NATURE AND PROVENANCE OF THE BUCEGI CONGLOMERATE PEBBLES. A PETROGRAPHIC APPROACH

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Abstract. This study deals with the provenance and identification of the pebbles belonging to the Bucegi Conglomerates (Albian, Carpathian Bend area). More than 150 thin sections were examined, the samples including magmatic, metamorphic and sedimentary pebbles sampled from 12 occurrences located in the Bucegi Mountains. The classification schemes recommended by IUGS were used for the petrographic identification of the magmatic, metamorphic, and sedimentary clasts. The frequency of the major petrotypes is the following: 70% sedimentary lithoclasts; 10% plutonic lithoclasts; 2% volcanic lithoclasts and 18% metamorphic lithoclasts. The study defines the petrogenetic, mineralogical, structural and textural markers, which represent the basis for areal correlation and comparative analysis with the rocks of the presumed source-areas. The identified petrographic spectrum is diverse and includes volcanic rocks, such as trachytes and rhyolites, basalts, eclogites and serpentinites as exotic elements. The petrographic markers used for the comparative analysis are: feldspar symplectites, biotite chloritization and the methamictic structures generated by the radioactivity of the zircon inclusions, the helicitic structures from albit and garnets, and the quartz and mica mechanical distorsions. The conclusions point to the existence of source-areas showing the petrographic spectrum of the present-day Leaota and Perşani Mountains. Eroded or subsided zones made of metamorphites, granitoids with secondary albite on potasium feldspar, red and metamictic biotite (MG1, MG2), calc-alkaline volcanic rocks and ultrabasites also acted as provenance areas for the investigated Bucegi Conglomerates.

Key words: Bucegi Conglomerates, Albian, Carpathians, Romania

1. INTRODUCTION

1.1. Principles and historical developments

The siliciclastic sediments, in general, and especially, the rudites include extensive information regarding their provenance areas. During the burial phase, the sediments have been lithified, while through exondation, the information on their history becomes available. Consequently, the sandstones and conglomerate clasts are highly interesting for their capacity to highlight the source-areas of the deposits.

Zuffa (1985) and Valloni and Mezzadri G (1984) are among the first scientists to systematically use the mineralogical nature of the clasts, in order to reconstruct their provenance areas. The "sandstone provenance" field was shaping up. Later, Dickinson and Suczek (1979) launched the *tectofacies* concept. They used the mineralogical nature of the clasts, respectively the **Q**-quartz – **F**-feldpar – **L**-lithic pattern, to suggest the source-area in the frame of global tectonics: *craton* (continental block), *recycled orogen, basement uplift*, and *island magmatic arc*.

Developping the "compared petrology" concept, Anastasiu (1984, 1986, 1992) attempted to clarify the origin of the green clasts from the East Carpathian flysch and molasse deposits. This was undertaken through cross-evaluation between the microstructural and mineralogical markers identified in the Cretaceous, Eocene, Oligocene and Miocene siliciclastic petrotypes, *versus* the Central Dobrogean rocks (Green Schists Zone; Mutihac and Mutihac, 2010), which were the supposed sources of the Moldavide (Săndulescu, 1994) sediments. This comparative analysis showed the petrographic diversity of the green schist elements and, consequently, of their provenance from other source areas than the Dobrogean one.

The Bucegi, Ciucaș or Ceahlău Albian conglomerates are polymictic in character, showing all the necessary characters of their clasts in order to allow the investigation for the source-areas reconstruction.

The Bucegi Mountains extensive outcrops have been always a challenge for the geologists: for stratigraphers, paleontologists, tectonicians and sedimentologists. A review of the published papers reveals the scarce information on the mineralogy and petrography of the Bucegi Conglomerates clasts. The aim of this paper is to use the petrographic approach for the reconstruction of the palaeosources which supplied the Carpathian Bent sedimentary basin, Albian in age. The unpublished Ciocârdel (2010) thesis embraces this subject.

1.2. Stratigraphic and sedimentological setting

Under the name of Bucegi Conglomerates is usually understood a rudaceous accumulation with a large development in the Carpathian Bending zone, especially known in the Bucegi Mountains (Fig. 1). Because they are overlying the Late Aptian-Early Albian deposits and that they are overlayed by Vraconian (Late Albian) deposits, the Bucegi Conglomerates were dated Albian in age (Murgeanu and Patrulius, 1957; Patrulius, 1969; Melinte-Dobrinescu and Jipa, 2007; Briceag *et al*., 2009).

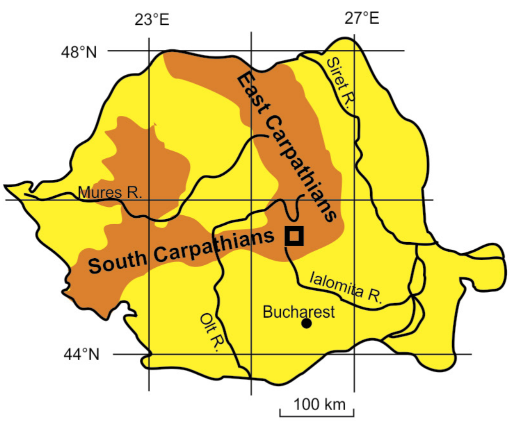
From the Albian sedimentary succession, almost 2000 m in thickness, of the northern part of the Bucegi Mountains, Murgeanu and Patrulius (1963) separated the following litho-stratigraphic units: the Lower Bucegi Conglomerates, the Middle Bucegi Conglomerates (MBC), the Upper Bucegi Conglomerates and the Babele Sandstone (Fig. 2).

Recently, Jipa *et al*. (2013) revised the Murgeanu and Patrulius (1963) lithostratigraphic scheme, in terms of the IUGS stratigraphic nomenclature. In this concept, the Bucegi Conglomerates is a formation-rank unit which includes in succession the Middle Bucegi Conglomerates, the Upper Bucegi Conglomerates and the Babele Sandstone, as litho-stratigraphic members (Fig. 3).

The rudaceous deposits, named by Murgeanu and Patrulius (1963) the Lower Bucegi Conglomerates, are considered by Jipa *et al*. (2013) a Late Aptian facies, which is not a part of the Bucegi Formation. The Bucegi Conglomerates scheme of Murgeanu and Patrulius (1963), revised by Jipa *et al*. (2013), applies only to the Albian deposits of the northern Bucegi Mountains. In the broad area of the Bucegi Formation, including, not only the Bucegi Mountains, but also the southern Leaota Mountains, more member-rank lithostratigraphic units occur (the Scropoasa-Lăptici Sandstone and the Runcu-Coman Sandstone).

From a tectonical point of view, the Bucegi Conglomerates are the effect of extensive uplift processes, active during the Neo-Austrian orogenesis (Murgeanu *et al*., 1963; Patrulius, 1969; Săndulescu, 1988).

The earliest sedimentological investigations, undertaken by Panin *et al*. (1963), Murgeanu *et al*. (1963), Mihăilescu *et al*. (1967), and Patrulius *et al*. (1967), showed that the Albian conglomerates from the Carpathian Bend area formed a large rudaceous fan. This fan is made, not only by the Middle Bucegi Conglomerates, but also by the synchronous and syngenetic conglomerates from the Ciucaş, Postăvaru-Piatra Mare, Perşani and Baraolt Mountains. In this framework, these authors considered that the Bucegi Conglomerates were accumulated in a shallow marine environment.



