THE NECESSITY TO WIDEN THE CHEILE BICAZULUI-HĂŞMAŞ NATIONAL PARK. SCIENTIFIC SUBSTANTIATION

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Abstract. The Bicaz Gorges - Hăşmaş National Park refers only to the mounts of Malm-Urgonian dolomites and limestones belonging to Hăşmaş Transylvanian Nappe. Many scientific objectives, namely geologic, geographic-geomorphologic, flora, and fauna support a widening of the National Park in order to include also the area located between Munticelu-Surduc and Muntele Fagului Saddle, the so-called "Creasta" Dămucului, or at least, to develop a buffer zone surrounding the National Park. This paper presents in detail the reasons which support our proposal. Detailed evidence of the particular features of the most important scientific objectives suggested to be included in the national park involve the outliers of Hăşmaş Nappe preserved in Munticelu-Surduc limestone mounts with Şugăului Gorges and Munticelu Cave, the outliers of Sub-Bucovinian Nappe from the Dămuc-Bicaz confluence, the fossil-bearing Klippen from Criminiş and Piatra Luciului and the outcrops of *Aptychus* Formation between Muntele Fagului Saddle and Piciorului Creek.

Key words: East Carpathians, Hăşmaş Transylvanian Nappe, „Creasta" Dămucului, Şugăului Gorges, Munticelu Cave, outliers, exotic klippen.

1. INTRODUCTION

The Bicaz Gorges - Hăşmaş National Park was established in 1990, through Order no. 7 of the Ministry of Environment, Waters and Forestry; the area designated through this order was 11 600 ha. Within its limits, this surface subjected to the protection regime, covers exclusively the area of the high limestone massifs, between the Bicaz Gorges and Fratele Mountain, belonging to the Alpine Hăşmaş Nappe. Prior to this decision, only three areas had a status of natural reserve: the subalpine meadows from the Hăşmaşul Mare and Munticelu Massif with the Şugăului Gorges.

With an area of 90 ha, the Munticelu Massif with the Şugăului Gorges got the status of reserve in 1971, through the Decision no. 290 from June, the 20th, of the former Executive Committee of the Local Authority of Neamţ County.

The Munticelu Massif with the Şugăului Gorges is located on the external limb of the Mesozoic Hăşmaş Syncline and shows a multitude of geological, geomorphological, floral and even faunitic elements that plead to maintain their status of protected area. At the same time, we can prove that the area south of Munticelu-Şugău needs to obtain a similar status. This area is „Creasta" Dămucului, located between Bicăjel and Dămuc Valleys, to the west and east, respectively, Bicaz River to the north and the springs of Valea Rece Brook to the south, *i.e.* the area between Surduc and Fagului Saddle. Several scientific objectives that recommend the area between Surduc and Fagului Saddle, in fact "Creasta" Dămucului, to be included in the protected area or, at least, in the buffer zone of the Bicaz Gorges - Hăşmaş National Park will be further presented.

2. OBJECTIVES RECOMMENDED TO BE INCLUDED IN THE NATIONAL PARK AREA

2.1. Munticelu - Şugăului Gorges area

The Munticelu calcareous massif. The most important objective in this area is the Munticelu Massif itself. The massif represents a N-S oriented limestone narrow crest (Fig.1), with widths ranging between 100 and 500 m and a length of 3 km, with a maximum altitude of 1337 m.

The limestones are white-grey or red and contain a faunal assemblage of corals, brachiopods and pachiodonts. The fossil fauna identified in these limestones, studied by Ciocârdel and Patrulius (1960), include: *Terebratula moravica*, *T. isomorpha, Lacunosella suessi*, and *Toucasia carinata*. This fauna proves the Late Jurassic-Urgonian age of the limestones.

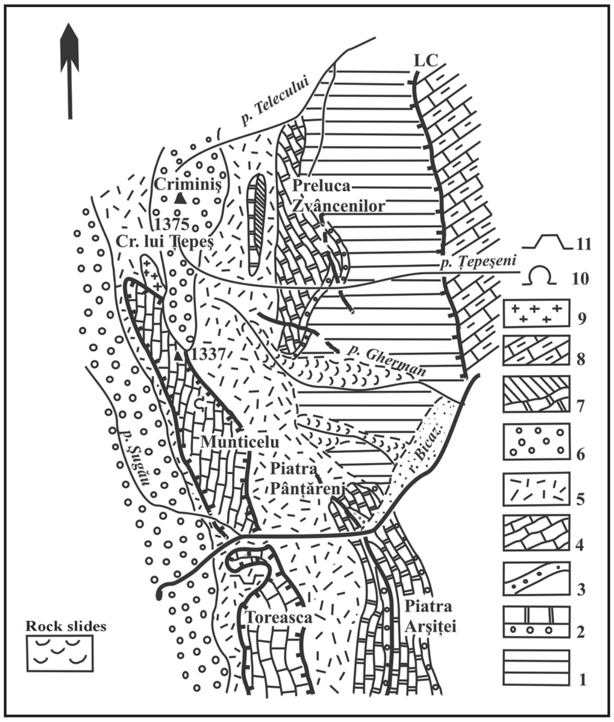

Fig. 1. Munticelu-Şugău area (after Grasu, 1973): 1 – Metamorphic rocks; 2 – Conglomerates, sandstone and dolomites (Triassic); 3 – Marls and sandstone (Middle Jurassic); 4 – Limestones of the Munticelu-Toreasca tectonic outlier (Tithonian-Urgonian); 5 – Wildflysch (Barremian-Albian); 6 – Bârnadu Conglomerates (Cenomanian); 7 – Olistolith with Triassic dolomites and Formation with *Aptychus* (Late Jurassic); 8 – Sinaia Flysch; 9 – Serpentinites; 10 –Munticelu Cave; 11 – Quarry (of Cement Factory).

Previously, it was considered that these limestones would be exclusively of Cretaceous (Aptian) age and that they would represent a large reef, coeval with the clays with blocks of the wildflysch (Atanasiu, 1928). The mining works for the limestone exploitation of the Surduc Massif (Toreasca), that constitutes the prolongation of Munticelu Massif, southward of Bicaz Valley, have surprised geologists, greatly. Eventually, the limestones were exhausted through the exploitation in descendant steps and, underneath them, the wildflysch was discovered. At the same time, the above-mentioned fauna was discovered, demonstrating that the limestones are older and unconformably overlie the younger stratigraphic unit, namely the Barremian-Albian wildflysch.

Currently, the wildflysch can be examined in the old quarry, where it underlies the small limestone cliff escaped extraction, from the confluence of the Şugău and Bicaz Valleys, known as Stan's Cliff (Fig. 2). This situation has confirmed the idea of Uhlig (1907), a Viennese geologist, that all limestone massifs from Hăşmaş, including those of Munticelu and Toreasca (Surduc), are in tectonic position, forming large outliers of a former nappe. In other words, the old quarry at the Şugău mouth is the only place, in the entire mountainous segment of the Hăşmaş, where we can see in outcrop the anomalous geometric position of the limestones belonging to the allochthonous Hăşmaş Transylvanian Nappe above the wildflysch deposits of autochthonous Bucovinian Nappe.

