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MESOZOIC FORMATIONS FROM POIANA BOTIZII, PIENINY KLIPPEN BELT OF ROMANIA

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Abstract: A sequence of competent Mesozoic rocks, characteristic of the Pieniny Klippen Belt, is cropping out at Poiana Botizii in the northern part of the Romanian Carpathians. It represents the interval late Middle Jurassic–earliest Lower Cretaceous. The formations are typical of the Alpine Mediterranean province and their succession is the following: pyroclastic rocks, banded radiolarian cherts, calcarenites bearing ophiolite fragments, limestone with nodular cherts, calcareous mudstones and siltstones with aptychi (Rosso ad Aptychus), Rosso Ammonitico Saccocoma limestones, pelagic Calpionellid limestones (Biancone). The Mesozoic sequence at Poiana Botizii is considered as belonging to a new and outer tectonic subunit of the Magura Nappe.

Key words: Late Jurassic–Early Cretaceous, lithostratigraphy, carbonate microfacies, Eastern Carpathians.

Introduction

The Romanian sector of the Maramureş Mts., situated in the north of the country, is bordered by the Gutîi Mts. to the west (Fig. 1: 7), the Lăpuş and Rodna Mts. to the south (Fig. 1: 2 et 4), and by the East Carpathians crystalline-Mesozoic ridge to the north–east (Fig. 1: 2 et 8). The terrane consists of metamorphic rocks, various facies of Mesozoic and Cenozoic rocks, and Neogene volcanics. The folded structure is complicated, with eastward and southward vergency.

A characteristic geological feature of the Romanian Maramureş is the occurrence of some exposures of Mesozoic formations characteristic of the Pieniny Klippen Belt. The most complete sequence of these formations crops out south of the Maramureş, in the area of Poiana Botizii village, especially in the Vărăştina valley. The exposure under discussion represents several scale-like klippen enveloped by the Upper Cretaceous and Paleogene deposits at the front of the Botiza slide-nappe. The main outcrops in the Vărăştina valley and on its left-side slope have become most appropriate for the detailed investigation of the klippen structure owing to the forest roads constructed since 1971.

The present paper contains an improved detailed revision of the stratigraphical data published by one of the authors concerning competent Mesozoic formations at Poiana Botizii (Bombiţă 1972). Our investigations in this area started again, incited by the new geological views regarding the Maramureş, published after 1972.

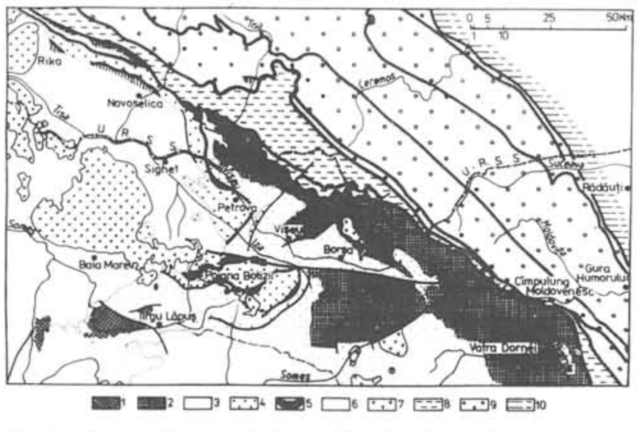

Fig. 1. Pieniny Klippen Belt position in Romanian Maramureş. General structural sketch.
1 – Inner Dacides, Bihor autochthonous; 2 – Middle Dacides, crystalline-Mesozoic Nappes; 3 – post-tectonical cover of the Dacides; 4 – Magura Nappe and its equivalent units towards south–east; 5 – Pieniny Klippen Belt; 6 – Neogene mollasses; 7 – Neogene volcanics; 8 – Outer Dacides, Black Flysch and Ceahlău Nappes; 9 – Moldavides, Teleajen, Audia, Tarcău, marginal folds and sub-Carpathian Nappes; 10 – foredeep and platform.

Historical data

The outcrops at Poiana Botizii were discovered in the first decades of the last century. They are situated in a region highly explored, due to its ore deposits, since the 18th century.

The diary of Lilienbach (1833), published by Boué, contains the first mention (p. 293) of two of the outcrops of "calcaire blanc... compact, à silex et à fossiles" in the Lăpuş Mts.; the most important is the present-day "La Piatră"

