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# Mineralogic, Structural and Petrogenetic Considerations on the Igneous Acid Rocks Cross-cutting the Metamorphic Basement of the Northern Part of the Sebeş Massif

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## Abstract

*Over 250 small bodies of acid, dike-like rocks, cross-cut and/or follow the main metamorphic foliation in the Northern part of the Sebes Massif. Their spatial distribution suggests a close relationship with the Cărpiniş-Câpălna formation, also called "the Răşinari Shear-Zone" (RSZ). This paper presents the results of the microscopic study of one of these bodies, situated on the Sebeş valley, at about 3 km south from the Căpâlna locality. The microscopic study revealed the presence of different small xenoliths, the recurrent zoning of plagioclase and the digestion of quartz. These features suggest that magma generating the studied petrographic body suffered contamination and even possible assimilation during its ascent, these processes modifying the composition of the melt during crystallization. The spatial relationship with the RSZ suggests that the emplacement of the bodies was structurally controlled and possibly even generated by the activity of the shear zone.*

**Key words**: *petrography, igneous rocks, Sebeş Massif*

## Introduction

The basement of the Sebeş-Cibin Massifs mainly consist of mezo-metamorphic rocks belonging to the Sebes-Lotru group, a pile made up of four main petrographic formations, which structurally upward are: i) augen gneisses, ii) micaceous gneisses, iii) quartzo-feldspatic gneisses containing lenses of peridotites and amphibolitized eclogites and iv) micaschists with levels of manganiferous rocks. The augen gneisses are found as core-domes [4] that are roofed by quartzo-feldspatic rocks. The pre-Alpine metamorphic evolution of the Sebeş-Lotru group consists of two medium-grade regional metamorphic events (M1 and M2), which were revealed by mineralogical and textural studies. The M1 event is evidenced by the presence of some relict mineral assemblages: biotite + oligoclase I + garnet I (in gneisses) and biotite + kyanite + staurolite + garnet I + oligoclase I (in micaschists). The M2 event is represented by the following assemblages: muscovite + oligoclase II + K-feldspar + epidote (in gneisses) and muscovite + oligoclase II ± sillimanite ± garnet II (in micaschists). The structural discontinuities in the Sebeş-Lotru Group became places of deformation concentration during the metamorphic event M2. Thus, the structural discontinuities behaved as shear zones, except the limit between the quartzo-feldspatic gneisses formation and micaceous gneisses formation.

One of the mentioned shear zone is the Răşinari Shear Zone [5]. It vertically cross-cut the metamorphic rocks pile of the Sebes-Lotru Group and spatially fits the Cărpinis-Căpâlna formation (mezo-metamorphic series, dynamically retrogressed). Mainly chlorite-bearing micaceous gneisses outcrop in the RSZ. The rocks affected by the shear zone show different combinations of plastic and brittle deformation as an overprinting result of a later brittle Alpine deformation, superposed on pre-Alpine, ductile deformation which is considered to be developed approximately during the M2 event. The ductile deformation stage turned the micaceous gneisses into biotite-bearing blastomilonites. Toward the axial plane of the RSZ, the ductile deformation increased and produced the breakdown and then recrystallization of the Mg-Fe silicates within the micaceous gneisses. The brittle deformation stage is due to an extensional stress that produced faults associated with cataclasis and metamorphic retrogression of the pre-existent minerals. Thus, carbonatation and hydration reactions in the gneissic and micaceous rocks produced low grade metamorphic assemblages consisting of chlorite, albite, ilmenite and rutile.

Spatial related to the RSZ occur over 250 bodies of small igneous porphiric bodies (fig. 1). Their frequency is higher near the central axis of RSZ, and their majority is located between Sibişel Valley at West and Sebeş Valley at East. These igneous bodies were studied from the petrographical point of view by Pavelescu (1955), Chivu (1968, 1970, 1973, 1977), Hârtopanu (1986), and more recently by Cioflică et al. (1981), Lupulescu et al. (1991) and Dobrescu (1994, 2001).