Şugău Gorges. Beside its geological-structural significance, the Munticelu Massif has the privilege to host, towards its southern part, a segment of gorges – the Şugău Gorges. On its longest course, the Şugău Creek flows on wildflysch and conglomerates (the Bârnadu Conglomerates), but upstream of its confluence with the Bicaz River, it crosses the limestone barrier on a NW-SE direction, sculpting along about 350 m, the narrowest gorges in the area. The wideness between the gorges walls reaches, in places, only 3-4 m.

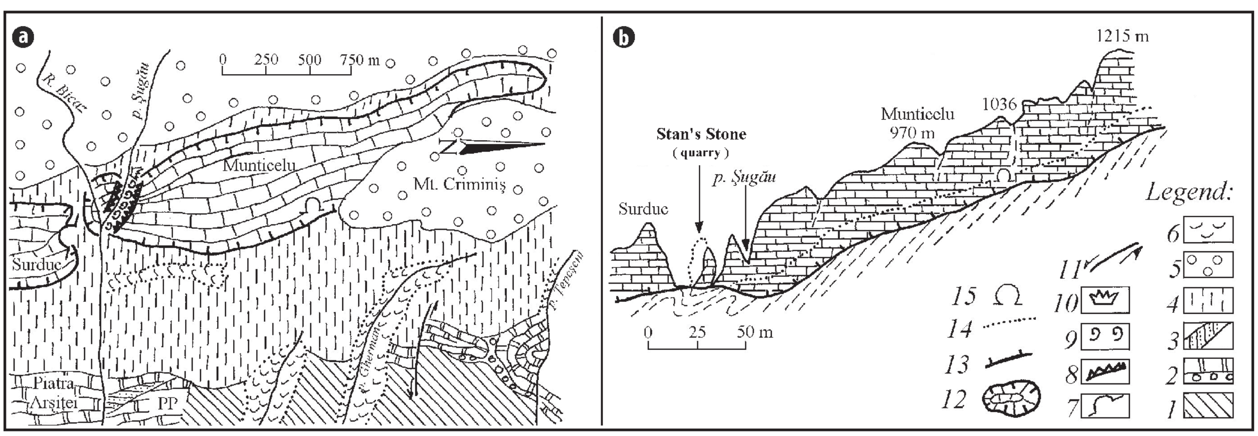

Fig. 2. Munticelu Massif: A – geological sketch; B – longitudinal section (after Mudura and Cioloş, 1958); 1 – metamorphic rocks; 2 – conglomerates and dolomites (Triassic); 3 – sandstone and marls (Dogger); 4 – wildflysch (Baremian-Albian); 5 – Bârnadu Conglomerates (Cenomanian); 6 – modern rock slides; 7 – quarry; 8 – valley in the gorges; 9 – potholes; 10 – travertine deposit; 11 – normal fault; 12 – limestones (Tithonian-Early Cretaceous); 13 – Nappe; 14 – outline of the bedrock at the contact with the limestone massif; 15 – Munticelu Cave.

In the Şugău Gorges, the lateral potholes, hanging up to 30 m height, as well as the modern potholes in the river bed, represent, not only an exokarstic microrelief, but the evidence for the epigenetic origin of the gorges, too. On the same line of reasoning, we have to mention the existence of the saddle from the right of the present valley, hanging 60 m above the Bicaz River bed. The saddle is the old bottom of an abandoned valley the Şugău Creek was flowing on, when its confluence with the Bicaz River 60 m higher from the present (Bojoi, 1971).

In the area of Şugău Gorges, namely, at the upstream entrance, there is a karst spring indicating underground water flow. At the mouth of this spring, it was the largest travertine accumulation from the entire area of Hăşmaş, a 30 m high body of limestone tuff that was plating the left wall of the gorges entrance. The travertine was dynamited by a local entrepreneur who was allowed to invest for the capture and distribution of the spring waters, and consequently was almost entirely destroyed.

According to the botanical investigations (Horeanu, 1979), in the Munticelu-Şugău Reserve, that was enlarged from 90 to 200 ha, a vascular flora was identified, including 529 taxa, representing 489 species, 21 subspecies and 9 varieties. The floristic fund is dominated by Eurasian elements (36.75%), followed by European (10.42%), Central-European (12.42%) and circumpolar elements (8.84%). An important role have the alpine (5.23%), mediterranean, sub-mediterranean, continental and pontic elements. The Dacic element is well represented (3.01%), including as main species *Aconitum toxicum*, *Cardamine glandulicera*, *Hepatica transsilvanica*, *Pulmonaria rubra*, *Symphytum cordatum*, *Silene zawadskii*, *Thymus comosus* etc. There are numerous Carpathian endemic species, favoured by the limy thermophile bedrock. This category is represented by *Larix decidua ssp. carpatica*, *Aconitum moldavicum*, *Silene dubia*, *Hieracium pojorâtense*, *Campanula carpatica*, *Poa nemoralis*, *Androsacae villosa ssp*. *arachnoidea*, *Primula leucophylla*. The cited author mentions that this area is the second place to find the species *Astragalus pseudopurpureus*, described by Guşuleac (1933).

As regards its fauna, the Şugău Gorges represent the preferential biotope of the little rock butterfly *Tichodroma muraria*, a bird declared nature monument, protected by law (Ciobanu *et al.*, 1972). It is also known as purple little butterfly, mountain *cojoiaca* or stone woodpecker. It has a short and irregular flight, with its wings opened like those of a butterfly. Its name of *cojoaică* derives from the way of peeling the moss from rock cracks in search of food. When it wants to fly in other places, it does not swing, but lets itself fall and, subsequently, opens its wings to take off, heavily fluttering with short movements.

The Munticelu Cave. It is the only cave with an authentic speleological heritage in the entire area of the Hăşmaş Mountains. It was discovered in 1973 by a group of pupils from the Bicaz Chei Village (Aurel Panţâr, Nicu Pop, Toader Ghenci, and Simion Dandu). The cave opens on the eastern slope of the Munticelu Massif, approximately 2 km north of the national road to Red lake and can be reached after 45 minutes of climbing (Fig. 2).

The investigation and description of the cave have been done by Acrâşmăriţei and Ciobanu (1973), while its topographic mapping was performed by Povară and Diaconu (unpublished data) (Fig. 3). Due to a slight fitting out, the entrance to the cave is through an oval arcade, 2 m high and over 1 m wide. Initially, there were several imposing stalagmite columns, double or triple, that used to split the entrance into two very spectacular corridors. From there, the visitor first reaches a 5-6 m high room, with sides of 45-50 m, called „the marvels room" by the authors (Fig. 3).