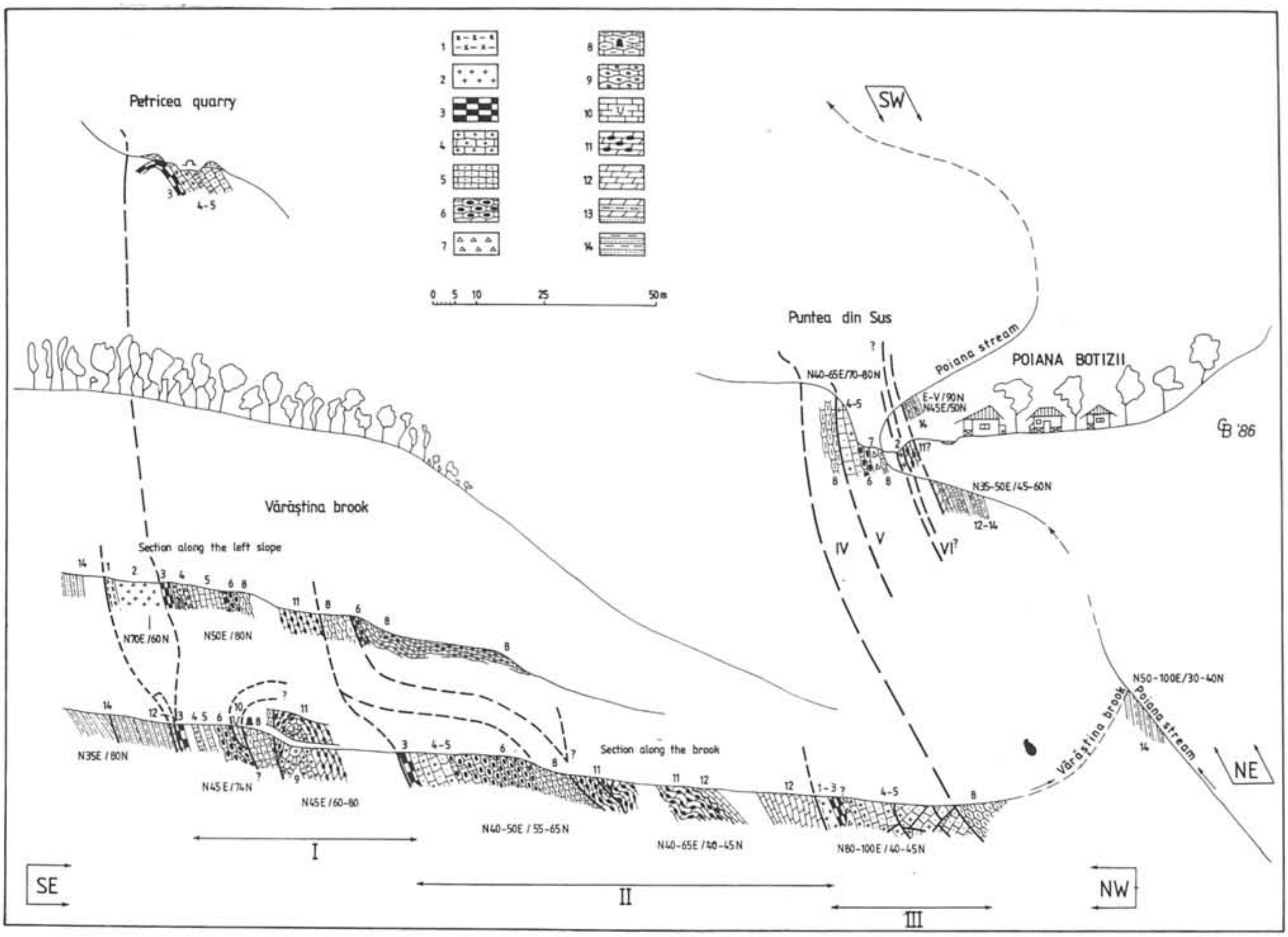

Fig. 2. Main exposures of the Pieniny Klippen Belt rocks at Poiana Botizii.
1 – cherry-coloured basinal clays with tuffaceous volcanoclastics and pumice blocks, Callovian; 2 – yellowish cinerites and cinerite sandstones, Callovian; 3 – red-greenish radiolarian banded jaspers, Callovian–Oxfordian; 4–5 – Petricea Formation, 4 – detrital turbidite limestones with volcanic fragments, 5 – light-grey, hard, finely fissured calcarenites, Oxfordian; 6–9 – Vărăştina limestones, 6 – pelagic creamy-grey-olive spotted limestones with cherts, 7 – lens-like quasihomogeneous breccia (hard-ground, erosive contact ?), 8 – red Aptychus-bearing shales alternating with nodular limestones, 9 – pink, grey-greenish, nodular limestones (Ammonitico rosso), tightly bedded and highly compressed, Kimmeridgian–Lower Tithonian; 10 – milky-grey, hard, pelagic, micritic limestones (Biancone tectonicaly placed in member No. 6), Lower Tithonian–Upper Berriasian; 11 – grey-olive marls with siliceous concretions (? Tissal); 12 – brick-red, marly siltstones (Scaglia); 13 – variegated Paleocene marls and silts; 14 – typical Eocene flysch (Tocila-Secul Group).

exposure, located in the hill lying to the south of the Băiuţ village.

The synthesis by Hauer and Stache (1863, p. 158, 363–364) presents the same outcrop of "Neocomian" red shales and nodular Aptychus limestones or gray calcarenites and Biancone limestones ("eine gänzlich isolierte Insel von weissen und rötlichen Kieselkalken mit Aptychen"), extended from Váh River in Czechoslovakia as far as Poiana Botizii in Romania, bearing unknown (by then) relations to the much cited "Karpathensandstein" and constantly dipping to NNW.

Primics (1886, p. 190) mentioned siliceous Aptychus limestones and red marls occurring within the "Karpathensandstein" in the area of the Lăpuş Mts.

In 1930 "le matériel exotique" from Poiana Botizii was rediscovered by Anton (1943). The first litho- and biostratigraphic study was made by this author who, with the help of Trauth, assigned these rocks to the Titonian–Neocomian of the Pieniny unit of the West Carpathians, as a "direct" south–eastward extension of it.