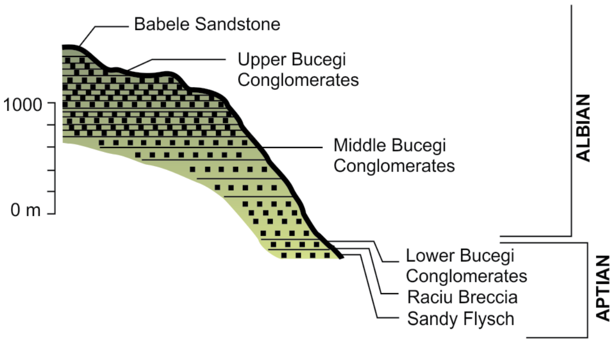


Fig. 2. Aptian-Albian sedimentary sequence, the northern part of the Bucegi Massif (based on Patrulius, 1969).

To the base of the debris flow texture of the Bucegi Conglomerates, Stanley and Hall (1978) argued that the accumulation of the Bucegi Conglomerates took place in the infraneritic or bathial environment of the submarine continental slope. According to Olariu *et al*. (2014), only the Middle Bucegi Conglomerates are to be assigned to a base-of-slope, deep marine environment. The Babele Sandstone deposits, much finer grained and showing frequent current lamination, are considered shelf accumulation.

The Middle Bucegi Conglomerates and, partly, the Upper Bucegi Conglomerates are studied in this paper.

1.3. Methodology

The 200 km^2 investigated area is marked by the following geographic coordinates: 45° 27′ 59″N - 45° 19′10″ S and 25° 36′18″N - 25° 31′46″E . The sampling was undertaken between the Mălăeşti River and the Păduchiosu Mountain (Fig. 4), in the following 11 occurrences: Păduchiosu Mountain, Vârful cu Dor, Furnica, Piatra Arsă, Babele, Izvorului River, Jepi River, Valea Seacă River, Cerbului River, Mălăeşti River and Urlătoarea River. The Bucegi Conglomerate samples were collected from the the lower boundary level (about 1100 m elevation) to the upper level from the Bucegi Mountains plateau area (2100-2200 m elevation).

The collected samples (233), pebbles and coarse-grained matrix, were subjected to macroscopic and microscopic examinations. The purpose of these studies was to define the petrotypes with their magmatic, metamorphic or sedimentary nature, their mineralogical composition and their characteristic microstructures. The thin section study, undertaken on more than 150 thin sections, focused on the mineralogical composition of the samples, the ratio between the light minerals fraction (quartz, feldspar, mica, chlorite, amphiboles and others) and the heavy minerals fraction (garnet, staurolite, disthene, ilmenite, sphene and others), the degree of alteration of the minerals, the microstructures and textures, and the cracks affecting the pebbles. All these features represent important markers, essential for defining the genetic and spatial characteristics of the analysed petrotype (Plate I).

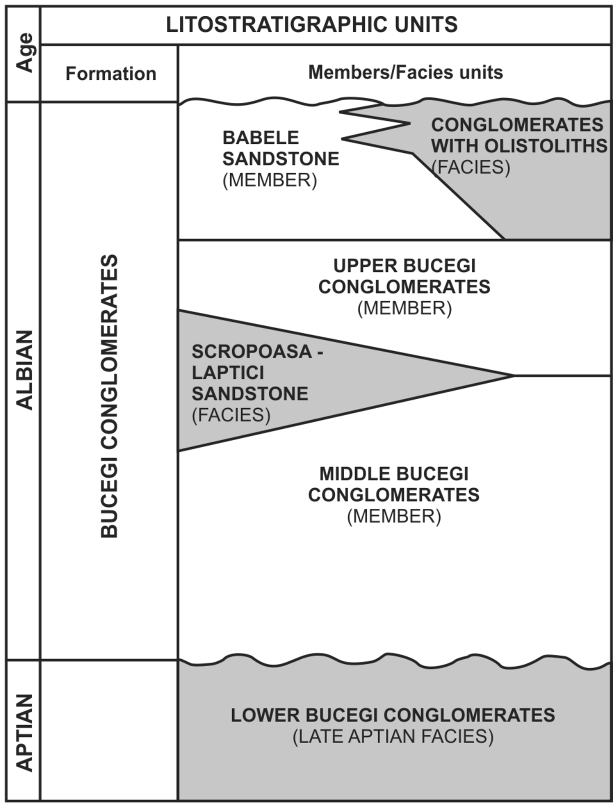


Fig. 3. Bucegi Conglomerates lithostratigraphic units (Jipa *et al.*, 2013).

Grain-size and morphometric evaluations of the pebbles were carried out, using the method of Krumbein and Sloss (1963), in order to identify the weathering degree achieved during the transport from the source-area, and to achieve supplementary criteria for source-area positioning.

1.4. Petrogenetic markers (mineralogy, petrography, microstructure)

The genesis context of the paragenesis is characteristic for the examined clasts (pebbles or petrotypes), and for their petrographic identification. To reveal the genesis context of the clasts, special examinations were applied to several significant minerals:

- for quartz inclusions: the presence of the ondulatory extinction, the degree of fissuration; symplectites and the possible corrosions have been carefully inspected;
- the plagioclase feldspar was studied for the anorthite content, and its possible zonality, for the type and degree of alteration;
- the potassium feldspar: a special attention was paid for the twin type, the extinction, exsolutions (perthites), graphic intergrowths, the alteration degree;
- in the case of mica, the optical study was focused on the degree of mechanical deformation, the biotite chloritization, the pleochroic haloes, the metamictic character, and the halo effects generated by the zircon inclusions.

Fig. 4. The sample location from the Bucegi Massif (Google Earth pictures).

The size variation, the roundness degree (Ro, or angularity index) and the massive, laminary, porphyric, nematoblastic microstructures (or textures) were the most important features surveyed in the case of the lithoclasts. For clasts larger than 1-2 mm, the composition and the relationships between the mineral components were identified, in order to recognize microstructural and textural features. In this way, the identification of petrotypes was accurately reached.

The IUGS-accepted classification systems regarding the magmatic, metamorphic, as well as the sedimentary rocks, were used (Costin and Ciocârdel, 2004; Anastasiu, 1998).

