by the scree were correlated to the geological substratum type, analyzing the way through which the different geological substratum type leads, in turn, to differences amongst the distribution of the fauna elements. The mechanical, chemical, biochemical behavior of the crystalline schists on the weathering is reflected by its ability to favor, more or less, the installation of microfauna.

Keywords: Leaota , mesovoid shallow substratum (MSS), mineralogical composition, scree, schist.

1. INTRODUCTION

Leaota Massif, though dominated by crystalline schist who covers approx. 74% of its surface (Murătoreanu, 2009), displays a relative geological diversity, namely it also hosts limestone, sedimentary or even magmatic rocks. In fact, in geology, this type of schist met in Leaota Massif, are known as “Leaota Crystalline” (Ilie, 1971; Mutihac, 1990; Mutihac & Mutihac, 2010). We proposed the analysis, from the mineralogical perspective, of the crystalline schist that appears in different scree, in order to see to what extent this type of rocks is capable of forming interclastic gaps (interclastic porosity) (Dorobăț, 2016; Dorobăț et al, 2018), which, in turn, will allow the circulation and hosting of different invertebrate species or even micro mammals. Also, the present study is a component of a wider frame, which analyzes the variation of the main ecologic factors, temperature and relative humidity, depending on the geological substratum. Weathering is the process where rocks are dissolved, worn away or broken down into smaller clasts. There are mechanical, chemical and organic weathering processes. In fact, the formation of the scree is dependent on the susceptibility of the crystalline rocks to disintegrate under the action of external factors, especially as a result of the cryoclastic (gelifraction) processes (Dorobăț et al, 2018). In turn, this susceptibility is a consequence of the mineralogical composition; therefore the formation

*Corresponding author, E-mail address: codrutza_dobrescu@yahoo.com

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of the scree (MSS), the size of the interclastic spaces, the depth to which they are large enough to allow the circulation of invertebrates are dependent on the mineralogical composition.

2. MATERIALS AND METHODS

We have randomly collected material in the different areas, samples of crystalline schist, in order to manufacture thin sections, for the analysis with the polarized light mineralogical microscope; for this, we collected several tens of kilos of schist from the scree that appears on the slopes that face the Ghimbav Valley (starting from approximately 200 meters upstream from the entrance in the Ghimbav Gorge), the adjacent slops to the forest road that connects the village of Valea Caselor with the Andolia forest canton Berbece’s Creek, Popii Valley and Bădenilor Valley (Fig. 1). The rocks were macroscopically analyzed in “fresh break”, so that the (bio) chemical alteration processes at the surface of the rock would not influence the microscopic analysis. Subsequently, we created thin sections which were the subject of microscopic analysis. We have been interested in these exclusive researches in the perspective through which the mineralogical composition determines chemical and biochemical reactions which, in a way or another, indirectly, influences the microfauna. We used for the determination of GPS position a GPSMAP® 76CSx device; the accuracy of the measurements depended on the way the satellite received the signal; most often, the altitude and distances were indicated with a tolerance of ± 7m (20 feet). We also used the compass of the device to determine the orientation of the mountain slops on which the screes we stationed. We used for the microscopic analysis a type of mineralogical microscope Carl Zeiss Jena Amplival Pol ● U with polarized light, which has compensators and polarizers, quartz wedge and which has rotating platinum.