In this room with many collapsed blocks, there was a rich karstic heritage with stalactites, stalagmites, anemolites, candle-type stalagmite columns, flowstones, drapes, waves and *gours* with festooned margins. A 15-20 m long gallery opens at the end of this room. Since it looks like that the cave continues somewhere at depths, on the direction of the gallery (Povară and Diaconu, 1973, unpublished data), it was named *„the gallery of hope"*. The continuation is suggested by the presence of a strong air current, that goes somewhere to another underground gallery.

On the left side of the large room, there are two secondary galleries about 15-20 m long; the first one, to the east, had the aspect of a catacomb richly adorned by stalactite formations. Remains of *Ursus spelaeus*, namely, skulls and postcranial bones, have been recovered here. Currently, it hosts colonies of bats belonging to the *Myotis* and *Rhinolophus* genuses. The second gallery is located to the south and represents a part of the cave. There is a small water basin here, named "*the stalactites' lake*" (Povară and Diaconu, 1973, unpublished data), as a large number of pearl stalactite formations are found here.

The most important element in Munticelu Cave was represented by the candle stalagmites, that were forming a real forest at the moment of discovery; it was the highest density of candle-stalagmites from Romania (Giurgiu, 1990). The candle-stalagmites are formed in the conditions of a constant, but not too abundant feeding, during which from the fallen drop precipitates the entire amount of calcite. Under these conditions, the stalagmite grows vertically, only at its tip. In the Munticelu Cave, the stalagmites used to reach 3 m in height, with diameters up to 3 cm. Other interesting speleothems were the fistulas (long, thin stalactites with hollows inside), which used to form real 'macaroni' rains, in several areas. Even a femur of *Ursus spelaeus* was found fixed within a stalagmite.

The serpentinites from the Cross of Ţepeş. Reported and mapped for the first time by Atanasiu (1928), these rocks were described towards the northern tip of the Munticelu Massif where the limestones shows a red color and a scoriaceous aspect at the contact with the serpentinites. According

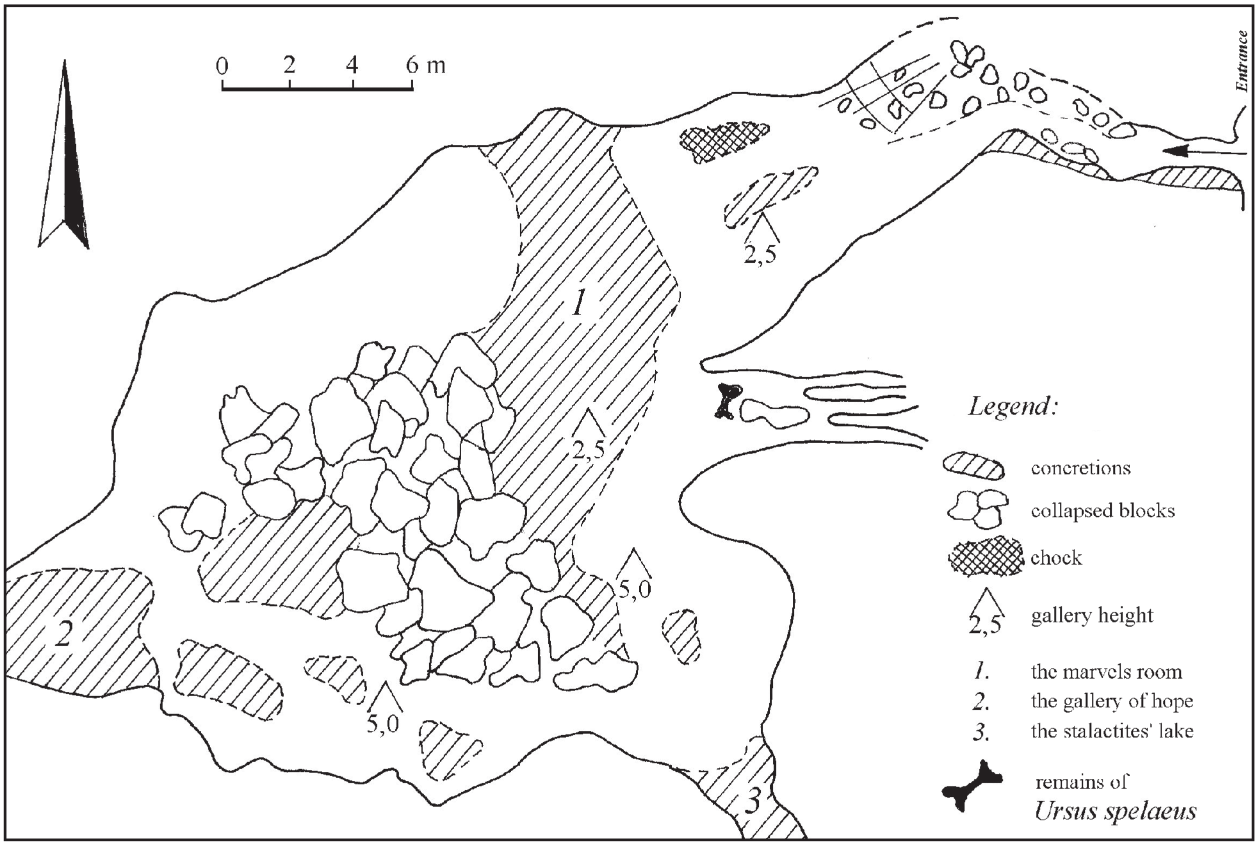

Fig. 3. Munticelu Cave (after Povară and Diaconu, 1973, unpublished data)

to Atanasiu (1928), the serpentinites engulf limestone blocks, that is, xenolitic bodies. The outcrop from the Cross of Ţepeş is one of the very few, from the entire Hăşmaş Syncline, where ultramafic rocks also occur; they represent remnants of the oceanic crust from the Transylvanide trough upon which the Malm-Urgonian succession of the limestone facies of the Hăşmaş Nappe has accumulated.

The Aptychus Formation from the Criminiş Mountain. The deposits we are presenting are situated in the upper drainage basin of the Ţepeşeni Creek, more precisely, on the divide between the former and the Telec Creek, representing the link between the Criminiş Mountain and Preluca Zvâncenilor (Figs 1, 2). These deposits have been mapped by Atanasiu (1928) who figured them on the map accompanying its paper on the Tulgheş zone, as a dolomite slab associated with jaspers, Callovian-Oxfordian in age.