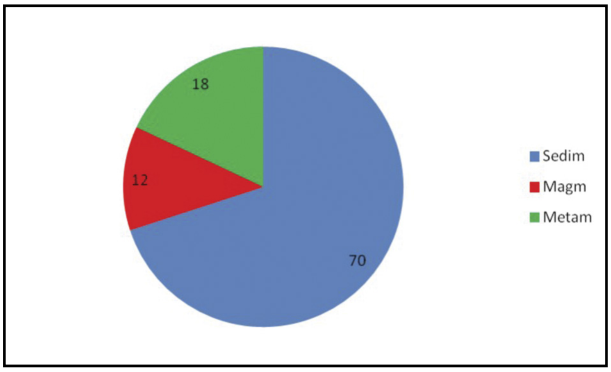


Fig. 5. Percentage (%) of the pebble petrographic categories for MBC (Middle Bucegi Conglomerates)

2. RESULTS

2.1. Description of pebbles

The petrotypes collected from the 12 Bucegi occurrences belong to all the three major petrographic categories (Fig. 5):

- *sedimentary lithoclasts* (Ls - 70%): limestones, sandstones, siltites, shales, silicolites;
- *magmatic lithoclasts* (Lp - plutonics 10% and Lv - volcanics 2%): granites, granodiorites, sienites, aplites, pegmatites, volcanics (trachytes, rhyo-dacites, ignimbrites);
- *metamorphic lithoclasts* (Lm - 18%): gneisses, paragneisses, phylites (chlorite schists, quartz - feldspar schists, epidotites), quartzites, albitites, amphibolites, cataclasites and mylonites, serpentinites, methagabbros.

The green rocks described by Murgeanu and Patrulius (1957), or the green schists cited by many authors are distinct petrogenetic groups. Their green colour is related to various paragenesis and other processes, from different tectonic and structural contexts. They are chlorite schists, chlorite-sericite schists, albite chlorite schists, serpentinites, epidotites and subordinated, magmatites and metamorphites with chloritized biotite.

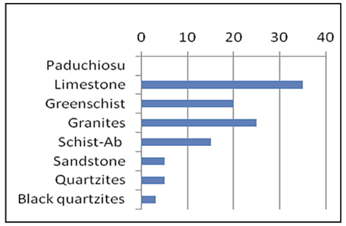
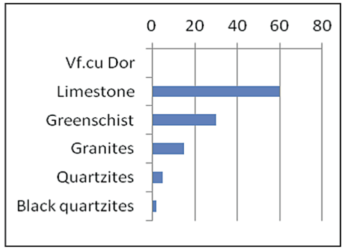
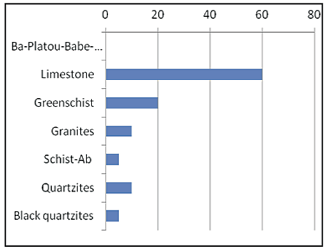
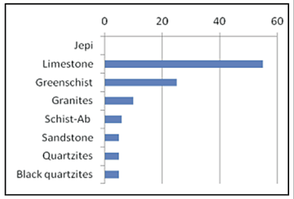
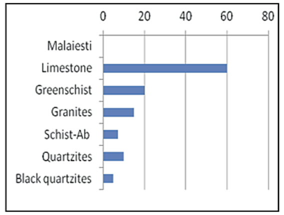
2.2. Grain-size, morphometric and petrographic features

The grain-size and morphometry characteristics reflect the degree and duration of the clasts weathering taking place during transport, from the the source-area transfer up to the sediments accumulation site. Both the size and the roundness (Ro) of the clasts varied extensively during a sedimentary episode, from megaclastic to arenitic values, and from well rounded (Ro: 0,9-1) to angular (Ro less than 0.2) (Plate II). Olistolithes of various sizes also occur, included within the conglomeratic sediment (Patrulius, 1969; Jipa *et al*., 2013).

The sedimentary lithoclasts collected from the Middle Bucegi Conglomerate sedimentary succession display the following features (Table 1):

- the limestone clasts (10-90%), from blocks to arenaceous size, with various roundness degrees (Ro = 0,1-1), belong to micrite, biosparite and biomicrite, pelmicrite, pelsparite, calcirudite and calcarenite petrotypes (Folk, 1974), or wackestone, packstone, grainstone, boundstone in the Dunham (1962) terminology. They are Triasic, Jurassic, up to Aptian in age, according to Patrulius (1969), who described crinoidal, glauconitic, bituminous and rudaceous limestone types;

Table 1. The petrotypes composition (%) of the Bucegi conglomerates from Păduchiosu Mountain, Vârful cu Dor, Babele, Jepi Valley şi Mălăieşti Valley stations.

Alt. m	Păduchiosul	Vârful cu Dor	Platoul Babe	Valea Jepi	Mălăieşti
2200 2034-2153 1798-2289 1812-2016 1477-1982 1820-1857 1293-1883 1557-1680 1642-1658 1388-1554 1295 800					

- the sandstone clasts (5-8%) are medium and fine grain-sized, with medium to very high sorted character and roundness degree of 0.3-0.9;
- the siltite clasts (1-2%) show very good sorting and variable muscovite (sericite) and chlorite content, and they appear with massive and parallel laminated microstructure;
- the claystones and massive clay (2%) appear as the base of the erosion channels or at the upper part of the conglomeratic units;
- the silicolites are accidental occurrences and represent fragments of crypto- or micro-crystalline silex or chaille. Radiolarian occurrence was not detected. The clasts are well rounded.

The magmatic lithoclasts are calc-alkaline and they represent petrotypes of granite, granodiorite, syenite, aplite, pegmatite and volcanic rocks (trachytes, alkali-feldspar rhyolite, ignimbrite, basalt (=diabase? Patrulius, 1969). These clasts occur as blocks or pebbles, with various roundness degrees.

The granites and the granodiorites are separated through the ratio between plagioclase and the potassium-rich feldspars (orthoclase and microcline) and through the anortite content of plagioclase minerals, which is higher in granodiorites. Their structures are holocrystalline, hypidiomorphic granular, and their textures are massive, unorganized. Quartz is lacking, pointing to syenites. The main petrographical markers are: potassium feldspars (microcline and/or ortoclase), with the genesis of pertites, Karlsbad twins and tartan twins.

Aplites are usually very fine-grained, allotriomorphic, with a white, grey or pinkish color index. Oligoclase is a white-plagioclase, while the potassic feldspar is an orthoclase. Biotite is very rare, and textures are unorganized.

Pegmatites can be recognized as a structural facies with largely crystallized granites, composed of interlocking hipidiomorphic phaneritic crystals, usually, larger than 2.5 cm in size; with pink feldspar (microcline) and graphics texture (ortoclase + quartz intergrowth has the appearance of runic writing). Currently, muscovite is not deformed.

Rhyolites are recognized by the presence of corroded quartz phenocrystals, of sanidine and of felsic matrix. The porphyritic structure is apparent. The corroded quartz and the felsic matrix represent an important petrogenetic marker (Fig. 6).

Trachytes are neutral volcanic rocks, with a microcrystalline structure and a fluidal texture. The potassic feldspar is sanidine, occurring close to oligoclase, and it is often Karlsbad twinned. The structure is porphyritic.

Ignimbrites or welded tuffs have rhyolithic or trachytic compositions, with a cryptocrystalline matrix, vitreous, with common fluid textures. Another marker for identification is the weathering of the vitreous mass, as it gradually passes into green celadonite.

Basalts (diabases?) or perhaps lamprophyre fragments are recognized through their aphanitic structure, the occurrence of olivine and pyroxene, and by their increased alkalinity of feldspars. They can get green, when subjected to changes with secondary chlorite and epidote.