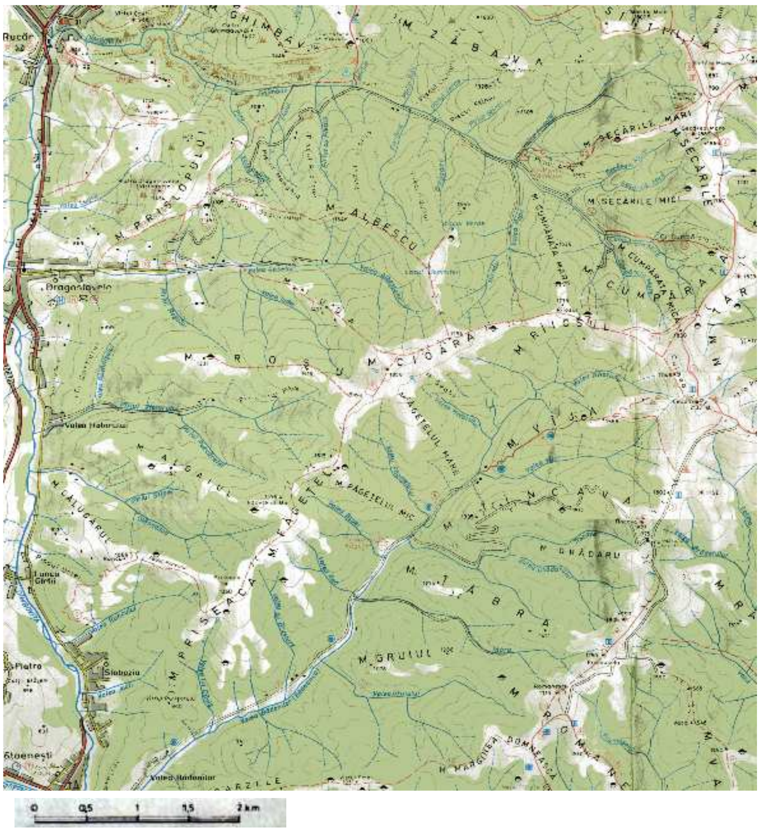

Figure 1. Leaota's Map; detail with the studied areas (after www.carpati.org)

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3. RESULTS AND DISCUSSIONS

MACROSCOPIC ANALYSIS

The macroscopic analysis (to the eye or using a magnifying glass) shows us a dark green-grey rock, displaying an obvious schistosity, which determines us define it as a metamorphic crystalline schist. Schistosity is emphasized by an alternance of dark, black, green or grey parallel bands, with other light bands, white or white-grey (Figs. 2a, 2b) The dark minerals (the melanocratic minerals) are represented by muscovite and biotite, which are part of the phyllosilicates family (mices). Light minerals (the leucocratic minerals) are the quartz and the feldspar. Using a magnifying glass, we can notice the scaly (lepidoblastic) texture of the mices. The quartz and feldspar crystals have a granular (granoblastic) texture. Sometimes, we can notice the presence of crystals in the mass of the rock, less than 0.1 mm, with vitrous shine, especially on the schistosity planes (possibly epidote). Some rock samples display micro cracks (Fig. 2b).