In a paper from 1969, Săndulescu analyzes the same deposits, interpreting them from petrographic point of view as dolomites associated with jaspers and silicified limestones. On geometric criteria, Săndulescu (1969) ascribes the jaspers and silicified limestone to the Ladinian, because they overlie Campillian-Anisian dolomites; the author also correlates these deposits with the jaspers interbedded with limestone with *Daonella indica* from the Piatra Zimbrului-Rarău. It is worth mentioning that, from a structural point of view, the deposits in question represent an olistolith incorporated in the wildflysch formation; this is demonstrated by the reverse stratigraphy of the succession. According to Săndulescu (1969), the deposits from the Criminiş Mountain belong to the allochthonous Transylvanian succession, hence, their correlation with the succession from Piatra Zimbrului-Rarău.

Subsequently, revisiting the area, Grasu (1973) demonstrated that the succession is, in fact, represented by Triassic dolomites, associated, not with jaspers, but with Late Jurassic deposits in the facies of the *Aptychus* Formation, representing together the Malm deposits of the autochthonous Bucovinian Nappe.

Lithologically, on top of the dolomites - in this stratigraphically inverted succession - there are red and spotted, grey-greenish micaceous argillites, with interlayers of fine-grained ferruginous sandstones and red, slightly banded, or green spotted limestone with calcite veins. The limestone and sandstones are thin to medium bedded (5-10 to 20 cm thick). Microfacies studies indicate that the greenish limestone shows a micritic background with frequent fine-grained quartz; some partly calcitized radiolarians are also seen. The red limestone shows a similar microfacies, but containing less quartz to which sericite is added. Consequently, their identification as jaspers is the result of a superficial examination, based on their lithological association with the red and green argillites that also occur in the Callovian-Oxfordian jaspers and radiolarites. In these deposits, Grasu (1973) identified a fauna with: *Lamellaptychus sparsillamellosus*, *Lamellaptychus lamellosus*, *Lamellaptychus rectecostatus*, *Laevaptychus* sp. and even belemnites, not determined specifically. Not only the presence of aptychi, but also the petrographic features of the deposits, demonstrate that they belong to the facies of the *Aptychus* Formation, the way it occurs in the Trotuş and Dămuc Basins and, mainly, in the Chicera Mountain, north of Munticelu-Criminiş area. The general aspect of the argillites and red-greenish limestone, as well as the presence of laevaptychi, indicate the lower member of this formation that, considering the fauna identified (Turculeţ and Grasu, 1965, 1968, 1969), stratigraphically belongs to the Late Jurassic (Kimmeridgian-Tithonian).

The tectonic interpretation deserves some further comments. As results from the geological cross-sections accompanying the geological study of the Tulgheş area (Atanasiu, 1928), the dolomites and jaspers from Criminiş, as they were considered, show a direct relationship with the dolomites of the external limb from Preluca Zvâncenilor, between them wildflysch deposits being interposed, sandwiched between two faults.

According to Săndulescu (1969), the succession represents allochthonous deposits belonging to the Transylvanian Nappe and representing an olistolithic body within the wildflysch. In fact, they belong to the Bucovinian succession and resemble, both from a lithological point of view, as well as according to the fauna, with the *Aptychus* Formation, especially, with the similar deposits from the Chicera Mountains, situated closer to the north. Therefore, in their olistolith condition, the deposits represent a sequence from the *Aptychus* Formation, teared together with its Triassic basement from the *in situ* succession of the external limb of the syncline and incorporated in the Cretaceous deposits.

The interpretation of Atanasiu (1928) could also be considered, because we cannot preclude a link between the Triassic-Jurassic deposits and the external limb succession from the Preluca Zvâncenilor, the distance between them being less than 200 m. Such an interpretation would make the Munticelu-Criminiş area the only place from the Hăşmaş Syncline where the *Aptychus* Formation in pelagic facies (Malm) of Autochthonous Bucovinian from Criminiş, gets closer to a minimum distance towards the reefal-neritic facies (Malm) of allochthonous Transylvanian Nappe from the Munticelu Massif, the distance between them being no larger than 1,5 km.

2.2. The Sub-Bucovinian tectonic klippen from the Gura Dămucului – Ciofu Creek area

The Mesozoic deposits we will describe further are found in the right bank of the Bicaz Valley, about 800 m upstream its confluence with Dămuc River, representing the rocks which locals call Maftei's Stone. They have been already reported by Atanasiu (1928) who ascribed them from the beginning to the Middle Jurassic (Fig. 4).

Băncilă *et al.* (1957) have published a detailed study related to the lithology and petrogenesis of these rocks and have considered that they represent a "pigmy reef", developed in the littoral area of the sea of Ceahlău flysch, synchronous with the Sinaia Formation. The conclusions related to the Neocomian age were based on a petrogenetic study, indicating a gradual transition from these deposits to the Sinaia flysch; the dolomites have been considered a 'magnesian accident', that had happened during accumulation of the Sinaia flysch.

In 1965, Grasu and Turculeţ discovered here a fauna that confirmed the Dogger age supposed by Atanasiu (1928). The same authors considered, at the same time, that the Triassic

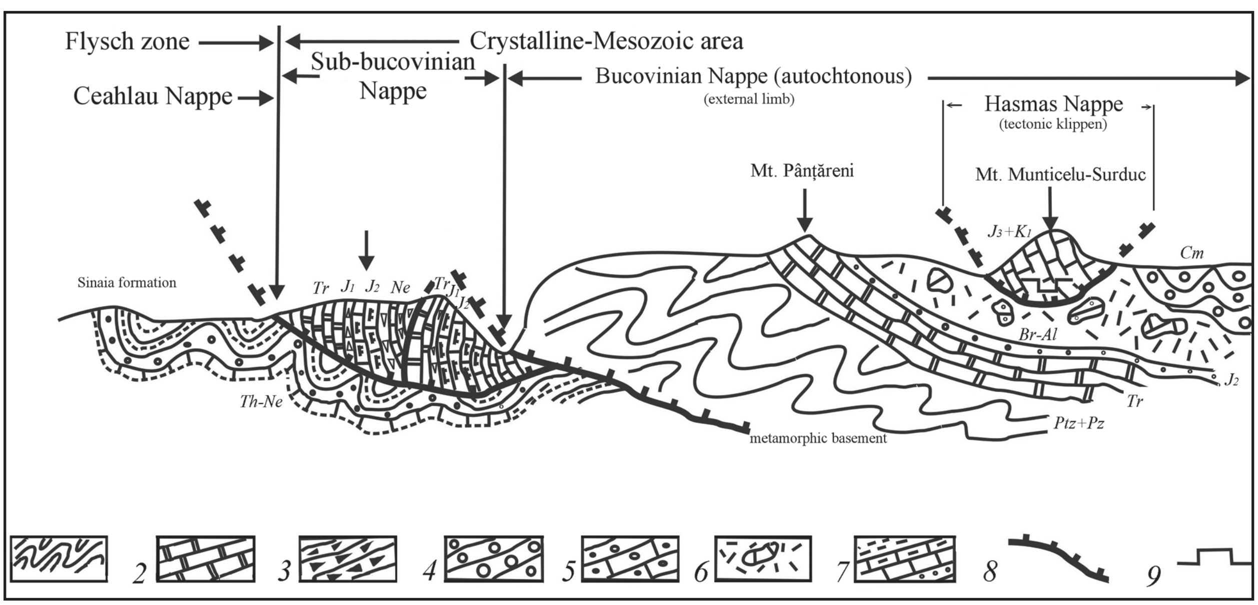

Fig. 4. Geological cross-section of the external limb of the Hăşmaş Syncline along the Bicaz River: 1 – low- and middle rank metamorphic rocks; 2 – dolomites; 3 – breccias; 4 – post-tectonic conglomerates; 5 – sandstone and sandy nodular limestones; 6 – wildflysch; 7 – sandstone, limestones, marls, clays (flysch); 8 – nappe; 9 – limestone quarry.

and the Dogger, respectively, belong to the Bucovinian succession; the idea was subsequently supported by other authors (Contescu, 1968; Preda, 1969, 1976).