The notes of Böhm-Bem (1944) and Méhes (1944) are also worth mentioning as preceding the modern studies, although the stratigraphical and structural data presented are rather inaccurate.

The regional investigations carried out in the Lăpuş Mts. or in Maramureş province after 1950 more or less concerned the Poiana Botizii Pieniny-type klippen (Dimitrescu and Bleahu 1955; Patrulius et al. 1960; Bombiţă 1972; Antonescu et al. 1975; Dicea et al. 1980; Săndulescu et al. 1982). Detailed stratigraphic information is contained in the last three contributions.

Description of formations

At Poiana Botizii small bodies of Mesozoic sedimentary rocks are tectonically juxtaposed against the widespread Eocene flysch (Tocila-Secul Group).

The main outcrops of Mesozoic rocks adjoining to this village (Fig. 2) are situated:

1 – along the lower course of the Vărăştina brook and along the recent forest road, in its left slope;
2 – in the northern extremity of the village, in the point called "Puntea din Sus";
3 – at "La Petricea", the main quarry above the lime kilns situated in the north–east of the village;
4 – at "La Piatră", in the hill north–east of the Strîmbu village (an old quarry);
5 – at Dealul Bisericii, near the wooden church in Poiana Botizii (another old quarry);
6 – at "Piatră Bulbucului" in the Poiana Botizii valley, next to the road, ca 1 km upstream from its confluence with the Vărăştina brook.

The Jurassic and Lower Neocomian sequence consists of the following lithostratigraphic units (Fig. 3):
1) cherry-coloured argillites including tuffaceous components and pumice blocks;
2) yellow cinerites associated with cinerite "sandstones" of basalt or basalt andesite composition (see Bombiţă and Savu 1986);

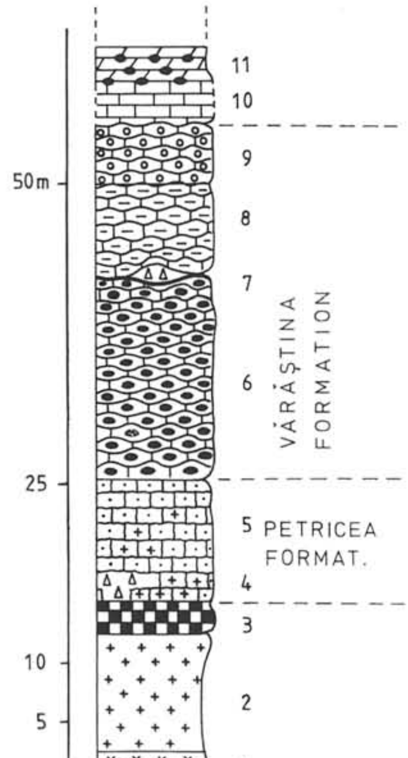

Fig. 3. Synthetic-stratigraphical column of the competent Mesozoic formations from Poiana Botizii, Pieniny Klippen Belt of Romania. 1 – red-violet pelites with tuffs and pumice blocks – Callovian; 2 – yellow cinerites and sandstones with pyroclastic material – Callovian; 3 – red-greenish banded jaspers, originally radiolarites – Callovian–Oxfordian; 4–5 – Petricea Formation: detrital-turbiditic limestones with ophiolitic fragments (4), hard, light-gray, finely fissured calcarenites (5) – Oxfordian; 6–9 – Vărăştina Formation: pelagic spotted limestones with cherts (6), lens-like breccia (7), nodular limestones and red Aptychus-bearing shales (8), nodular compresed limestones (Ammonitico Rosso) (9) – Kimmeridgian–Lower Tithonian; 10 – micritic, pelagic, milky limestones (Biancone) with *Calpionella* – Lower Tithonian–Upper Berriasian; 11 – Lower Cretaceous incompetent formations. The thicknesses are approximate.

3) multicoloured Upper Callovian–Oxfordian cherts;
4–5) Oxfordian calcarenites (Petricea calcarenites);
6–9) Kimmeridgian–Lower Tithonian argillaceous, partly nodular micrite limestone (Vărăştina limestones);
10–11) Lower Tithonian–Berriasian micrite limestone of Biancone type.

Multicoloured cherts (Upper Callovian–Oxfordian. Fig. 3: These banded cherts with thin interstratified argillites and argillaceous micrites were described by Bombiţă and Savu (1986). In the Dealul Bisericii (loc. 5) the argillaceous micrites contain calcisphaerulids and siliceous microplankton (radiolarians), the latter determined by P. Dumitrică: *Andromeda podbielensis* (Ožvoldová), *Angulobracchia purisimaensis* (Pessagno), *Bernoullius dicera* (Baumgartner), *Cingulotурris carpatica* Dumitrică, *Emiluvia antiqua* (Rüst), *Hsuum brevicostatum* (Ožvoldová), *Mirifusus mediodilatatus* (Rüst), *Paronaella bandyi* Pessagno, *P. mulleri* Pessagno, *Perispyridium ordinarium* (Pessagno), *Podobursa tricantha* (Fischli), *Spongacapsula palmerae* Pessagno, *Tetratrabs zealis* (Ožvoldová), *Triactoma blakei* (Pessagno), *T. cornuta* Baumgartner, *T. jonesi* (Pessagno) and *Tritrabs hayi* (Pessagno). The radiolarians are poorly or moderately preserved. The assemblage is assigned to the Upper Callovian and Oxfordian zones 4–8 of Baumgartner (1984). The same age has been previously admitted by Antonescu et al. (1975) and Săndulescu et al. (1982).