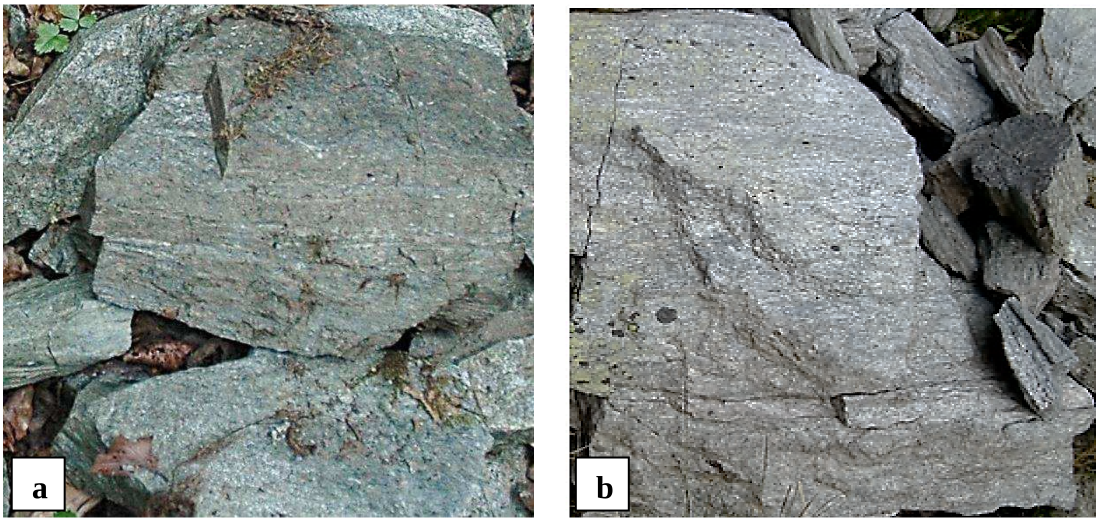

Figure 2 - 2a. Crystalline schist from Pârâul lui Berbece Valley with obvious schistosity; 2b. Crystalline schist from Popii Valley with obvious schistosity, displays micro cracks (from Dorobăț, 2016)

MINERALOGICAL ANALYSIS of the rocks, by using thin sections observed by using the petrographic microscope with polarized light, led to the identification of the mineralogical composition of the schist, presented in Table 1.

Mineralogical aspects of analyzed schist, using the microscope, are presented in figures 3-11. Thus, we noticed that:

Quartz appears in all analyzed sections and it represents a mineral mainly from the quantitative perspective, as in reaches 42% of the total mass. The shape of the crystals is irregular, with sizes between 0.05-0.70 mm. frequently, in larger feldspar crystals, quartz inclusions are present. Moreover, we can also find some quartz crystals that, in polarized light, are featured by a undulatory (undulose) extinction generated by the biotite, illmenite and muscovite inclusions.

Plagioclase feldspar is represented by the albite; of the plagioclase, anorthite is rarely present, under 5-7%. The percentage of these minerals averagely represents approximately 22% of the total mass of crystalline schist. Plagioclase feldspar does not display chemical alteration and are in contact with potassium feldspar, as most of the crystals have a idiomorphic shape.

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Table no. 1. The mineralogical composition of crystalline schist in Berbece's Creek and Popii Valley

Nr. crt.	Mineral	Chemical formula	Size (mm)	% (quantitative mineral compound)	Obs.
1.	Quartz	SiO_2	0.05-0.7	40-44	
2.	Plagioclase feldspar	$NaAlSi_3O_8 – CaAl_2Si_2O_8$	0.05-0.5	20-24	Albite
3.	Biotite	$K(Mg,Fe)^{3+}[Si_3AlO_{10}][OH,F]_2$	0.02-0.03	29-33	
4.	Chlorit	$Mg_5Al[Al,Si_{3,}O_{10}](OH)_8$	0.02-0.03		
5.	Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$	0.01-0.25	3-5	
6.	Epidote	$Ca_2Fe^{3+}Al_2[Si_2O_7][SiO_4](O,OH)$	0.03-0.15	0.05-1	
7.	Potassium feldspar	$KalSi_3O_8$	0.1-0.4	traces (insignificant)	Orthoclase
8.	Garnet	$Al_4[(OH)_8Si_4O_{10}]$	0.007-0.01	traces	
9.	Limonite	$HFeO_2*nH_2O$	<0.005	traces	
10.	Calcite	$CaCO_3$	0.05-0.15	traces	
11.	Opaque minerals	$FeTiO_3$	<0.1	traces	Illmenite

Muscovite represents approximately 4% of the rock, as laminated packs with a perfect clevage, with right extinction and high birefringence colours. We also meet, in the rock mass, sequences of muscovite, which is also present as inclusions in some minerals, such as feldspar and quartz. Muscovite crystals reach sizes between 0.01 and 0.25 mm.

Biotite, alongside chlorite, represents approximately 31% of the crystalline schist analyzed volume. Biotite crystals reach sizes between 0.02 and 0.3 mm. It is present as sequences and laminar packs which display a very good pleochroism, with brown shades and right extension. Biotite is affected by chlorination, due to the chemical alteration processes that were supported by rocks, as this mineral is pseudo transformed by chlorite, and the oxide and hydroxide separates are very visible on the cleavage planes. Sometimes, biotite is replaced by epidote. Frequently, biotite crystals are slightly associated to the muscovite ones.