Metamorphic lithoclastes (Lm - 18%) cover the amphibolite facies (medium pressure and average to high temperature), the greenschists facies (medium pressure and temperature) and anchimetamorphites. The identified petrotypes are: gneisses, paragneisses, micaschists, amphibolites, phyllite-greenschist (chlorite schist, quartz-feldspar-epidote shale), quartz, cataclasite and mylonite, serpentinite, eclogite, metasandstone, metabasites.

High degree metamorphic rocks (ocular gneisses, plagioclase gneisses, paragneisses, micaschists, and amphibolites) have granoblastic structures, ocular textures, linear or massive.

Microcline is the dominant potassic feldspar, along with white-oligoclase, biotite and muscovite. The ratio of these minerals controls the petrotype. The accessory minerals (heavy fraction) are ubiquitous: garnet, staurolite, zircon, sphene, rutile. Petrogenetic markers are distinguished: suture contacts, orientation of feldspar and quartz inclusions, poikiloblastic structures.

Low degree metamorphic rocks (phyllite - chlorite schists, chlorite schists with albite porfiroblasts, epidotites - quartzites) have microgranoblastic structures, strong schistosity (foliated structure), repeated mineralogical deformations (Fig. 7).

Dominant paragenesis groups: the undulatory extinction of quartz, chlorite and sericite with strong mechanical deformations, ocular albite, and paragenetic inclusions of minerals, less opaque minerals, pyrite and ilmenite.

Mylonites and cataclasites - metamorphic shear rocks formed through fracturing both high grade and low metamorphism rocks. The following retromorphic features are identifying these types:

- the occurrence of secondary or tertiary foliation generated by shearing;
- deletion of porfiroblastic structures;
- brittle deformation and rotation of albite crystals (ocular);
- generating rhythmic structures of alternating laminae with white quartz / albite / chlorite-sericite or muscovite-biotite;
- secondary metasomatic silica and calcite paragenesis;
- postdeformation recrystallization.

Eclogites and serpentinites can be recognized through their secondary products. Prime minerals - olivine, pyroxene, garnet - are substituted retromorphically by chrysotile-chlorite-epidote antigorite inducing the green colour. Minerals, such as amphibole-garnet-rutile-omfacite represent relict minerals. The structures are microbedding and simplectite.

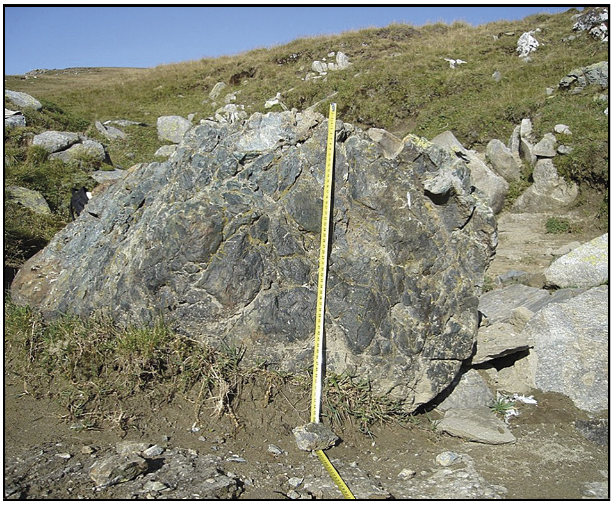


Fig. 6a. Serpentinite boulder with 1,1m diameter (Babele area; GPS: h=2129m).

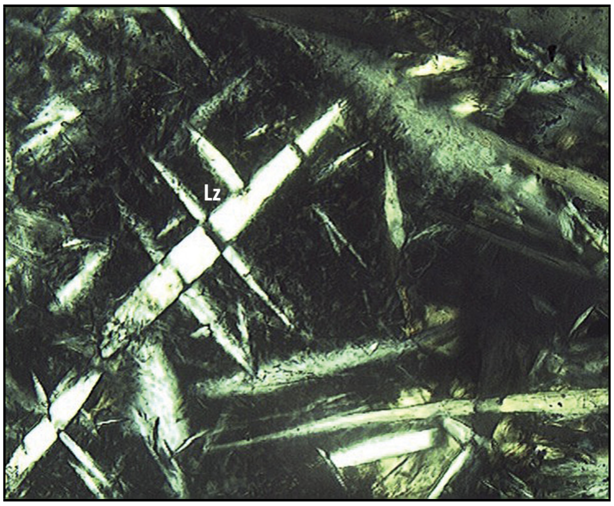


Fig. 6b. Serpentinite: antigorite and lizardit (Lz) Nc 250x.

Fig. 6c. Ignimbrite rhyolitic boulder (Urlătoarea Fall valley); GPS: h=1221m.

Fig. 6d. Rhyolite-Ignimbrite: Volcanoclast with corroded quartz in a matrix. Np 40x.

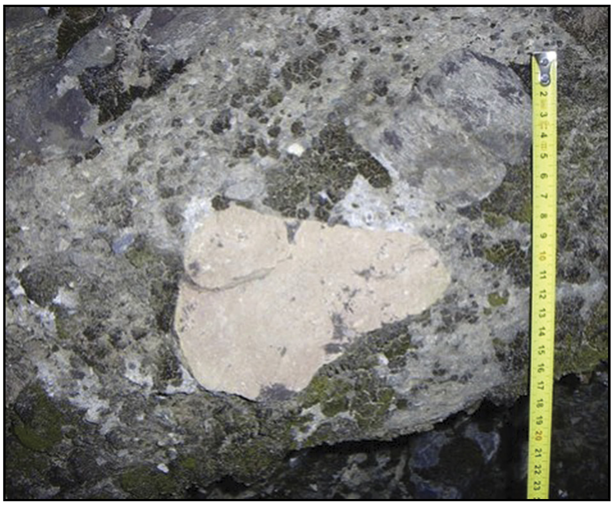


Fig. 6e. Trachyte boulder (Bucegi Plateau; h=1873m).

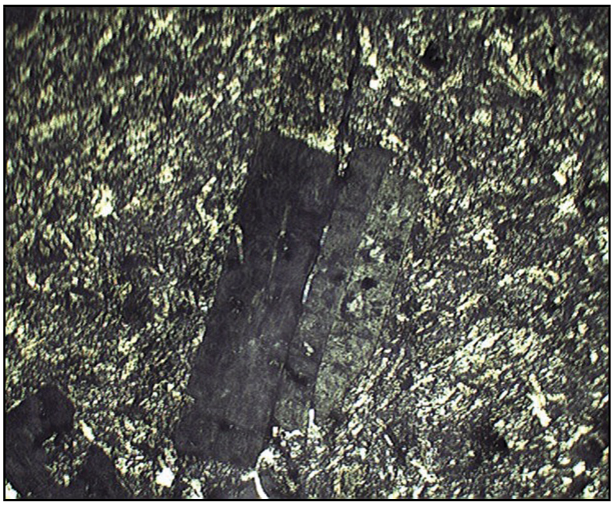


Fig. 6f. Trachyte with sanidine: fenocrystal Karlsbad twin. Nc 40x.

Fig. 6. Petrogenetic markers – exotic elements.