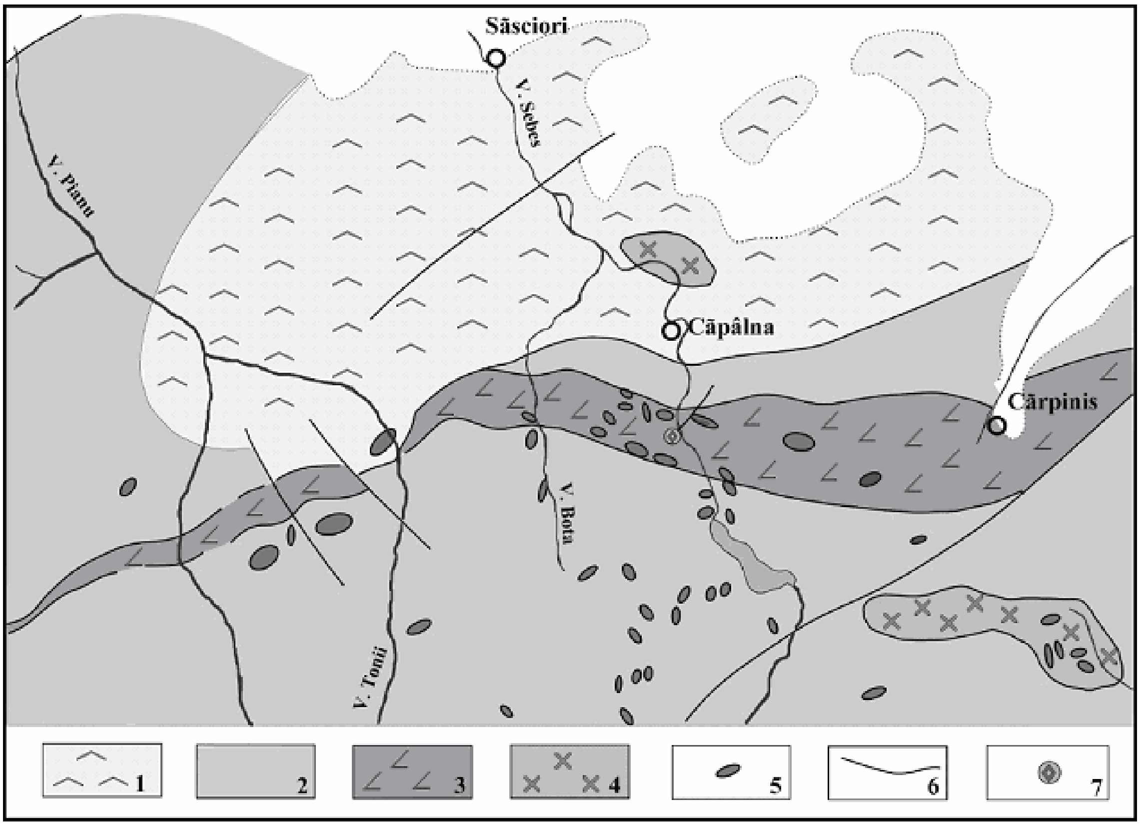


**Fig 1**. Map sketch of the Căpâlna Region - Northern part of the Sebeş Massif:
1 – Oligoclase biotite banded and augen genisses; 2 – Muscovite biotite paragneisses;
3 – Răşinari Shear Zone; 4 – core-domes of granitoidic gneisses;
5 – Granodioritic igneous bodies; 6 – Tectonic limits;
7 – Studied igneous body (after Stelea [7]).

The studied rocks were first described as quartz-porphyres (Pavelescu, 1955) and then porphyric microgranodiorite, dacites, porphyric granites or tonalites (see [2],[3]). Dobrescu [3], based on geochemical and isotopical studies, concluded that the magma which generated the igneous studied rocks was formed by partial melting of a mantle source or a lower crustal source, possible such as basalts, quartz bearing eclogites, garnet bearing amphibolites or mafic granulites. The magma ascent was interpreted as fast, so that no fractional crystallization or other differentiation process could have occurred, as well as no favorable condition for contamination.

The present study concerns with one of these acid igneous body situated on the Sebes Valley, at approximately 3 km South of Căpâlna locality (fig. 1). The studied body is a dyke of about 4 m thickness, cross-cutting the metamorphic rocks. Thin sections were made from the collected samples, and were microscopically studied under the polarized light. The present study points out some petrographical and textural features that are incompatible with the fast ascent and no contamination hypothesis of Dobrescu [2],[3].