Chlorite is present as a secondary mineral in crystalline schist, resulted from biotite through chemical alteration processes. From the quantitative perspective, we could not calculate the ratio between the biotite and chlorite proportion in the rock, due to the fact that the chemical alteration phenomena developed on the cleavage plans of biotite, and its substitution with chlorite is made in different proportions. Pseudomorphosis phenomena of the chlorite on the biotite are either complete or in intermediary or incipient phases. Chlorite crystals reach sizes between 0.02 and 0.3 mm.

Potassium feldspar represents just a small part of the rock, approximately 0.25%, with crystals between 0.1 and 0.4 mm, with numerous inclusions. Orthosis is the most frequent in this feldspar category.

Epidote is slightly present in the crystalline schist mass, approximately 1%, with crystals that, under the microscope, present high relief and very clear birefringence, shiny colors of yellow, red,

*Corresponding author, E-mail address: codrutza_dobrescu@yahoo.com

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green etc. unevenly spread. The aspect of the epidote is granular, and the sizes of the crystals vary between 0.03 and 0.15 mm. Epidote is a secondary product in the rock.

Garnet presents only shades in the analyzed schist, with sizes of only microns, until the hundredth of a millimeter (0.005 – 0.01 mm). Garnet appears as isotropic inclusions in the feldspar (especially potassium) and quartz crystals.

Calcite is a mineral whose crystals vary in size between 0.05 and 0.15 mm and is sporadic in rocks, as traces, as a secondary mineral, resulted from the alteration of some minerals that include Ca, such as some plagioclase feldspar.

Limonite is present as traces and its origin is also explained by chemical alteration phenomena, as it is a secondary mineral, resulted from the alteration of biotite, epidote or even of illmenite. We notice brown-red dispersion aureoles, which appear either on the cleavage planes of altered minerals, either around their crystals.

Illmenite is an opaque mineral, appears in insignificant volumes, also as traces, as inclusions in the crystals of other minerals, being sometimes featured by specific crystallization facets, with crystals lower than a tenth of a millimeter.

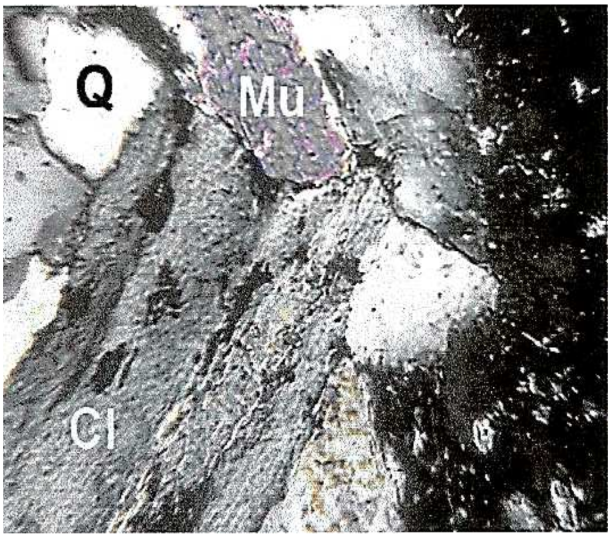

Figure 3. Quartz-feldspar schist with biotite and muscovite
(x 2550; N+; x = magnification of image; N+ = imagine in polarized light; original)

Rock texture: schist; structure: lepido granoblastic; quartz (Q), chlorite (Cl), muscovite (Mu) as lamellar packs