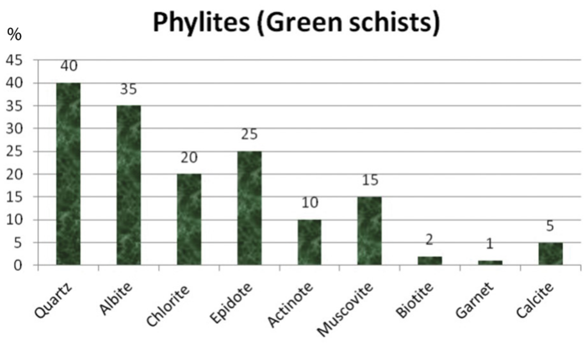


Fig. 7. Mineralogical composition of the green schists (phylites).

A small ratio of clasts is represented by metamorphic rocks: they were generated through early (progressive) metamorphism of certain igneous rocks (metagranites, metabasites) or of several sedimentary rocks (metasandstones). Early recrystallization of minerals and debris deformations are obvious processes.

2.3. Granoclasts from conglomerate matrix – qualitative and semi-quantitative examination

The conglomerate matrix (ground-mass) is a syndepositional product. Therefore, the nature of the source-area of conglomerates can also be identified by the composition of the matrix.

The qualitative and semi-quantitative microscopic examination revealed the features and nature of the matrix granoclasts, mostly, particles smaller than 1 mm in size, which can be noticed and identified (Ciocârdel, 2010).

The matrix arenitic granoclasts are well to poor sorted, with a low roundness index (Ro=0.1-0.3). Mineralogically, they are Qz, Ab, $Plg_{10\text{-}20\%\ An}$, Fk, Mu, Bi, Cl, Gr, Ep, Tu, Ru, Op, Ap, St; main minerals (Qz, Fdp, Mu, Bi) have specific inclusions, helicitic (snowball) structures, poikiloblastic, mechanical deformation, partial alterations.

The physiographic and optic characteristics of the matrix granoclasts (extinction, morphology, inclusions, alteration type, intergrowths) are similar with the features of conglomerate pebbles from the Jepilor River, Urlătoare River, Mălăești glacial sections.

3. DISCUSSION: PALAEOSOURCES AND PROTOLITHS

The data regarding the textural features (grain-size and morphometry), the petrographic diagnosis, the mineralogy and microstructure characteristics represent important information on the palaeosource-areas and their protoliths for the Middle Bucegi Conglomerates pebbles.

The basement of the Leaota Mountains is a presumed provenance area, which supplied the clastic material for the Lower Carpathian sedimentary basin. Our investigation proved that this crystalline area includes protoliths with mineralogical, textural and structural characteristics, features which are almost identical to the analyzed conglomerate clasts (Plate III). There is an unambiguous petrographic correspondence between many petrotypes of the Bucegi Conglomerates and the Leaota-type metamorphic rocks (described by Negulescu, 2006; Costin-Luffi, 2001; Săbău, 2000; Gheucă and Dinică, 1986; similar to our samples). The MG1 and MG2 metagranites, which were not identified in the present-day Leaota Mountain area, make an exception for this assessment.

We have to accept the idea that some petrotypes which do not have correspondents in the modern Leaota outcrops belonged to some eroded or buried compartments (the subaerial Leaota compartments; Ciocârdel, 2010).

The clastic petrotypes of the Middle Bucegi Conglomerates and the Leaota mineralogical and petrogenetic markers, on which the comparative analysis developed in this paper is based, are presented in Table 2.

The similarities between the pebbles and the assumed protoliths provide a good confidence ground to identify the Albian source-area of the Bucegi Conglomerates in the emerged terrains of the Leaota massif (Plate III).

Source distance (proximity) can be assessed using the roundness index (Ro) and size distribution of the poorly sorted, mature clasts:

- The sources were intermittently active, the intensity of weathering and the movement of clasts (regardless of agent and slope) had obvious relapses. Processing clasts and their maturation could occur within the basin through the lingering effect of waves on the sediment (clasts), followed by resedimenting processes. The mixed structures of the arenitic units may be a proof for this process;
- The petrographic nature of clasts (gravel, pebbles or cobbles), the defining paragenesis, the microstructures and textures allow direct correlations with still active sources. During the Albian, the sources occurred in the area of reworked orogenic belts, close to the sedimentary basin;
- The Albian sedimentary mixture, estimated through the most common petrotypes occurring from sources close to the basin, was undertaken based on exotic (volcanic) clasts from remote sources. The exotic clasts can be assigned to sources including alkali and calc-alkaline palaeovolcanites, no longer existing today. Those sources were certainly represented by temporary heights during the Albian.

Assuming pre-Cretaceous sequences (Triassic, Permian), in which volcanic clasts (trachytes, rhyo-dacites, serpentinites, eclogites) were recycled, is proven by the high degree of reworking of these volcanic clasts. Moreover, the first generation pyroclastic sequences with vitroclasts and bombs were not represented through the studied clastic elements.

Table 2. The lithoclast petrography (frequency, provenance areas and protolith similarity MBC)

	Lithoclasts from MBC	Frequency (%)	Protolith: possible provenance	No correspondence in active area	Petrogenetic markers; Protolith similarity
	V. Jepi - 2081 m, Vf. cu Dor - 1492 m; V. Izvorului - 1295 m; V. Seacă - 1000 m.				
1	**Limestones**	**10 – 90**			
2	**Sandstones**	**5 – 8**			
3	**Green philites (Ab-Cl-Ep)**				Selfsame paragenesis: Cl-Ep-+/-Act; Mu-Cl; the occurrence of secondary or tertiary foliation; Bi relict;
	Gneisses		**50-60**		
	Gneisses (plagioclase)		**5**	No correspondence	
	Phyllite-greenschist		**20-30**		
4	**Chlorite schists with albite porfiroblasts**	**3-6**	Valea Bolboci, Valea Urlătoarea		Selfsame paragenesis: Ab-Mu-Qz-Cl-Ap; orientation of feldspar and quartz inclusions, poikiloblastic structures.
5	**Albitites (Granofels)**		Leaota		Selfsame paragenessis, lens segregations
6	**Granitoides**	**5-15**	Valea Bughiței-Iezer, Valea Brăteiului		
	MG1			No correspondence	Selfsame paragenesis Fk is subtitued by Ab; red biotite, Plagioclase (Ab-Ol) is replaced by clay minerals
	MG2		Iezer-Păpușa-Făgăraș		
	MG3		Granites Albești		
7	**Micaschists**		Leaota Iezer-Păpușa		
8	**Quartzites**	**5**	Leaota		
8	**Black Quartzites**	**5**	From pegmatites, micaschists		Selfsame paragenesis next to Chlorite schists with albite porphyroblasts
9	**Amphibolites**	**1**	Leaota		
			Ab-Amphibolites		Selfsame paragenesis
	Metabasites	**1**		No correspondence	
	Serpentinites		Poiana Mărului - Leaota?		
	Epidotites			Reworked	
			Retromorphic Eclogites		Selfsame paragenesis
10	**Trachytes, Rhyolites**	**1-2**	Poiana Mărului, Brașov, Piatra Mare, Holbav	Partial correspondence	

An active carbonate platform with linear reefs and atolls, located close to the shore, operated cyclically, with different intensities. In the same time, the occurrence of atolls with steep slopes, next to the continental slope, explains the detachment motion of large limestone blocks, described as olistolites by most authors.