## Petrographical Features of the Studied Rocks

The studied igneous rocks (fig. 2) presents continuous variations from phaneritic porphyric texture in the core part of the body to aphanitic, porphyric textures in its periphery (the matrix in the core part of the body is larger crystallized). Millimetre sized fenocrystals of quartz and feldspar float within a light-grey matrix. Generally, the feldspar phenocrysts are larger in size then those of quartz. The texture is massive and compact. There are thin, rare joints filled with secondary carbonates.

The microscopic study of the phenocrysts shows that:

- The quartz phenocrysts are both euhedral and anhedral. The shape of euhedral sections suggest hexagonal prisms ended with pyramids (fig. 3). Some of the anhedral phenocrysts are obviously affected by igneous resorbtion, preferentially tracking certain crystallographic directions (fig. 3 and 5).
- The plagioclase phenocrysts occur as both zoned and relatively unzoned grains, where the most frequent are the zoned ones (fig. 6). Most of the feldspar phenocrysts are polysynthetically twinned. At some of the zoned phenocrysts, a rim of albite was observed. Some of the plagioclase phenocrysts are altered, clay minerals, the sericite and calcite being the secondary products. Preferentially localized alterations with clay minerals on some feldspar phenocrysts are indicative for the recurrent zoning (fig. 7).
- The biotite has been rarely found as phenocryst (fig. 9).
- The hornblende is present as rare ruiniform phenocrysts and it is strongly altered to chlorite + epidote secondary products (fig. 10). In the unaltered parts of these phenocrysts, the characteristic pleocroism and birefringence colors can still be observed.
- Primary, igneous epidote has rarely been found as small phenocrysts (fig. 12).

The fine-grained groundmass of these igneous rocks (photo 3, 8, 9) is made of anhedral crystals of quartz, plagioclase, K-feldspar, biotite and muscovite. The preponderant crystals are those of acid plagioclase followed by quartz and K-feldspar. The muscovite crystals are extremely rare.

The accessory minerals are: zircon, apatite and rutile. Zircon was found as very small crystals included in plagioclase and biotite. Early crystallized from the melt, it was included in some later formed phases. Apatite was identified as marginal inclusions in the plagioclase phenocrysts (fig. 11), while rutile occurs as small, thin needle crystals included in biotite.

The secondary minerals are: clay minerals, calcite, sericite, epidote, chlorite and opaque minerals. Clay minerals developed on the expense of plagioclase phenocrysts (fig. 7 and 12); Calcite and sericite are resulted from the alteration of some parts of the plagioclase phenocrysts (fig. 8); Epidote, chlorite and opaque minerals resulted from the alteration of the hornblednde phenocrysts (fig. 10). Some chlorite also developed on the expense of biotite (fig. 11).

Other important microscopic features of the igneous rocks:

In the analyzed rocks there was noticed the rare presence of some rock fragments (hollocrystaline aggregates), consisting of microcline-perthite, quartz and strained muscovite (fig. 15). The texture and mineralogical composition of these fragments indicate that they were not formed by crystallization of the melt which generated the studied rocks. They can be classified only as xenolithes.

Relatively frequent are the overgrowths of quartz on quartz (fig. 13) and of plagioclase on plagioclase (fig. 14).

Concerning the igneous crystallization order it can be mentioned that the first felsic minerals that started to grow are the quartz or the plagioclase. The K-feldspar is present exclusively in the groundmass in the spaces between the acid plagioclase and quartz microcrystals, being the last felsic to crystallize. Among the mafic minerals, the zircon was most probably the first to crystallize followed by the hornblende and biotite.

## Petrographic Classification of the Rock

According to the IUGS classification (1989) for igneous rocks such a rock in classified based on the modal composition – the ratios between the volumes of the felsic minerals. Taking into account the volume ratios and that the rock has a content of mafic minerals smaller than 90%, the correct petrographic names are: *biotite microgranodiorite* for those parts of the igneous bodies where the texture is phaneritic and *biotite dacite* for those parts of the igneous bodies where the texture is aphanitic.