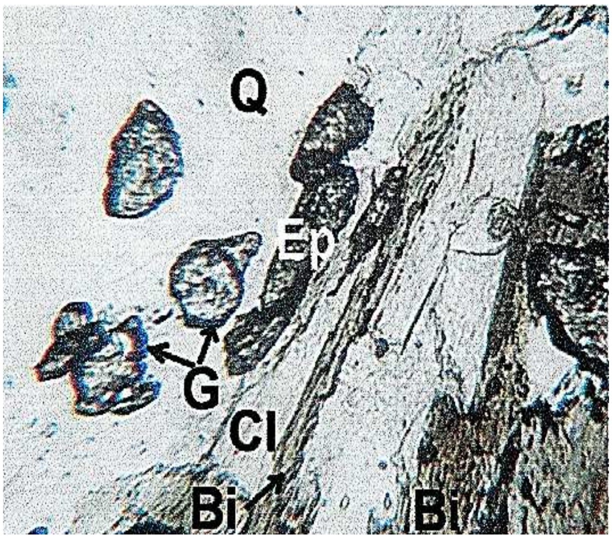

Figure 4. Quartz-feldspar schist with biotite and muscovite

(x 509; N+; original)

Rock texture: schist; structura\e: lepido granoblastic; quartz with garnet (G) epidote (Ep), biotite (BI), chlorite inclusions (Cl)

Legend: ***Lepido granoblastic structure*** = granulated crystals mixed with crystals with parallel follicular aspect; most of them are follicular

Grano blastic structure = granular crystals with approximately equal sizes on the three directions

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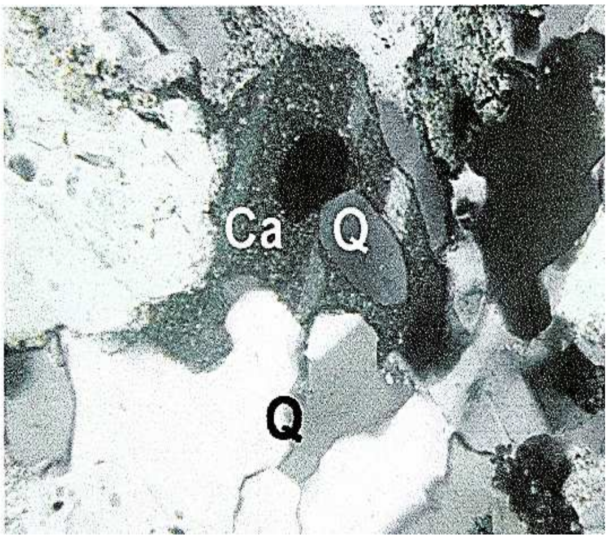

Figure 5. Quartz-feldspar schist with biotite and muscovite (x 509; N+; original)

Massive texture; structure: grano blastic; Quartz crystals with xenomorph outline (Q) and calcite Ca)

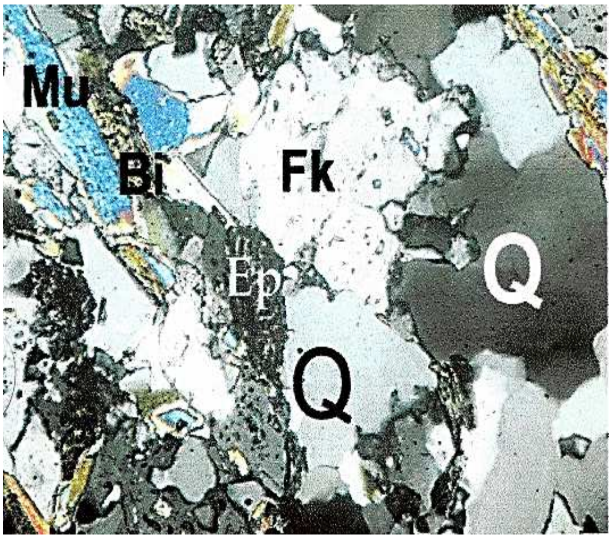

Figure 6. Quartz-feldspar schist with biotite and muscovite (x 257; N+; original)

Rock texture: schist; structure: lepido granoblastic; Quartz crystals with xenomorph outline and undulatory extinction (Q), muscovite (Mu), biotite (Bi), granular epidote (Ep), potassium feldspar with corosions (Fk)