The occurrence of secondary, intrabasinal sources, buried today, must be also accepted. The result of qualitative and semi-quantitative analysis of granoclasts indicate their sindepositional, partly intrabasinal nature, generated by the progressive degrading of lithoclasts, and suggests a tectofacies indicating recycled orogens (Dickinson and Suczek, 1979).

Jipa *et al.* (2013) and Olariu *et al.* (2014) also support the idea of Albian active palaeosources, within the proximal shelf, next to the depositional centre (Leaota Zamura pass).

4. CONCLUSIONS

The aim of this paper is to identify the petrography of the Bucegi Conglomerates pebbles in order to define the provenance of their coarse-grained clastic material (Albian, Carpathian Bend area). The results of the optical study of more than 150 magmatic, metamorphic and sedimentary pebbles were correlated with known petrotypes from the areas close to the Bucegi Mountains, which were considered as possible source areas. Most of the sampled clasts belong to the Middle Bucegi Conglomerates, while only a small number of Upper Bucegi Conglomerates clasts were analysed. The optical investigation was supplemented with information on pebble size and morphometry, and with micro- and macro-structural analyses of the Bucegi Conglomerate sedimentary succession.

The investigation focused on mineralogic and petrographic markers (such as feldspar simplectites, biotite chloritization, metamictic structures generated by the radioactive zircon inclusions, albite and garnets helycitic structures, mechanical deformation of mica and quartz, etc.). These markers were used for correlations within the whole formation, and for the comparative analysis of potential provenance areas.

The conglomerate clasts revealed the petrographic diversity of the Albian source-areas, which supplied lithic fragments and granoclasts of magmatic, metamorphic and sedimentary rocks. The occurrence of exotic clasts (volcanic: trachytes and rhyolites, basalts, eclogites, and serpentinites), with petrogenetic and tectogenetic significance, is a factor outlining more accurately the provenance areas.

The comparative analysis revealed that the Bucegi Conglomerates clasts came from source areas similar to the Leaota and Iezer-Păpușa Mountains (Gherasi *et al.,* 1966), but also from provenance areas which are eroded or buried today. These unidentified source-areas include metamorphites, granitoides with altered potassic feldspars, biotite, metamictic red biotite (MG1, MG2), metamictic red [MG1, MG2 = metagranite 1, metagranite 2 (Iezer-Păpușa type)], calk-alkaline volcanic rocks and ultrabasites.

The processes which recycled pre-Cretaceous sediments and induced higher roundness degrees of the pebbles are considered. During the whole Albian, recurrent carbonate source-areas were active next to the ruditic sedimentation.

This analysis of the Bucegi Conglomerates provenance areas hints to similar studies related to the synchronous Ciucaș and Ceahlău Conglomerates, sharing similar geotectonic and depositional frameworks.

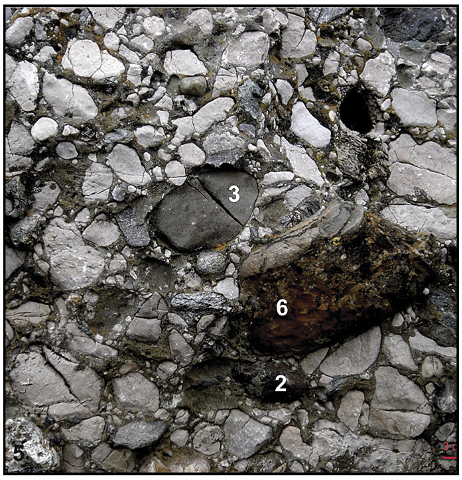
ACKNOWLEDGEMENTS

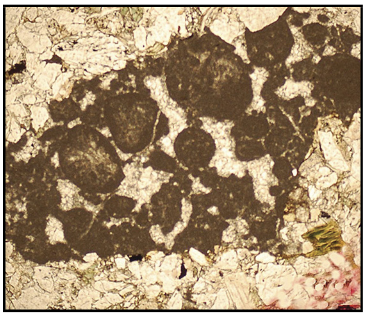
The authors express their gratitude to Mihai Emilian Popa, PhD, Geology and Geophysics Department, University of Bucharest, who has critically read the manuscript of the paper. This work was partly supported by a grant of the Romanian National Authority for Scientific Research, CNCS — UEFISCDI, project number PNII-PCE-2011-3-0162.

PLATE I

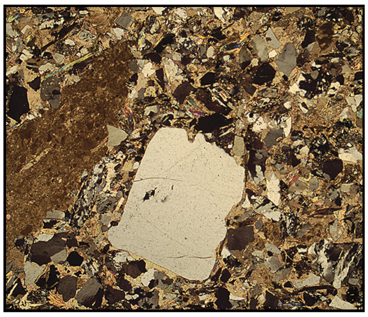
Microscopic Images (thin sections) on the Middle Bucegi Conglomerates lithoclasts, Jepi Valley.

Polimictic orthoconglomerates with carbonate lithoclast (1), green phylites (2), albitites (3), Ab-schists (4), granitoides (5), silicolites (6); Jepi Valley – J3 station.

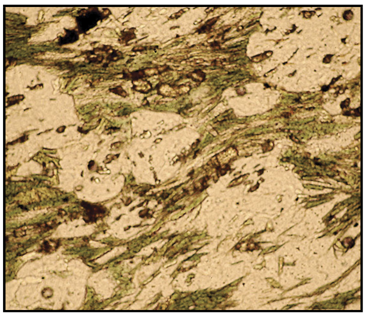




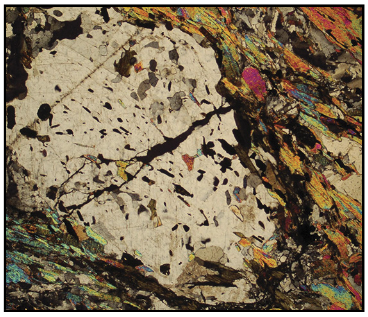
1 – Carbonate lithoclast – limestone, oopelsparite. Np, x 30.



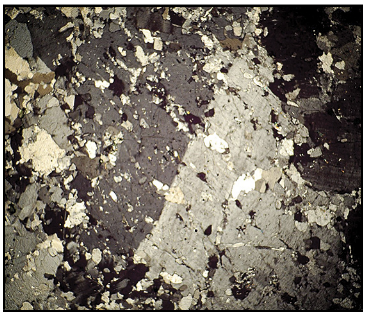
2 – Green phylites with quartz and siltite porphyroclasts. Nc, x 30.



3 – Albitite from green schists group, with Ab- porphyroclasts. Np, x 30.



4 – Quartz cracked with helicitic structure, and primary foliation. Nc, x 30.

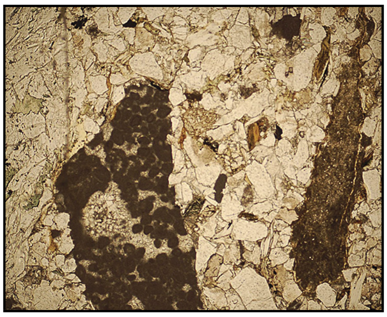


5 – Karlsbad twin in granitoides with biotite. Nc, x 40.