**Fig 2**. Macroscopic texture of the studied rock

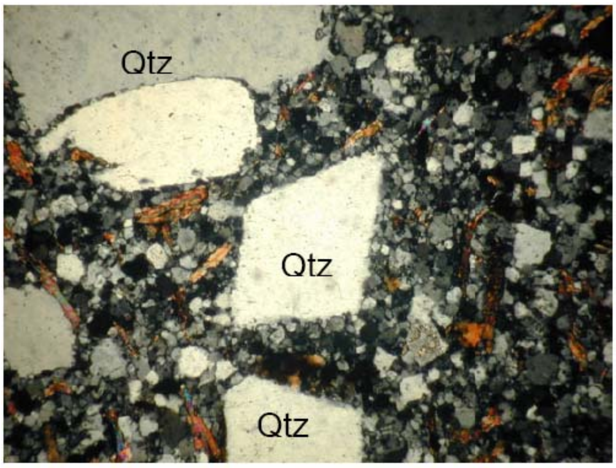


**Fig 3**. Quartz phenocrysts and groundmass containing small amount of biotite (N+, 40X)

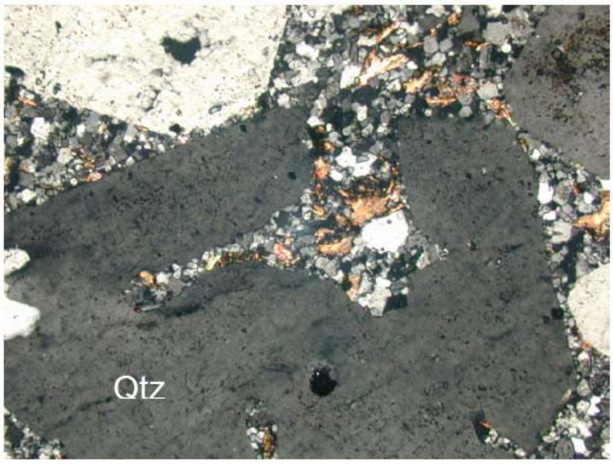


**Fig 4**. Partially resorbed quartz phenocryst (N+, 40X)

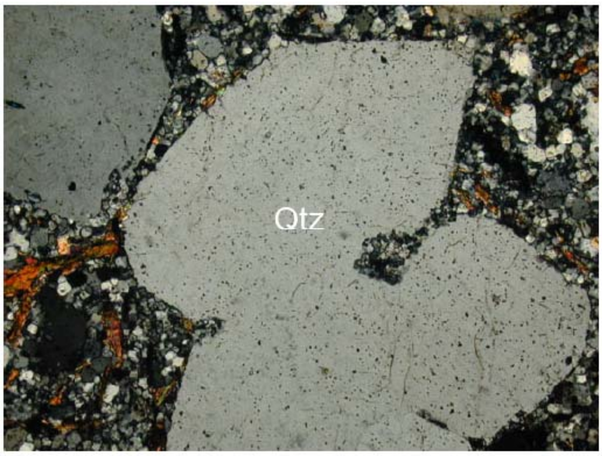


**Fig. 5**. Partially resorbed quartz phenocryst (N+, 40X)

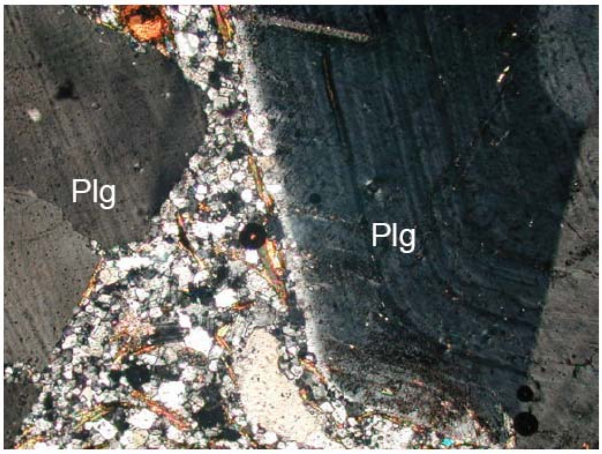