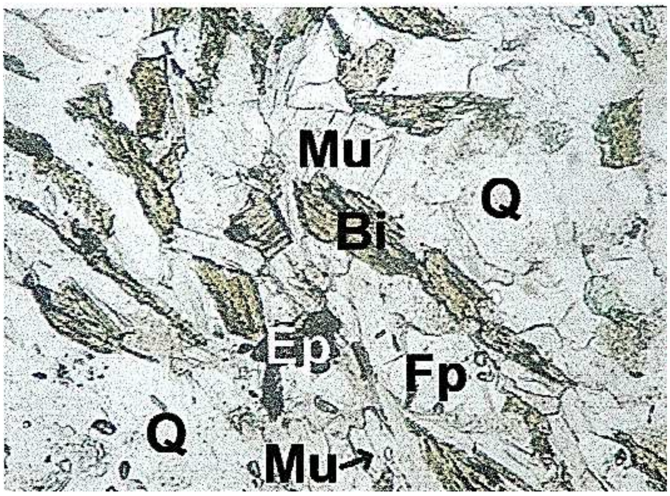

Figure 7. Quartz-feldspar schist with biotite and muscovite (x 257; N ll; N II = normal light image; original)

Rock texture: schist; structure: lepido granoblastic; xenomorph quartz crystals (Q) possible undulatory extinction, mices in lamellar packs: biotite (Bi) and muscovite (Mu), plagioclasis feldspar (Fp), albite variety, granular epidote (Ep)

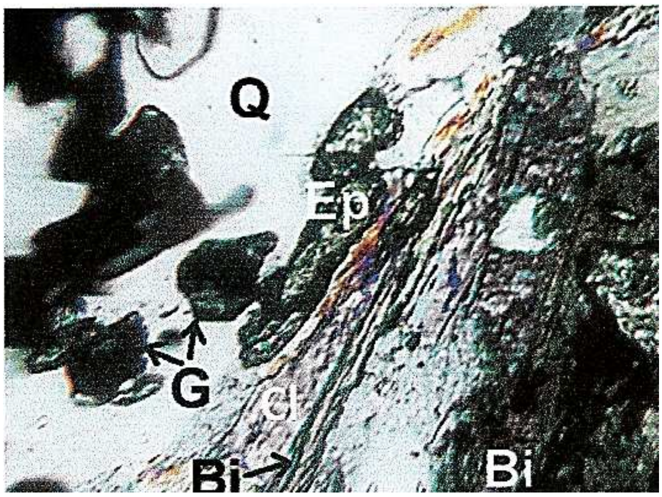

Figure 8. Quartz-feldspar schist with biotite and muscovite (x 2550; N+; original)

Rock texture: schist; structura: lepido granoblastic; Quartz (Q) with epidote inclusions (Ep) and garnet (G), biotite (Bi) chlorite (Cl)

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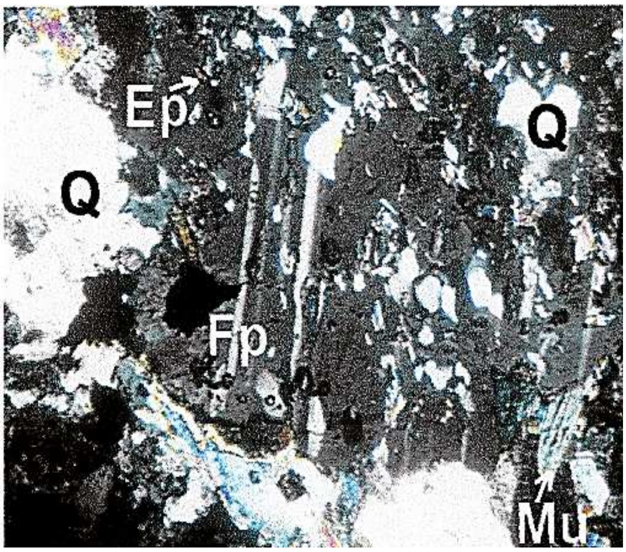