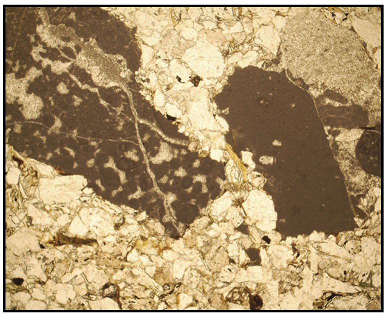
6 – Rectangular cracks filled with iron oxides. Np, x 40.

PLATE II

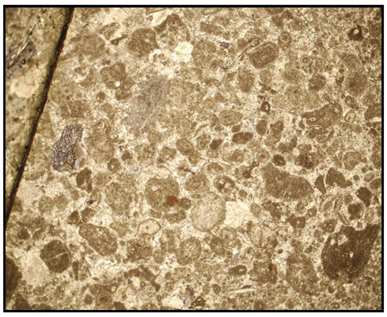
Microscopic Images (thin sections) with microstructuraly markers from the Middle Bucegi Conglomerates lithoclasts, FUS sequence, Jepi Valley.



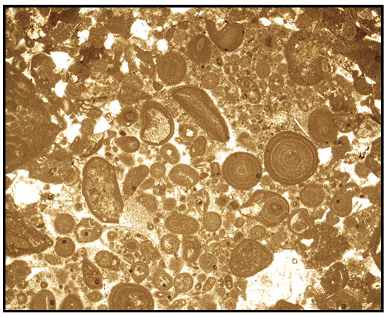
1 – Pelsparite rounded clast.
Np, x30



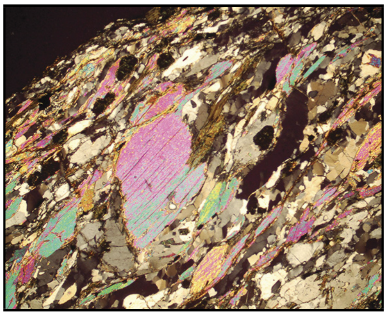
2 – Angular micrite and biopelsparite clasts.
Np, x30



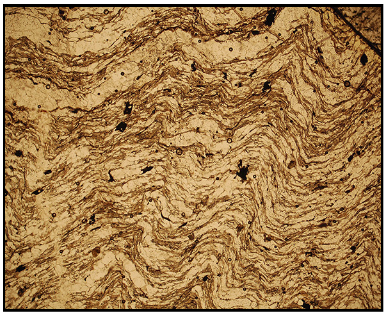
3 – Calcarenite no-organized structure.
Np, x20



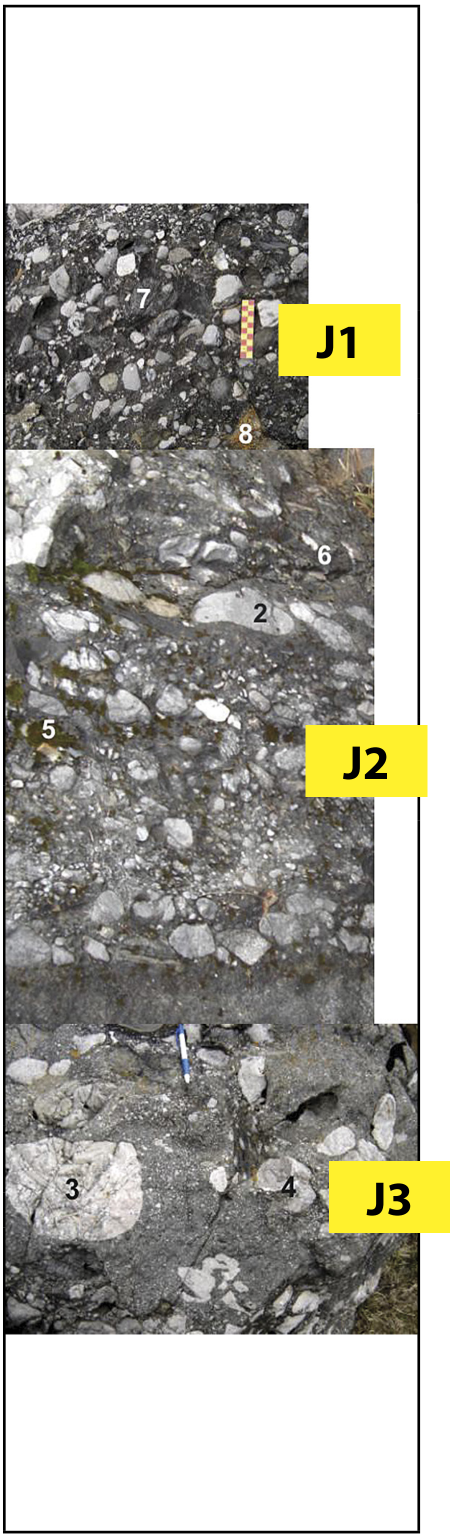
4 – Oopelsparite - low sorted.
Np, x20



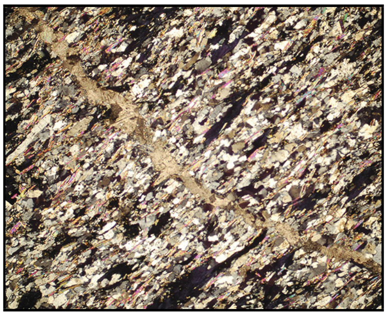
5 – Mu-micaschiste with good foliation.
Nc, x30



6 – King folds in phylites.
Np, x20



9 – Fining-up sequence (FUS) – Jepi Valley,
J1–J2–J3 stations.



7 – Calcite vein into chlorite phylites.
Nc, x20

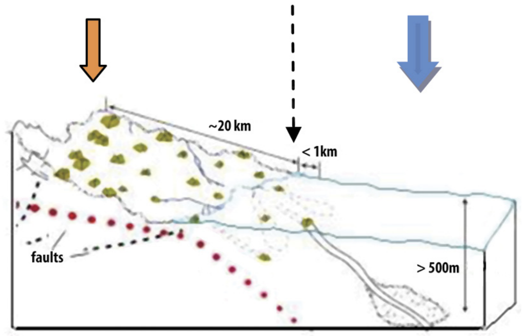
8 – Relict biotite in granitoides.
Np, 30

PLATE III

Mineralogical and structural markers; comparative presentation: samples from Leaota, Ob.Bolboci, Moeciu outcrop areas versus Bucegi conglomerates clasts.