Eventually, it was accepted that these deposits belong to a new structural unit, the Sub-Bucovinian Nappe, representing here a tectonic outlier entrained in the front of the Bucovinian Nappe (Săndulescu, 1975; Grasu, 1976; Grasu *et al.*, 1995). Later investigations (Grasu, 1976; Grasu *et al.*, 1995) showed that, from the Bicaz Valley, the Sub-Bucovinian succession extends southward, on the left of Dămuc, through Stan's Creek, up Ciofu Creek. In the Bicaz Valley the succession forms two scales (Fig. 5, 6).

Basically, the Sub-Bucovinian column from Gura Dămucului includes Triassic-Neocomian deposits, characterized by many stratigraphic unconformities, small thickness and notable intervention of rudites (Fig . 7).

Triassic. As in the Bucovinian succession, the Sub-Bucovinian Triassic starts with quartzitic conglomerates and

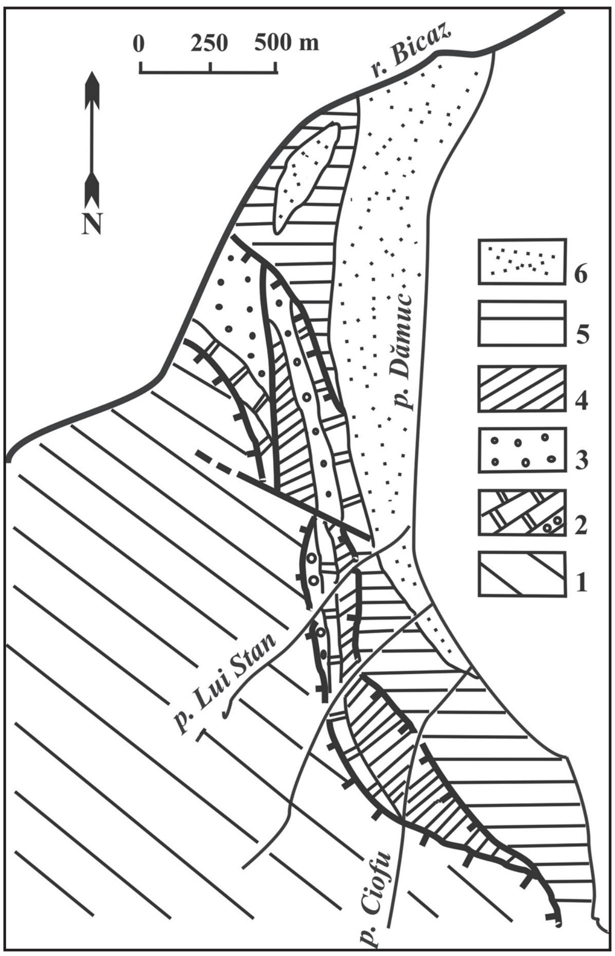

Fig. 5. Geological sketch of the Sub-Bucovinian tectonic klippen from Gura Dămucului between Bicaz River and Ciofu Creek (after Grasu *et al.*, 1995): 1 – **Bucovinian Nappe** (Tulgheş Group); **Sub-bucovinian Nappe:** 2 – conglomerates and dolomites (Triasic); 3 – Limonitic breccias, quartz-silty limestones (Liassic + Dogger); 4 – breccias and clayey limestones (Neocomian); 5 – **Ceahlău** Nappe (Sinaia Formation); 6 – Quaternary.

ferruginous quartzose sandstones, occuring only on Stan's Creek (Fig. 5). The succession continues upsequence with dolomites, which, in the western scale (Fig. 5) show a 7 m thick basal layer of well bedded rocks (centimetric thick), grey and with calcite veins, followed by massive, grey-yellowish dolomites, up to 15 m thick. According to Săndulescu (1975), the lower part of column would consist of marly limestone and would correspond with 'the Campil schists', while the massive dolomites would represent the Anisian. In fact, their chemistry indicates that the stratified rocks are dolomites, more precisely, dolomicrites with rare sericite flakes, like the massive dolomites (intradolosparites), both types being placed in the Leighton-Pendexter triangle in the field of pure dolomites (Grasu *et al.*, 1995; Fig. 8).

Liassic. Quartzitic limonitic breccias, 1,5-2 m thick, reworking dolomites have been ascribed to Eoliassic. At Gura Dămucului they occur between the dolomites and the Dogger limestone (Săndulescu, 1975).

Dogger. The Middle Jurassic deposits, 12-15 m thick, are characterized by three types of limestones: 1) massive, hard with a dense network of calcite veins, following the Eoliassic breccias; 2) grey-blackish fossil-bearing limestone with nodular aspect, with bivalves, brachiopods, belemnites and rare ammonites, containing a fossil fauna Bajocian in age (Grasu and Turculeţ, 1965) with *Bositra buchi*, *Modiola cf. borrisiaki*, *Entolium demissum*, *Astarte integra*, *Chlamys* aff. *fibrosus*, *Kallirhynchia* cf. *concinna*, *Tubithyris globata*, *Cererithyris fleischeri*, *Lobothyris cortonensis*, *Parkinsonia parkinsoni*, *Hibolites semihastatus*, and *Belemnopsis sp*. and 3) black, muscovite-bearing well bedded limestone.