Layers of olive-green micrite limestones interbedded in the uppermost part of the cherts (Vărăştina valley) contain the Oxfordian species *Colomisphaera fibrata* (Nagy) (see Nagy 1966) associated with frequent *C. carpathica* (Borza).

In the upper scale, along the Vărăştina valley, there is an outcrop of breccia with well cemented cherts fragments close to the contact between the radiolarian cherts and the overlying calcarenites (Fig. 2), but in unclear relation.

Petricea Formation (Oxfordian)

These limestones, 10–15 *m* thick, overlying the cherts, were mentioned as "microdetrital limestones" (Bombiţă 1972) or "detrital limestones" (Săndulescu et al. 1982).

In the Vărăştina valley, at Puntea din Sus, La Petricea and Piatra Bulbucului, this formation consists of two members (Bombiţă and Savu 1986): the lower member is represented mainly by calcarenites containing basic volcanic lithoclasts (Fig. 3: 4), and the upper one consists of compact biocalcarenites with a small amount of fine igneous grains (Fig. 3: 5).

In the La Petricea quarry the exposure shows bedded cherts grading into calcarenites through flat-bedded, reddish or dark cherry-coloured limestones variously silicified (including true cherts), of several *cm* to tens of *cm* thick bedding, alternating with partly silicified red-brown to brown-black siltites. The limestones bear stratiform or discoidal and cauliflower-like cherts up to one meter in diameter.

The light-grey Petricea calcarenites (with rare interbedded calcirudites) form layers ranging usually from 10 to 50 *cm* in thickness, rarely exceeding 60 *cm*, with flat, rough, rugged-grainy, even spongy faces (due to dissolution), splintered into slab-like blocks along joints or thin interlayers of red siltstone. Micritic and biomicritic limestones are also interlayered in calcarenites and replace them at the top of this formation.

The calcarenites exhibit three types of fabric: grainstone, grainstone-packstone and rarely packstone-wackestone, with different sorting and a wide range of grain-size from very fine to coarse. Different allochem ratios indicate their bioclastic or pelloid character, seldom oolitic or intraclastic, transitional types being present too.

The grainstones are usually well-sorted and fine- to medium-grained. They consist of peloids (mainly representing micritized bioclasts) and pellets, seldom of rounded micrite extraclasts, various bioclasts (echinoid plates, large bivalve fragments generally neomorphosed and with micritic envelopes, thalli of calcareous algae, corals, benthic foraminifers), ooids, oncoids and intraclasts consisting of pelagic-derived micrites or biomicrites with calcitized radiolarians and sparse thin-shelled bivalves.

Locally the grainstone contains a small admixture of terrigenous fraction represented by coarse-grained quartz, quartzite and basaltoid lithoclasts. The bivalve and foraminifer bioclasts usually show minimicrite envelopes probably formed in intertidal or shallow subtitidal environments. The cement and matrix consists essentially of sparitic to finely microsparitic neomorphic calcite, syntaxial calcite overgrowths on echinoid fragments and scarce, very thin and discontinuous fibrous grains fringes. The different proportions of various carbonate grains give grainstone its bioclastic-peloid, peloid, peloid-bioclastic and rarely ooidic appearance.

The calcarenites of packstone and, mainly, packstone-wackestone types contain different amounts of carbonate and terrigenous grains of the same type, generally poorly sorted and coarser. Noteworthy is the higher frequency of oncoids, ooids, biomicrite extraclasts and pelagic-derived micrite-biomicrite intraclasts, including skeletons or remains of planktonic microorganisms (especially calcitized radiolarians). Another feature is the heterogeneous fabric consisting of pelagic micrite-biomicrite matrix and, subordinately, by sparite-microsparite cements (neomorphic, syntaxial, fibro-radial).

The carbonate of calcarenites and calcirudites is represented mainly by grains which formed on a shallow carbonate platform. It is associated with pelagic-derived micrite and biomicrite intraclasts and matrix; the calcarenites also contain thin interlayered micritic limestones of pelagic origin. These features indicate that the carbonate sediments were derived mainly from a shallow carbonate platform and accumulated in a basin-slope environment, below the aragonite compensation depth and above the calcite compensation depth.

Redeposition of carbonate sediments from shallow marine to basinal environment and reworking of weakly lithified pelagic-derived micrite sediments were due particularly to turbidity currents resulting in the formation of the so-called "biogenic" turbidites or calciturbidites (see Stow and Piper 1984).

The carbonate Jurassic deposits of the Outer Western Carpathians, which are mainly of pelagic origin, also contain interbedded carbonate turbidites of a quite varied provenience (Eliáš and Eliášová 1984).

The micrites and biomicrites interlayered with the Petricea calcarenites represent mainly pelagites. It is difficult to quantify the contribution of platform-derived versus pelagic-grained carbonate sediments, and to decide to what extend they are partly or entirely turbidites (Stow and Piper 1984). The interlayered stratiform, lenticular and nodular cherts were probably formed during an early diagenetic stage by carbonate sediment silicification (especially of metastable aragonite and high-magnesian calcite).