**Fig. 6**. Plagioclase phenocrysts – the right one is Karlsbad twinned and zoned (N+, 40X)

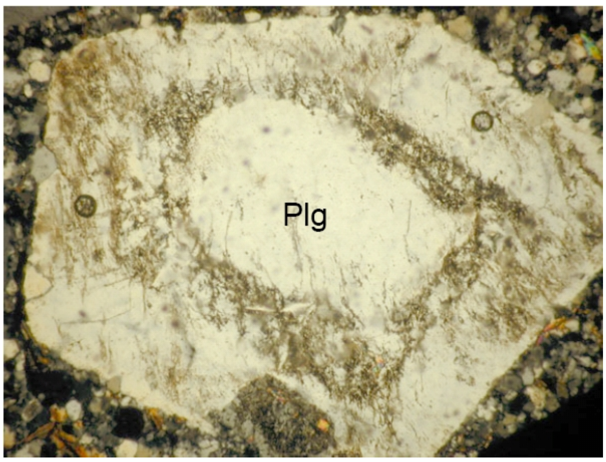


**Fig. 7**. Plagioclase phenocrysts preferentially altered to clay minerals on its most basic part (N+, 40X)

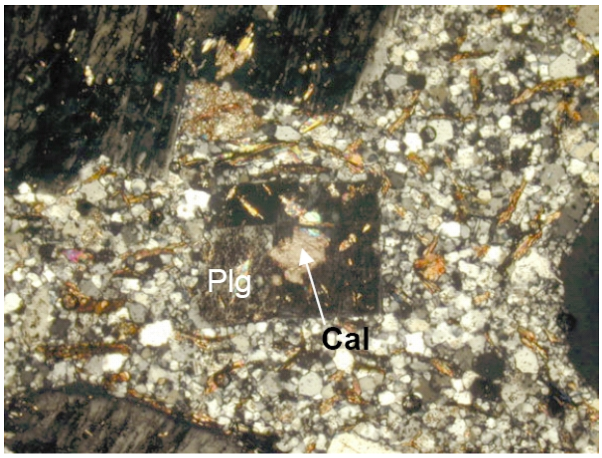


**Fig. 8**. Plagioclase phenocryst with secondary calcite in its centre (N+, 40X)

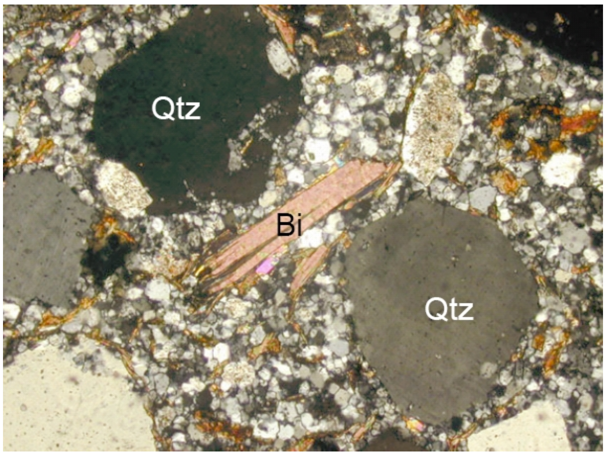


**Fig. 9**. Biotite phenocryst, near anhedral quartz phenocrysts (N+, 40X)

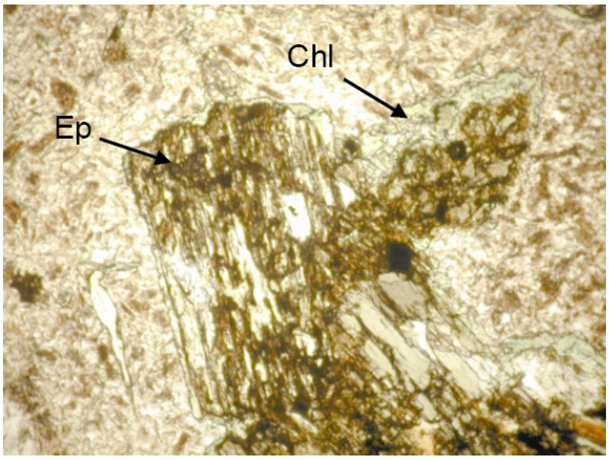