The first two types correspond to pelsparites with bioclasts (benthic foraminifera of the genera *Lenticulina*, *Trocholina,* textularids, and miliolids, rare brachiopod valves, bivalves, but, mainly, echinoderm plates and spines), and biopelsparites. The pores of the echinoderm plates, as well as

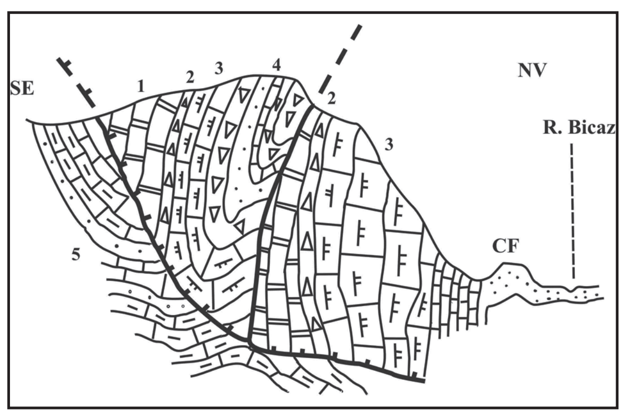

Fig. 6. Geological cross-section through the scales of the Sub-Bucovinian tectonic klippen from Gura-Dămucului (after Grasu *et al.*, 1995): 1 – Triassic (bedded and massive dolomites); 2 – Liassic (limonitic breccias); 3 – Dogger (quartz-silty pelsparites and biosparites); 4 – Tithonian-Neocomian (rudites, litharenites and tintinnids-bearing clayey micrites).

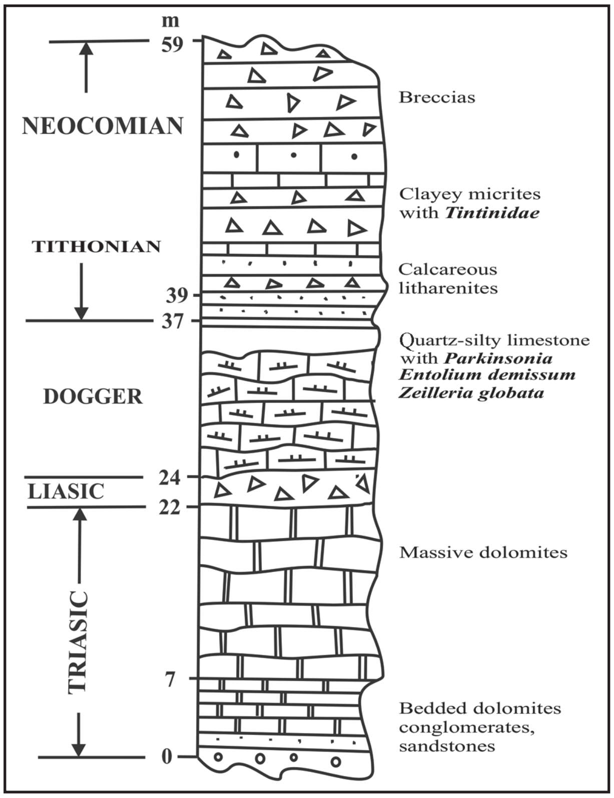

Fig. 7. Lithostratigraphic column of the Sub-Bucovinian succession at Gura Dămucului (after Grasu *et al.*, 1995).

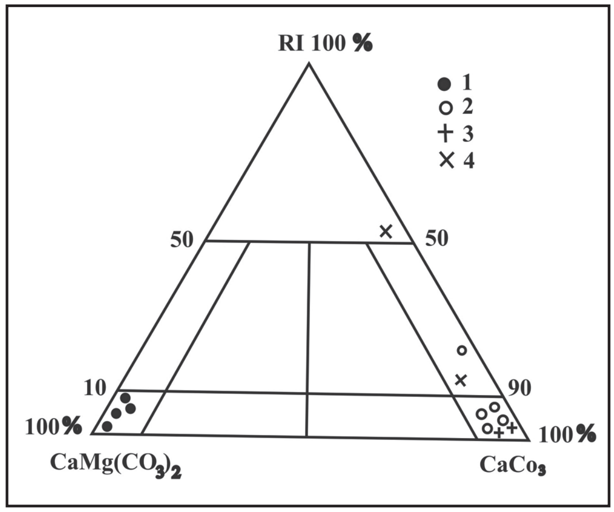

Fig. 8. Leighton-Pendexter triangle diagram of Sub-Bucovinian carbonate rock samples from Gura Dămucului area (Ciofu Creek) (after Grasu *et al.*, 1995): 1 – **Triassic** (bedded and massive dolomites); 2 - **Dogger; Neocomian**; 3 – Tintinnids-bearing micrites and biomicrites; 4 – Litharenites and sandy biopelsparites.

the foraminifers chambers are often filled with chlorite and pyrite that usually, through oxidation, turn into a limonite-hematite powder, staining the limestone in red.

The allogenic fraction is formed by quartz of arenite or silt size, muscovite and rare feldspars, rutile, tourmaline, and epidote being sporadically observed. The neoformation minerals are represented by pyrite, chlorite, but mainly plagioclase feldspars. The latter ones may reach over 4%, being clear and idiomorphic. According to Băncilă *et al.* (1957), it is almost pure albite, with less than 3% content in anortite.

The black, well bedded limestone are microscopically micrites and microsparites with rare quartz of silt size and sericite flakes; their chemistry indicates pure limestone and sandy or quartz-silty limestone (Fig. 8). The presence of chlorite and pyrite indicates reducing, anoxic environments. In the case of Dogger limestone, the mentioned minerals occur, mainly, in the foraminifer chambers, indicating that the environment was restricted and protected by the complex architecture of the foraminifer tests, where it was installed, following the bacterial decomposition of organic matter after the death of organisms (Marchand, 1975).

Neocomian. The presence of the Tithonian in the Sub-Bucovinian succession from Gura Dămucului is not certain, but Săndulescu (1975) supposes that the black well bedded limestone overlying the nodular Dogger limestone would be this age. Here, there is evidence for the presence of Neocomian deposits. With a thickness of about 20 m, they are found in the eastern scale (Fig. 6) from Gura Dămucului and on Ciofu Creek (Fig. 5) and include the following petrographic types: polymictic rudites and microrudites, calcareous litharenites, sandy biopelsparites, micrites and clayey micrites. Micrites and clayey micrites are interbedded with the rudites and are very rare. In the eastern scale, there are only two such intercalations, with thicknesses of 15-20 cm, while on the Ciofu Creek, they develop as a single bed, 0,80 m thick. From such clayey limestone, Săndulescu (1975) identified the following tintinnids assemblage: *Calpionellopsis oblonga*, *Calpionellopsis simplex*, *Calpionellites darderi*, *Calpionella alpine*, and *Tintinopsella carpatica*, that would indicate the Late Berriasian and the Valanginian. These micrites also contain autigene feldspars, namely albite, showing a remarcable idiomorphism. Sometimes, the large number of tintinnids indicates that rocks are biomicrites (Grasu *et al.*, 1995). We consider that these deposits represent an equivalent of the Aptychus Formation from the Bucovinian Nappe, but with a pronounced ruditic feature, due to their sedimentation on the palaeogeographic ridge of the Sub-Bucovinian realm.