The only fossil recorded (Săndulescu et al. 1982) is *Nautiloculina oolitica* Moh., a foraminifer species without biostratigraphic value. The Oxfordian age assigned by Săndulescu et al. (1982) to the calcarenites was assumed considering the age of underlying and overlying formations.

Data on volcanic rocks in the formations 1–5 of Fig. 3 were briefly summarized according Bombiţă and Savu (1986).

The klippen at Poiana Botizii contain products of two magmatic phases. At first, there are small fragments, or even medium-sized blocks of ophiolite rocks – spilite and albite-plagiaplites. They are considered to have been initially injected during an Early Jurassic or even older distension stage, possibly the beginning of the Tethys opening (the Oxfordian grainstone contains reworked fragments of fossil oceanic lithosphere). Tuffs, porphyritic tuffs, basaltoid andesites and oligophyres, vitreous rocks and medium-sized blocks with porous texture similar to pumice stone, as products of late Middle Jurassic–early Late Jurassic island arc orogenic volcanism occur *in situ* and correspond to a compression stage associated with subduction, that is the scraping and the obduction of the former-phase ophiolites. The green spilitic elements were carried from the obduction melange by erosion and resedimented into the Oxfordian grainstones.

Therefore, in spite of the limited area of their outcrops, the Pieniny Klippen at Poiana Botizii are supposed to mark a suture of the former neo-Tethys ocean but, for the moment, with uncertain outside connection (see also Chanell et al. 1979; Debelmas et al. 1980; Aubouin 1984; Săndulescu 1984, 1985; Bombiţă and Savu 1986).

Varastina Formation (Kimmeridgian–Lower Tithonian)

Limestone sequence of micrites and biomicrite is more or less argillaceous, partly nodular, ca 30 *m* thick, with subordinate siltites and allodapic calcarenites. They were initially considered as interlayered in the Petricea calcarenites (Bombiţă 1972) and then, by taking into account the new occurrences, were called "couches à Aptychus" by Săndulescu et al. (1982).

The sequence of these limestones consists of three members:

a) Limestones and differently lithified marly limestones, olive-green or cherry coloured, 6–8 *m* thick, with green and mauve stains and thin interbedded siltites (Fig. 3: 6). The layers include nodular cherts with dense siliceous core and diffuse margins.

At Puntea din Sus these cherty limestones are overlain by a lense of hard breccia, 2–3 *m* thick (Fig. 3: 7), consisting of siliceous pebbles with resinous-mat lustre (Bombiţă 1972).

b) Bedded nodular micrite and argillaceous biomicrites, 5–6 *m* thick, hard, grey-coloured with yellow, light brown or red shales, apparently lacking in cherts. The main feature are interlayered argillaceous-marly cherry-coloured siltites, with abundant aptychi (Fig. 3: 8), known therefore as the Aptychus "shales" or "beds".

c) Thin nodular micrites and biomicrites, grey, green or red in colour with sparse interlayers of thin argillaceous siltstones. This member is well exposed within the lower scale in the Vărăştina valley, as a compressed sequence (Fig. 3: 9).

The micrites and argillaceous biomicrites of the Vărăştina limestones represent typical basinal pelagites and hemipelagites. They contain calcareous nannofossil skeletons (coccoliths, nannoconids and frequent calcisphaerulids), fragments of *Saccocoma, Globochaete,* calcitized radiolarians, thin-shelled bivalves, aptychi and sparse ammonites (only moulds), belemnites, brachiopods and fish teeth.

The rare calcarenite interlayers in micrites are calciturbidites which originated in a supposedly adjoining shallow carbonate platform. Based on proportions of different carbonate particles and on their different sorting degree, several texture types are distinguished: bioclastic, peloid scarce ooidic, oncoid or intraclastic grainstone, grainstone-packstone and, seldom, packstone-waskestone. The carbonate cement consists of neomorphic sparite-microsparite, syntaxial sparite overgrowths and sparse thin fibroradial calcite fringes.

The allochems of these calcarenites are represented by echinoid or, more frequently, crinoid bioclasts, benthic and rarely planktonic foraminifers, bivalve cortoids, algae, peloids, scarce ooids and oncoids. It is to note also the presence of micrite or biomicrite intraclasts associated with an insignificant terrigenous fraction represented by quartz, quartzite, feldspar and, rarely, basaltoid lithoclasts.

The stratigraphically important fossils of the Vărăştina limestones are planktonic microfossils and aptychi. It is difficult to determine the age of the three above defined members, and even their lithostratigraphic sequence; we must take into account some possible local hiatuses, resedimentation of microfossils, corrosive action of the bottom water on the biogenic material or subsequent tectonic imbrications. Therefore it is more appropriate to discuss the age of the Vărăştina limestones as a whole.

In some micrites there are various fragments of *Saccocoma* sp., previously considered as typical of the Kimmeridgian–Lower Tithonian pelagic limestones; subsequently, the *Saccocoma* biozone was limited to the Kimmeridgian, and even to its lower part, owing to the delimitation of other microfossil biozones (Borza 1984).