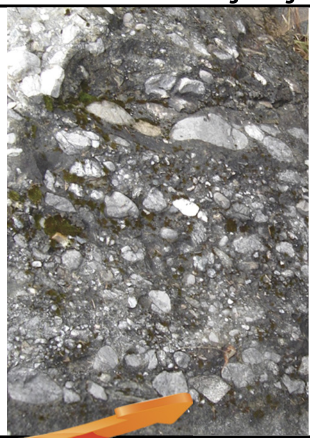
ALBIAN

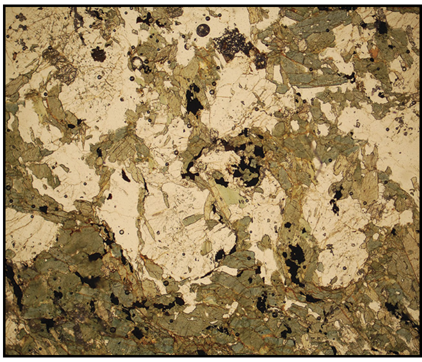
Palaeosuorce area | **Basin**



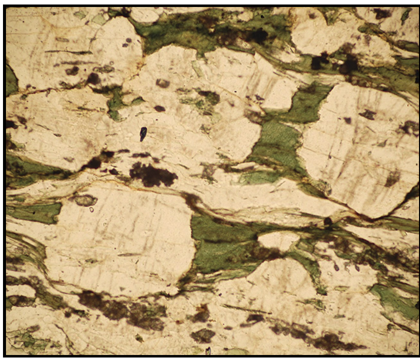
ACTUAL

Middle Bucegi Conglomerates

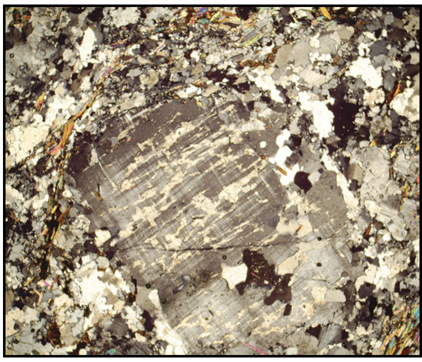




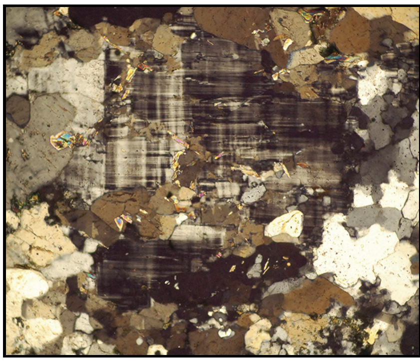
Mineralogy:
Ab-Cl-Qz-Op;



Mineralogy:
Ab-Cl-Qz-Op;
Albite porphyroblaste and chlorite overgrowth.

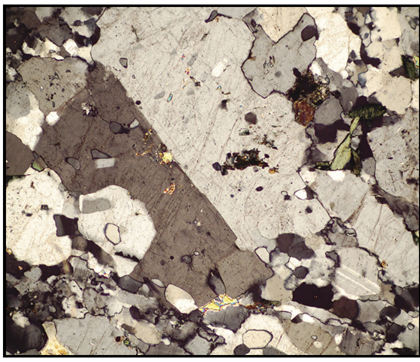


Mineralogy:
microcline phenoblaste in microcrystalline matrix (qz-fdp).



Mineralogy:
Mi-Ab-Qz-Bi;
grill twins and sutural boundaries.

Mineralogy:
K-feldspar with Karlsbad twin, allotriomorph.

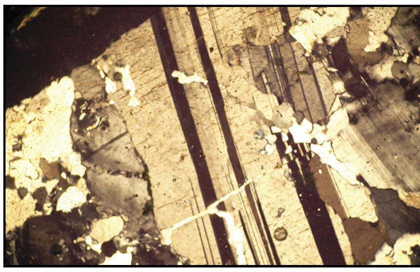


Mineralogy:
K-feldspar with Karlsbad twin, allotriomorph.
+**Qz-Ab** inclusions (megaporphyric).

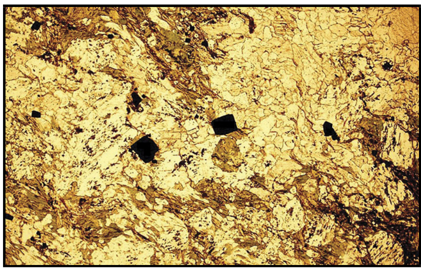
PLATE III

(continuation)

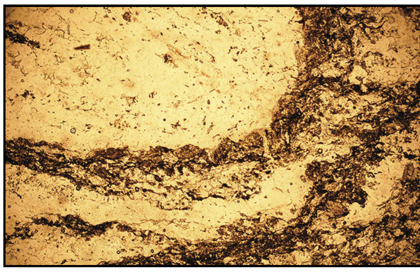
Mineralogy: Plagioclase pheno-blast (oligoclase) with Albit twin.



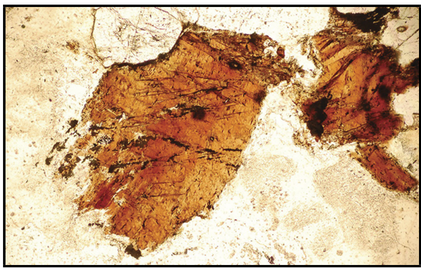
Mineralogy: **Ab - twin-Qz**; myrmekites; cracks.



Mineralogy: **Qz-Ab-Ep-Op** and microfold.

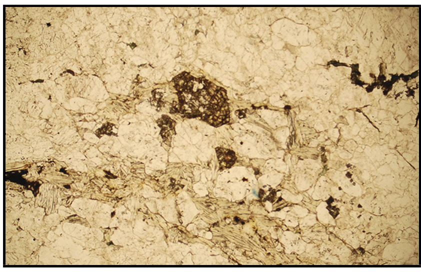


Mineralogy: **Qz-Ep-Cl-Op**; microfolds and secondary foliation.

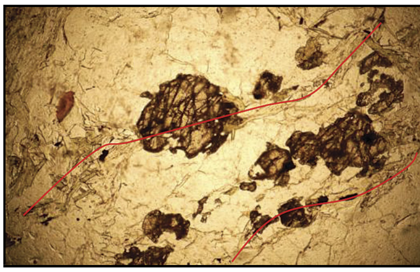


Mineralogy: **Bi-Qz-Plg** Iron Bi with zircon inclusions.

Mineralogy: **Red Bi** with halo around the **Zr** inclu-sions, metamictic effect-**Qz-Plg**.

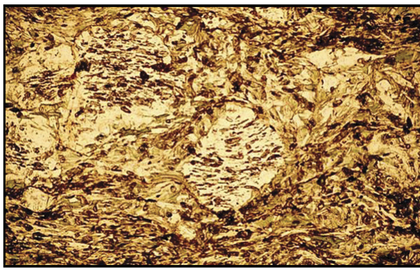


Mineralogy: Paragneisses (**Qz-Ab-Bi-Mu**) with garnet.

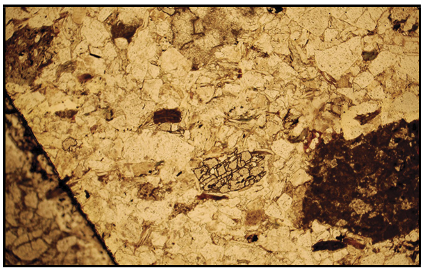


Mineralogy: **Gr-Mu-Qz-Ab**; primary foliation

Mineralogy: Helicitic structures in Albite.



Mineralogy: **Ab-Cl-Ep-Se-Op**; Helicitic structures in Albite; primary foliation.



Mineralogy: Cracked quartzite.

Mineralogy: **Qz-Op**; Cracks rectangular system; iron oxides.

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