Figure 9. Quartz-feldspar schist with biotite and muscovite (x 257; N+; original)

Massive texture; structure: grano blastic; plagioclasis feldspar crystals (Fp), albite, with muscovite (Mu) and quartz (Q) inclusions

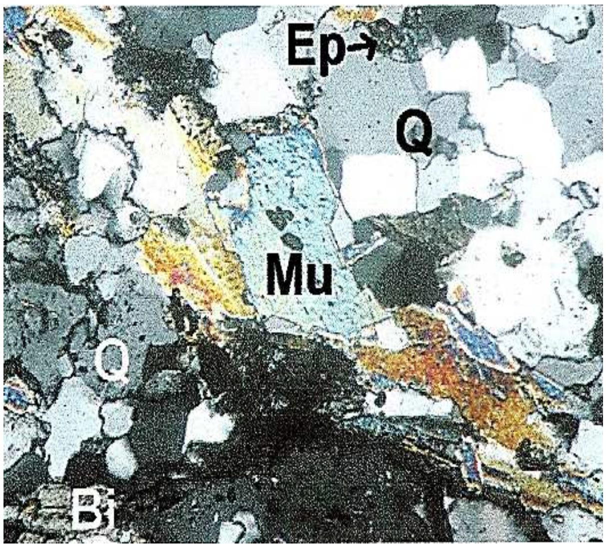

Figure 10. Quartz felspar schist with biotite and muscovite (x 257; N+; original)

Rock texture: schisty; structure:lepido granoblastic; xenomorph quartz crystals (Q), biotite (Bi), muscovite (Mu), epidote (Ep)
(x 509; N ll; original)

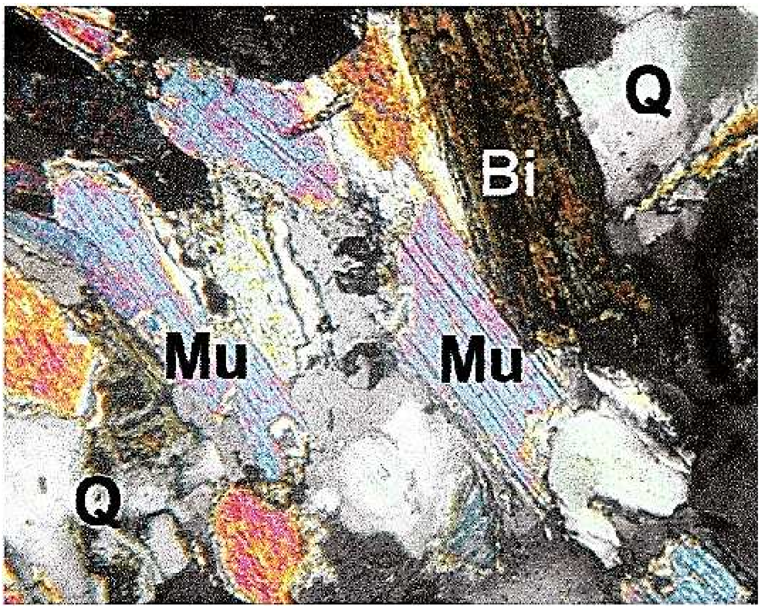

Figure 11. Quartz-feldspar schist with biotite and muscovite (X 509; N+; original)

Rock texture: schisty; structure: lepido granoblastic; Quartz crystals with undulatory extinction (Q), mice varieties as lamellar packs of biotite (Bi) and muscovite (Mu)
Regarding the metamorphosis that generated them, the mineralogical composure is also the one that suggests the classification of this schist in a certain category (Fig. 12).