The Vărăştina limestones yield also calcisphaerulid assemblages indicating the *Carpistomiosphaera borzai* Zone (latest Kimmeridgian–earliest Tithonian), the *C. tithonica* Zone (earliest Tithonian) and *Parastomiosphaera malmica* Zone (early Tithonian pro parte) (Nowak 1968, 1976; Golonka and Sikora 1981; Borza 1984).

Carpistomiopshaera borzai is associated with *Colomisphaera carpathica* (Borza) and rare specimens of *Stomiosphaera moluccana* Wanner. The *Carpistomiosphaera tithonica* Zone has the index species concurrent with *Colomisphaera pulla* (Borza) and rare specimens of species persisting from the preceding zone. In the *Parastomiosphaera malmica* Zone the index species is associated with species from preceding zones, mainly *Colomisphaera pulla* (Borza), *Carpistomiosphaera tithonica* Nowak and *C. borzai* (Nagy), with *Cadosina semiradiata* Wanner and, frequently, various species of *Colomisphaera* of which the most widespread is *C. carpathica* (Borza).

The data presented above point to Kimmeridgian–early Tithonian (pro parte) age of the Vărăştina limestones.

Most of the aptychi collected previously belong to the middle member of the Vărăştina limestones (exposed in the Vărăştina valley), namely to the *Carpistomiosphaera tithonica* Zone. Their first determination (Bombiţă 1972) proved inaccurate (Turculeţ 1974) which made the revision of diagnoses necessary.

The Rosso ad Aptychus is common for the Tethyan Upper Jurassic (Renz 1972, 1978, 1979, 1983; Hsü 1975). In spite of some older and more recent valuable contributions to the taxonomy and stratigraphical range of aptychi (Trauth 1931, 1935, 1938; Gąsiorowski, 1960; 1962), the determinations are sometimes doubtful as the classification is still provisional and the stratigraphic ranges of the taxa are incompletely known.

The following inventory was established by revising the specimens illustrated by Bombiţă (1972, Pls. I–III): *Punctaptychus monsalvensis* Trauth (Pl. I: 1, 2), *P. punctatus* (Voltz) (Pl. I: 8, 9, 10, 15, 16; Pl. II: 1, 2, 3), *P. punctatus* (Votz) *fractocosta* Trauth (Pl. I: 14), *Lamellaptychus beyrichi* (Opp.) *fractocosta* Trauth (Pl. I: 6, 7), *L. beyrichi* (Opp.) (Pl. I: 12, 13; Pl. II: 4, 5), *L. rectecostatus* (Pet.) (Pl. II: 7, 8), *L. inflexicostata* Trauth (Pl. I: 11), *L. inflexicosta* Trauth or *L. lamellosus* (Park.) *cinctus* Trauth (Pl. II: 9), *Laevaptychus latus* (Park.) (Pl. II: 10, 12, 13, 14; Pl. III: 2), *L.* cf. *obliquus* (Quenst.) (Pl. II: 15), *L. obliquus* (Quenst.) (Pl. III: 1, 3), *L. latissimus* Trauth (Pl. II: 11). Specimens in Pl. I: 3, 4, 5 and Pl. II: 6 are still not determined.

According to Durand-Delga and Gąsiorowski (1970) the biostratigraphic significance of the population of aptychi is determined mainly by the assemblage of *Lamellaptychus* of group A "à structure relativement compliquée" (e. g. *L. beyrichi* Opp.), *Laevaptychus* "à allure normale" (e. g. the longeval *L. latus* (Park)), the "très élancé" *L. obliquus* (Quenst.) and the robust *Punctaptychus punctatus* (Votz) prevailing in the Poiana Botizii assemblage.

Our assemblage is assigned to the Upper Kimmeridgian-Lower Tithonian interval (Durand-Delga and Gąsiorowski 1970; Bombiţă 1972; Dicea et al. 1980). This group of aptychi, characterized by abundant *Lamellaptychus* gr. A, type *beyrichi*, frequent *Punctaptychus* and *Laevaptychus*, and seemingly absent *Laevilamellaptychus*, represents the west-Tethyan province wich extend from Crimea and Anatolia to Mexico (Gąsiorowski, 1985).

Micritic limestones (Lower Tithonian–base Upper Berriasian)

This last condensed typical pelagic lithostratigraphic unit (pelitomorphic limestone, Biancone – Bombiţă 1972) is exposed in the lower scale along the Vărăstina brook (Fig. 2: 10), in the klippe in Dealul Bisericii, and in the klippe La Piatră above the Strîmbu village.

Before the year 1971 the section in the Vărăştina valley contained several outcrops of these white-grey coloured limestones. They were blown up in order to construct the forest road. At present the formation is represented by a single calcilutite block, 2 × 0.75 *m* in size, located at the base of the lower scale, due to deformation, between olive-coloured micrites bearing cherts and the Aptychus shales (Fig. 2). In Dealul Bisericii and La Piatră quarries the white micrites occur also as blocks.

This formation consists of bedded finely-veined, light-grey or milky-white micrites and biomicrites, representing mainly pelagites. These are limestones of Biancone (Maiolica) type bearing abundant microplankton (coccoliths, calcitized radiolarians, calpionellids, calcisphaerulids, *Globochaete alpina* Lombard, *Nannoconus*), scarce aptychi, thin-shelled bivalves, planktonic and benthic foraminifers. There are also scarce interbedded allodapic calcarenites (turbidites) consisting of grainstone, grainstone-packstone and, more rarely, of packstone-wackestone.