As known, the sedimentary cover of the Sub-Bucovinian nappe occurs in other areas, both in tectonic windows (Valea Putnei and Tomeşti-Ciuc), as well as tectonic klippen (Bâtca Rotundă, Borca, Holdiţa and Ostra) (Vodă, 1980), but nowhere as complete and fossil-rich as at Gura Dămucului; that is the reason why the succession here may be considered the most representative for this tectonic unit. Palaeogeographically, the frequent stratigraphic discontinuities and frequency of rudites demonstrate that the Sub-Bucovinian sedimentary realm corresponded with a more elevated relief than those of the Bucovinian and infra-Bucovinian realms.

2.3. The sedimentary Klippen reworked in the Wildflysch Formation from Piatra Luciului

These klippen are located on the external limb of the Hăşmaş Syncline, in the upper drainage basin of Frunţii Creek, left tributary of Dămuc River. Here, they are incorporated in the clays with blocks, specific to the Wildflysch Formation, that overlie Triassic dolomites supporting, quite seldom in this area, Dogger deposits. In the area of "Creasta" Dămucului, the erosion was more effective than in the rest of the syncline. Beside the blocks and olistolithic bodies of the Triassic, Liassic, Dogger and Tithonian age with their respective faunas, the perimeter from Piatra Luciului is, also, interesting because here the richest fossil fauna in the wildflysch deposits was described (Fig. 9).

The Werfen Formation. In the upper drainage basin of Frunţii Creek and on the divide separating it from the Bicăjel

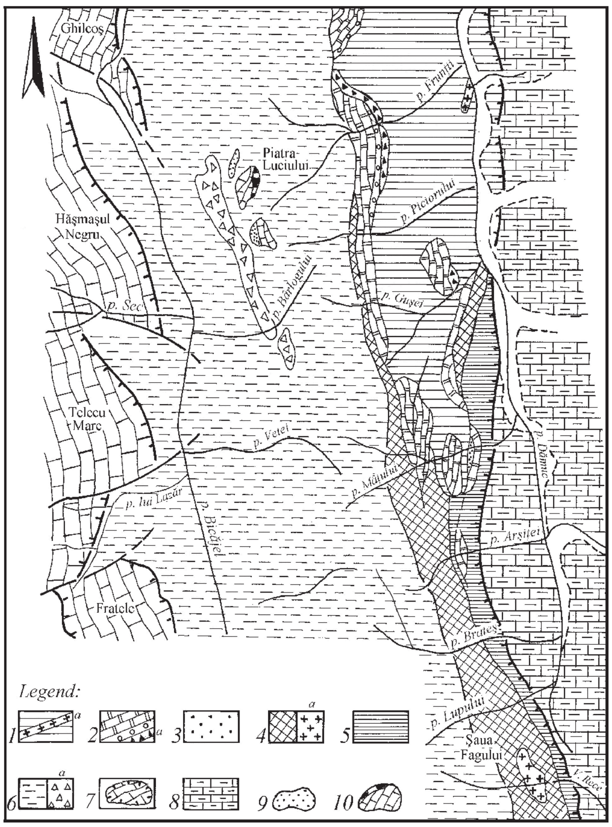

Fig. 9. Geological map of „Creasta" Dămucului between Frunţii and Valea Rece Creeks (after Grasu, 1971): **Bucovinian Autochthonous**: 1 – metamorphic basement (Tulgheş + Bretila-Rarău Groups); 1a – within plate basalt dykes; 2 – Triassic (conglomerates, sandstone and dolomites); 2a – Hăşmaş Breccia (Permian); 3 – Dogger (sandstone and sandy limestones); 4 – Lower Member of Formation with *Aptychus* (Kimmeridgian-Tithonian); *4a* – pyroclastic-tuffogenous complex; 5 – Upper Member of Formation with *Aptychus* (Neocomian); 6 – typical and paratypical wildflysch (Barremian-Albian); 6a – calcareous megabreccias; 7 –**Hăşmaş** Nappe (Kimmeridgian-Urgonian); 8 – **Ceahlău Nappe** (Sinaia Formation); 9 – Liasic + Dogger olistolith bodies in wildflysch; 10 – limestone olistoliths (Tithonian- Neocomian) in wildflysch, associated with jaspers.

Creek, in the wildflysch deposit, there are numerous blocks of grey platy limestone with calcite veins, fine, muscovitic marls, with a silky aspect and calcareous sandstones with veins filled with white or pink calcite; many split apart beds of limestone have slickensides on their surfaces.

From such rocks the following species were recovered (Grasu, 1972, 1973): *Costatoria costata*, *Pseudomonotis inaequicostata*, *Pecten discites*, *Gervilleia exporrecta*, *Natiria costata*. Lithologically, but mainly faunistically, these limestones belong to the basal Triassic in Werfen facies, of the allochthonous Transylvanian succession. They are similar with those described by other authors in Poiana Albă, Curmătura or in the watershed of Gherman Creek, east of Munticelu (Herbich, 1878; Băncilă, 1941; Grasu, 1970, 1971; Săndulescu, 1975).

Liassic. The Liassic deposits from Piatra Luciului were discovered by Preda and Pelin (1969, 1976). They are located immediately south of the Piatra Luciului Stone, as a knoll projecting up from the surrounding rocks. According to the mentioned authors, it consists of microruditic sandstone overlain by black sandy limestone with marls interbeds, followed by the Dogger deposits, then, by massive limestone in Stramberg facies (Tithonian). From the deposits ascribed to the Liassic, a fauna with *Zeilleria subcornuta*, *Zeilleria quadrifida*, *Spiriferina tumida*, *Spiriferina alpina,* fragments of belemnites and rare ammonites was recovered; such fauna would indicate a Domerian age of these deposits and they were correlated to the Domerian deposits from the Ghilcoş Creek. Further observations (Grasu, 1972, 1973) demonstrated that the deposits represent spathic limestone, showing a microfacies of biosparites with abundant echinoid and crinoid debris. The microfauna is frequent, often being observed sections through *Nodosaria*, *Frondicularia, Lenticulina*, and species of *Spirillina liasssica* and *Spirillina turgida* frequent in the Liassic.

In this location, over the *Spiriferina* and *Spirillina* - bearing spathic limestone, we could not identify the unit ascribed to Dogger by the previous authors. The spathic limestones are followed by similar rocks with rare belemnites, in thin sections showing the same Liassic microfauna with *Nodosaria*, *Vidalina martana*, *Globochaete alpina*. etc. The echinoderm debris is abundant and, sometimes, represents the only constituent of the rock; the quartz is quite rare. Their microfacies seem similar to the deposits in Hierlatz facies (Liassic) from the Red Lake area, where the same fauna with *Spiriferina* and microfauna with *Spirillina* were described (Grasu and Turculeţ, 1967; Grasu, 1970), and not with the Domerian ones, which are sandy and marly-sandy.