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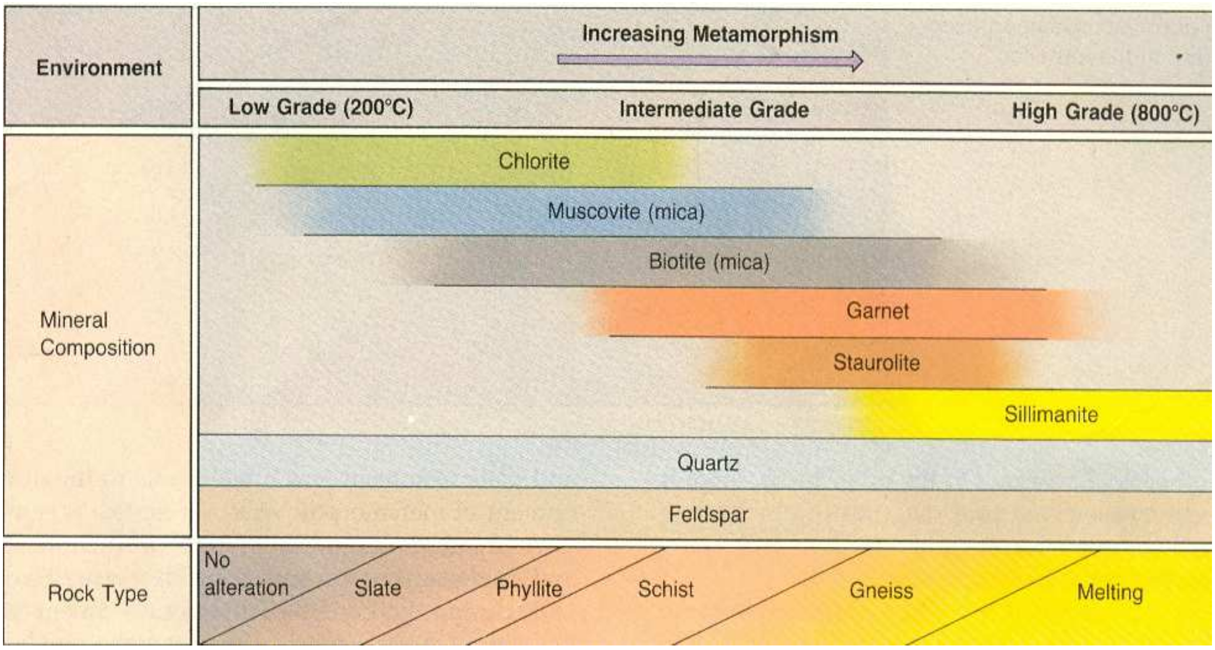

Figure 12 .The variation of mineralogical composition on the metamorphism degree (From Bush, 1990)

In the schist samples, alongside quartz and feldspar, which are mandatory ingredients, we notice the presence of some indicator minerals, biotite and chlorite (29 - 33%) and muscovite (3 - 5%) and the quasi-absence of garnets (analysis has shown that it is present as traces, insignificant, between 0.007 - 0.01% of the rock mass). The lack, in the rock, of indicator minerals for the kata metamorphism (high intensity metamorphism), such as garnets or staurolite, the presence of muscovite, but the supremacy of biotite over muscovite, lead us to conclude that the rock is a meso-metamorphic schist, the result of a low - medium intensity metamorphism. The existence of chlorite is mostly secondary, due to biotite.

4. CONCLUSIONS

These rocks are included in the category of the quartz-feldspar crystalline schist with biotite and muscovite with a lepido-granoblastic structure (lepido-granoblastic layers).
The rocks are meso-metamorphic schists, the result of a low-medium intensity metamorphism. We classify this meso-metamorphism in a more incipient status, as garnets lack.
Regarding the existence of feldspar in large volumes in the texture of these schist (20-24%), we can say that it favors the occurrence of clay minerals (residual clay) of through their chemical decomposition.
The alteration of the primary minerals (chlorite) under the action of humidity and of the oxygen in the air is very advanced in the older scree; the desintegration and chemical alteration process of this older schist is hard and, at depths bigger than approximately 50-60 cm, there were no more interclastic spaces, which would ease the existence of some MSS specific living beings.

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