**Fig. 10**. Green hornblende phenocrysts almost completely replaced by epidote and chlorite (N||, 40X)

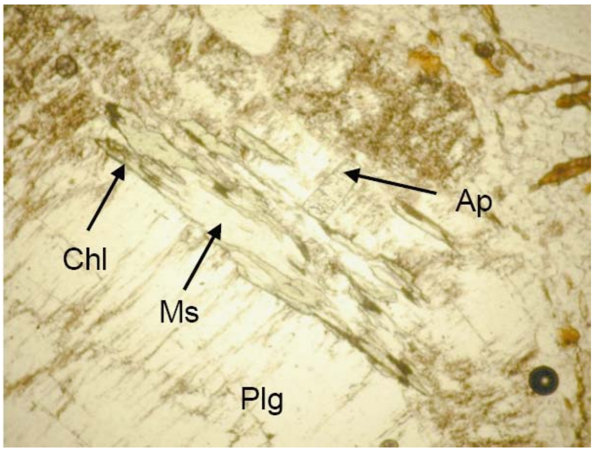


**Fig. 11**. Clorite, muscovite and apatite marginally included in plagiocse phenocryst (N||, 40X)

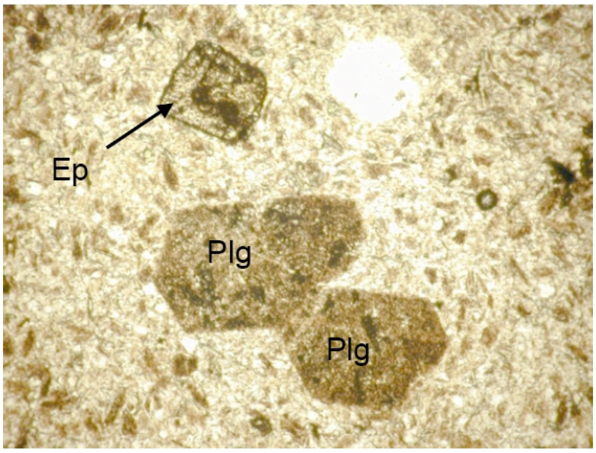


**Fig. 12**. Rare phenocrysts of primary epidote near plagioclse phenocrysts completly altered to clay minerals (NII, 40X)