The allochems of calcarenites consist of different, frequently cortoid bioclasts (echinoderm fragments, usually neomorphosed mollusc shell fragments, micritized thalli of calcareous algae, benthic foraminiferal tests of miliolid type etc.), peloids, less abundant ooids and pelagic-derived micrite intraclasts. Their cement is represented by microsparite-sparite, syntaxial calcite overgrowths on echinoid grains and by fine, fibro-radial calcite. The matrix of carbonate grains in wackestones consists mainly of pelagic micrite.

Except for the micrite intraclasts of pelagic origin, the majority of other allochems was derived from shallow subtidal carbonate platform and resedimented by turbidity currents below basinal slope where accumulation of pelagic carbonate sediments prevailed.

The early Tithonian–early Late Berriasian age of the micrite limestones is based on the observed calcisphaerulid species. Some samples collected in the very small outcrop in the Vărăştina valley have yielded a calcisphaerulid assemblage abunding in *Parastomiosphara malmica* (Borza) which indicates the Lower Tithonian (pro parte; Malmica Zone, Nowak 1976; Borza (1984). It is associated with *Colomisphaera carpathica* (Borza) (common), *C. pulla* (Borza) (scarce), *Carpistomiosphaera borzai* (Nagy) (scarce), *Stomiosphaera moluccana* Wanner (scarce), *Saccocoma* sp. (rare to common) and *Globochaete alpina* Lombard (common). This assemblage occurs sometimes in intraclastic wackestones and seems to be partly resedimented.

Some samples collected in Dealul Bisericii have yielded several specimens of the genus *Chitinoidella*, such as *C. boneti* Doben, concurrent with *Saccocoma* sp. (rare), *Colomisphaera carpathica* (Borza) and *Globochaete alpina* Lombard. The *Chitinoidella* Biozone indicates approximately the latest Early Tithonian–earliest Late Tithonian age of these limestones.

Other samples from the Vărăştina valley and Dealul Bisericii contain calpionellid assemblages characteristic of the *Calpionella* (*C. alpina-Remaniella* non-differentiated subzones) and the *Calpionellopsis* (*Cs. simplex* Subzone, basal part) standard zones, corresponding to the Lower, Middle and lowermost Upper Berriasian (Allemann et al. 1971; Pop 1974, 1986; Remane et al. 1986).

The *C. alpina-Remaniella* subzone assemblages include *Calpionella alpina* Lorenz (morphologically varied, frequent or abundant forms), *C. alpina/elliptica* (scarce), *Crassicollaria parvula* Remane (common or rare), *Cr. massutiniana* (Colom) (rare), in some samples only *Cr. brevis* Remane and *Cr. colomi* Doben, both occurring in the basal part of *C. alpina* Subzone, *Tintinnopsella carpatica* (Murg. & Filip.) (rare, small forms) and *Remaniella* sp. (rare), indicating the *Remaniella* Subzone.

The assemblage of the *Calpionella elliptica* Subzone is represented by typical forms of the index species, *Calpionella alpina* Lorenz (varied small forms), *Tintinnopsella carpatica* (frequent, medium to large typical forms), *Remaniella dadayi* (Knauer) and scarce small forms of *Crassicollaria parvula*.

Finally, only in a few samples collected in Vărăştina valley there are scarce specimens of *Calpionellopsis simplex* (Colom), suggesting the base of the *Calpionellopsis simplex* Subzone of the *Calpionellopsis standard* Zone; it is concurrent with *Tintinnopsella carpatica* (typical and frequent forms), *Calpionella elliptica* Cadisch, *C. alpina/elliptica* (probably cross-sections of *C. elliptica*) and frequent small forms of *C. alpina*.

These biostratigraphic data indicate the latest Early Tithonian–earlier Late Berriasian age of the micritic limestones. The Biancone limestones seem to pass gradually in to the first shaly formation the (?) Tissal Beds (Bombiţă 1972) (Fig. 2: 11).

Discussion and conclusions

The competent formations of the Pieniny Klippen Belt at Poiana Botizii were deposited within a time interval of ca 35 m.y., from the late Middle Jurassic to earliest Lower Cretaceous. During this time interval the sedimentation was generally continuous. Some local and short gaps are either synsedimentary erosional ones or due to later tectonic deformation of Tertiary age. On the whole, this sequence is a product of mixed sedimentation in the basin area, mainly pelagic (slow, widespread and continuous), subordinately turbiditic. According to Birkenmajer (1985b, 1986), the biogenic siliceous and calcareous pelagic sediments represent a pelagic stage related to bottom spreading.

The Jurassic–Lower Cretaceous sequence includes: 1 – calcareous biogenic rocks (prevailing); 2 – volcanoclastic rocks and 3 – associated siliceous biogenic rocks (both subordinate). The lithological features of the sequence are typical for sedimentary evolution of the western Tethys (Hsü 1975; Ogg et al. 1983).