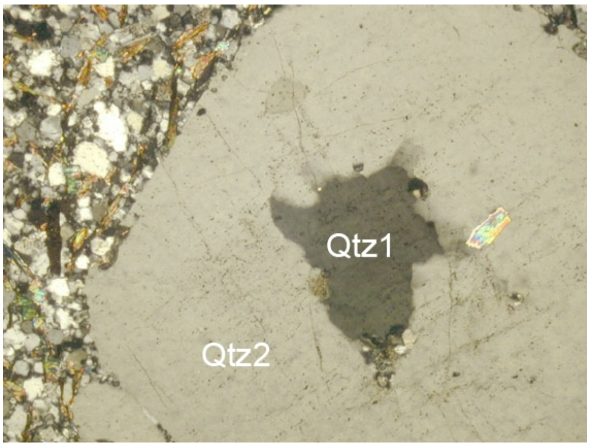


**Fig. 13**. Phenocryst consisting of quartz overgrowth (Qtz2) on quartz (Qtz1) (N+, 40X)

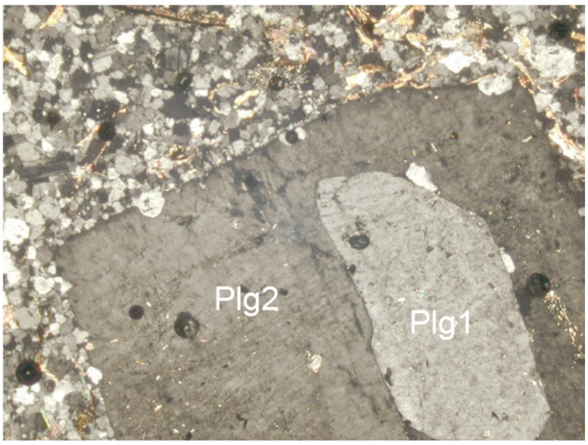


**Fig. 14**. Phenocryst consisting of plagioclase overgrowth (Plg2) on plagioclase (Plg1) (N+, 40X)

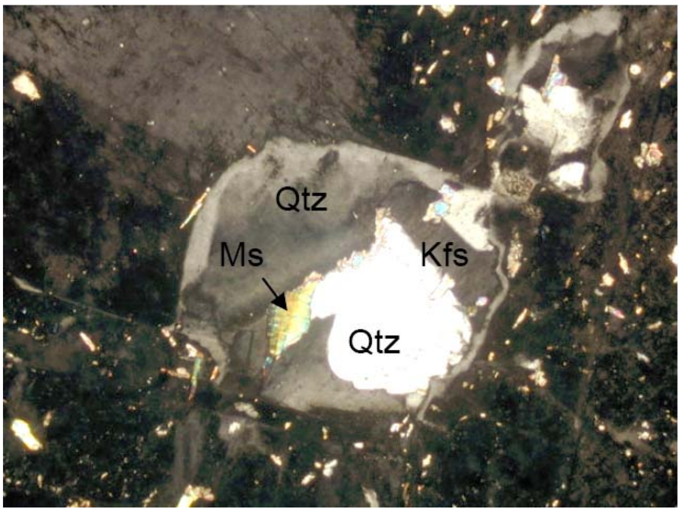


**Fig. 15**. Xenolith composed of microcline-perthite, quartz and strained muscovite (N+, 100X)

## Discussions and Conclusions

The presence in the studied igneous rocks of some xenoliths consisting of microcline-perthite, quartz and strained muscovite (fig. 15) clearly suggests assimilation processes by the magma. The overgrowths of quartz on quartz (fig. 13) and plagioclase on plagioclase (fig. 14), as well as the recurrent zoning of some plagioclase phenocrysts (recurrent zoning being marked by the preferentially localized alterations with clay minerals – fig. 7) strongly suggest that the contamination and assimilation processes were responsible for the compositional changes of the parental magma during crystallization.

Concerning the deep origin of the protolite, it can be accepted that a crustal material (not a mantelic one) has melted. The Raşinari Shear-Zone could have provided this opportunity: by a local increase of temperature in the presence of water, metagranite bodies (so common in the Sebeş metamorphic formations) could have reached the melting point. As it is well known [1] the presence of some melts and the releasing of some fluids have the role to localize the strain and consequently to start ductile deformations in a dominant simple shear tectonic regime (*i.e.* the formation of a shear zone). In accordance with this idea, I can suggest that the spatial association of the igneous bodies and the Raşinari Shear-Zone is not accidental and that some incipient melting could have represented the cause for the initiation of the shearing process in the depth and development of the RSZ. As a feedback effect, the action of the shear zone at its deep levels locally produced the increase in temperature (by friction) and caused the reaching of the melting point of the metamorphic rocks and/or granitoids and thus the acid magma was generated. Furthermore, the emplacement of the magma was structurally controlled by the discontinuities created by the shear zone. On its ascent way, the magma could have incorporated fragments (xenoliths) from the metamorphic basement, which were partially melted, leading to the changing of composition during cooling and crystallisation.

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# Consideraţii mineralogice, structurale şi petrogenetice asupra rocilor magmatice acide care străbat fundamentul metamorfic al părţii nordice a masivului Sebeş

## Rezumat

*Peste 250 de mici corpuri tip dyke de rocă magmatică acidă, taie şi/sau sunt dispuse concordant cu principala foliaţie metamorfică în partea de nord a Masivului Sebeş. Distribuţia lor spaţială sugerează o strânsă relaţie cu formaţiunea de Cărpiniş-Căpâlna, de asemenea numită „Zona de Forfecare Răşinari" (ZFR). Această lucrare prezintă rezultatele studiului microscopic al unuia din aceste corpuri situat pe Valea Sebeşului, la aprox. 3 Km S de localitatea Căpâlna. Studiul microscopic a evidenţiat prezenţa a unor mici xenolite, zonalitatea recurentă a plagioclazului şi resorbţia magmatică a cuarţului. Aceste trăsături sugerează că magma care a generat corpul petrografic studiat a suferit contaminare şi chiar o posibilă asimilare în timpul ascensiunii sale, aceste procese modificându-i compoziţia în timpul cristalizării. Relaţia spaţială cu ZFR sugerează că punerea în loc a corpurilor a fost controlată din punct de vedere structural şi chiar generată de activitatea zonei de forfecare.*