The depositional environment of the Pieniny Klippen Belt were approximately uniform in its basinal part (Birkenmajer 1975) and the same appear to have been in the Romanian Maramureş: Upper Callovian–Oxfordian – siliceous sediments succeeding a fissure volcanic activity; Oxfordian – siliceous and carbonate sediments in alternation; Kimmeridgian–Lower Tithonian – carbonate sediments related to increased carbonate pelagic bioproductivity resulting in formation of limestones or red marly-limestones (nodular limestones – Rosso Ammonitico and Aptychus shales); Lower Tithonian–Berriasian – prevailing pelagic carbonate sediments as a result of calcareous plankton dominance. Stratigraphic condensation, local gaps and hardgrounds have been recognised in the Poiana Botizii Klippen. There are also some effects of subsequent strong compressional processes as microdiapirism, boudinage or brecciation.

The main problem with respect to the general structure of the Romanian Maramures area is: to what element of the Carpathian orogen should the Poiana Botizii klippen be assigned?

Anton (1943) was the first one who related them to the large Pieniny unit as its prolongation to northern Transylvania. Bombiţă (1972) adopted the same view also considering the Maramureş Eocene flysch, the equivalent (isopic) of Benatina and Myjava Flysch of Eastern Slovakia klippen cover. Meanwhile, Patrulius (1956, 1960) compared the Paleogene flysch of the central Maramureş trough (Petrova block) with the flysch assigned to the Magura unit (Hieroglyphic Beds) of the Polish and Soviet Outer Carpathians.

Săndulescu (1982, 1984, 1985) drew the following conclusion: the front scales of the Botiza Nappe, including the Pieniny-type klippen, are related to and represent an extension of the Pieniny Klippen Belt from Ukraine, Poland and Slovakia. Inside and outside the scales the Romanian Maramureş area includes two different tectonic units, the Botiza Nappe to the west and Petrova-Magura Nappe to the east, exhibiting different litho- and biostratigraphic features as a result of their origin from two different sedimentary basins.

According to Mutihac (1987) the Poiana Botizii klippen are not a prolongation of the Pieniny Klippen Belt, as they do not overthrust the Magura-Petrova-Botiza Nappe but, on the contrary, they are situated at the base of the latter. It is, however, disputable whether the Poiana Botizii klippen represent Transylvanian Klippen as the author considers.

About two decades ago, Andrusov visited the Poiana Botizii outcrops and remarked (D. Patrulius, personal communication) that there were neither relevant similarities nor a connection between these outcrops and the western sectors of the Pieniny Klippen Belt well known to him. Neverthless, according to Andrusov (1975) the Pieniny belt, "à tectonique infiniment compliquée", ends up in the Rodna Mts. of northern Romania.

After examining the Poiana Botizii exposures, Birkenmajer (1985, 1986) has recently proposed a third hypothesis: the Poiana Botizii exposures include Mesozoic sequences equivalent to those of the Grajcarek tectonic subunit separated in the Polish Carpathians. This subunit is delimited in the innermost (southern) area of the large Magura unit, adjoining to its tectonic contact with the Pieniny Klippen Belt and incorporated in it during the late Laramian stage. Moreover, the idea that the innermost zone of the Magura Nappe has its roots in the Pieniny Klippen Belt appeared in the early years of the last two decades (Birkenmajer 1970).

Other recent stratigraphic sketches (Koszarski et al. 1985) show the Jurassic–Neocomian sequence of the inner area of the Magura Nappe developed in a facies characteristic of the Pieniny Klippen Belt.

Since the beginning of this century some Jurassic exotics from the Cretaceous and Tertiary flysch assigned to the Magura Nappe have been examined and variously interpreted by Uhlig, Rzehak, Oppenheimer and Neumann (for references see Eliáš and Eliášová 1984), as well as by Matějka, Chmelík, Řehánek and particularly by Andrusov and Birkenmajer (for references see Birkenmajer and Myczyński 1977). In a recent detailed study on the distribution of the Jurassic standard facies and microfacies in the Magura unit from the Western Carpathians (Eliáš and Eliášová 1984) these exotics, namely "Posidonia Beds", radiolarites, Ammonitico Rosso, Aptychus limestones and Biancone limestones, similar to those of the Pieniny Klippen Belt, are described.

On the other hand, due to the distance involved, the Mesozoic formations of Grajcarek type in the Romanian Maramureş could show some facies differences when compared to the coeval ones from Homole-Trzy Korony-Grajcarek groups defined by Birkenmajer (1977) within the Magura succession. The differences are obvious in the Jurassic and mainly in the Cretaceous developments (discussion with Birkenmajer in Sept. 1986). However, considering at present these differences, the outcrops at Poiana Botizii might also represent a new facies-tectonic zone of the Pieniny type, *the Poiana Botizii new subunit,* with particular features and outwards of the Grajcarek subunit.

Therefore, the following hypothesis is suggested for consideration: the outcrops at Poiana Botizii show the Mesozoic substratum of Pieniny type belonging to the Magura Nappe. The Romanian Maramures area is supposed to represent the south–eastern end of the Magura Unit. The south–eastern continuation of the Pieniny Klippen Belt *sensu stricto* and its tectonic contact with the Magura Nappe (namely the Grajcarek subunit) would be placed in the Romanian sector of the Maramureş to the west of Poiana Botizii meridian, buried there under the deposits of the Middle–Upper Neogene major transgression and the Baia Mare Neogene volcanics.

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