Dogger. Pelin (1969) and, later, Preda (1976) mentioned two outcrops of Dogger rocks, one associated with the mentioned Liassic and another, at about 100 m north-west of the calcareous knoll of Piatra Luciului (1191 m). The fauna described by the authors include: *Montlivaultia caryophyllata*, *Thecocyatus discus*, *Anabacia complanata*, *Kallirhynchia concinna*, *Chlamys dewalquei*, *Camptonectes lesn*, *Entolium demissum*, *Entolium cingulatus*, *Pholadomya murchisoni, Myo-*

phorella signata, *Plagiostoma* sp, belemnite fragments and very rare ammonites.

Macroscopically, the fossil bearing rocks in this area look like fine-grained calcareous sandstones, associated with rare spathic limestone. Beside the fauna identified by the mentioned authors, Grasu (1972, 1973) found rare specimens of small sized *Terebratula*, *Eopectinidae* and *Trigoniidae,* species of genera *Lopha*, *Pinna*, and rare gastropods of *Nerinella* group. Rocks of the Middle Jurassic have also been identified on Piciorului Creek, as olistoliths within the wildflysch; they are blocks of sandstones with diameters of 1-1,5 m, in which Grasu (1972,1973) found a fauna with: *Entolium demissum*, *Pinna buchi*, *Pinna opalina, Ostrea* cf. *calceola*, *Chlamys* sp., *Astarte* sp.

Tithonian. Associated with the Liassic and Dogger deposits from the Frunţii Creek's spring, there are large limestone klippen, that from Piatra Luciului reaching remarkable size. They are white to grey limestone ascribed to the Tithonian (Pelin, 1969; Preda, 1976) or to the Tithonian-Neocomian (Săndulescu, 1975).

The limestones are homogenous and compact and are different from those situated immediately to the west and incised by the right tributaries of Bicăjel Creek, where the megabreccia aspect is obvious. The Tithonian age and the similarity with Stramberg limestone are not yet demonstrated, but this could be done through a detailed microfacies study.

Remarkably, sometimes these limestones are intimately associated with jaspers (Grasu, 1972, 1973), as can be observed on the eastern side of the limestone massif from Piatra Luciului, right in the path leading to Stânjeni, where the latter show a greenish, or even brown, colour and are well stratified, strongly resembling the Callovian-Oxfordian jaspers from the surroundings of Red Lake. However they do not show the massive aspect of silicoliths that normally accompany the pyroclastic-tuffogenous formation from Fagului Saddle or Toşorog-Tulgheş, described by Băncilă and Papiu (1962).

According to Pelin (1969) and Preda (1976), the Liassic, Dogger and Tithonian limestones from Piatra Luciului would be *in situ*, forming the western limb of a syncline, its inverted succession continuing eastward, underneath the Cretaceous wildflysch, where it might overlie the Triassic dolomites from the external limb of the Hăşmaş Syncline. However, the authors ignored the presence of *Aptychus* Formation (Kimmeridgian-Neocomian), in its detrital-pelagic facies, extending from the Trotuş Drainage Basin to Piciorului Creek, where it disappear, below the transgression surface, overlain by the wildflysch deposits. Hence, there would be only a distance of 1-1,5 km between the Tithonian in neritic-reefal Stramberg facies and the detrital-pelagic, bathial facies of the *Aptychus* Formation. This short distance can be explained only by tectonic relationship between the two different deposits. This way, the Liassic and Dogger, as well as the Tithonian block from Piatra Luciului, the Werfen Triassic included, are nothing than olistoliths inside the Cretaceous wildflysch. Through their fauna, the Liassic and Dogger of neritic type similar to the Bucovinian series from the rest of the syncline, prove that they have been 'stripped' from the autochthonous suite and included in the wildflysch deposits; their association with the Stramberg limestones cannot be but accidental.

The Transylvanian Liassic and Dogger show completely different facies, with faunas consisting almost exclusively of ammonoids, as is the case of the Adneth Liassic from Curmătura and of the ammonite bearing oolithic ferruginous limestones from Red Lake area, with their fauna described by Herbich (1878) and Jekelius (1922); the latter are lately interpreted as olistoliths (Săndulescu, 1975), interpretation which is possible, if not even almost certain.

If in case of the Liassic and Dogger successions the facial differences between the autochthonous Bucovinian and the allochthonous Transylvanian are approximately clear, the association of the Stramberg limestones with the Callovian-Oxfordian jaspers requires an explanation, as the latter are usually ascribed to the Bucovinian series, overlying the Dogger and overlain by the wildflysch. It can be assumed that the stratigraphic interval of the Callovian-Oxfordian would have corresponded to a moment in which both domains, Transyilvanian and Bucovinian, have had similar sedimentary conditions that determined accumulation of similar or almost similar deposits (Grasu,1970,1972,1973).

The fauna of the wildflysch deposits. From the surroundings of Piatra Luciului, Noszky (1950, *in* Săndulescu, 1975) described the richest fauna from the wildflysch. There is no detailed information regarding its provenance, namely, if it was sampled from the wildflysch, or from the flysch units (namely the paratypic wildflysch of Săndulescu, 1975). This fauna includes: *Rhynchonella bertheloti*, *Nucula pectinata* var. *caucasica*, *N*. cf. *compressa*, *Arca neocomiensis*, *A*. aff. *moreana*, *A*. cf. *securis*, *A. raulina*, *Trigonia undaticostata*, *T. fittoni*, *T*. cf. *diverticulata*, *T*. aff. *ornata*, *Venicicardia* cf. *abtruncata*, *Astarte* cf. *numismalis*, *A*. cf. *incrassata*, *Opis* cf. *mayori*, *Isocardia* sp., *Corbis cordiformis*, *Cardium* cf. *lelegardense*, *C*. aff. *coniacium*, *Cyprina* cf. *ligeriensis*, *C*. sp. aff. *forbesiana, Venus vassiacensis*, *Cytherea* cf. *intersisa*, *Panopea schroderi*, *P*. *elongatastriata*, *Corbula striatula*, *C*. aff. *parvula*, *Pinna* cf. *sulcifera*, *Gervilleia anceps*, *Lima dauphiniana*, *Pecten* sp. aff. *raduleides*, *Janira atva*, *J. neocomiensis*, *J. corneta*, *J. matheroniana*, *Plicatula placunea*, *Spondylus* cf. *coquandianum*, *Ostrea* aff. *carinata*, *O*. *tuberculifera*, *Mytilus* cf. *lanceolatus*, *Phasianella conula*, *Solarium* cf. *duphiniana*, *Cerithium neocomiensis*, *Chenopus* aff. *calcaratus*, *Anochura carinata*, *Lathyrus* aff. *gracilis*, *Desmoceras* cf. *difficile*, *Pulchelia pulchellis*.

2.4. The *Aptychus* Formation

The sedimentary unit known, initially, as *Aptychus* Beds was described, for the first time, in the Rarău syncline from the East Carpathians (Paul, 1876). For decades, this formation was not treated as a stratigraphically independent unit, being associated, most often, with the Eocretaceous deposits and, struc-

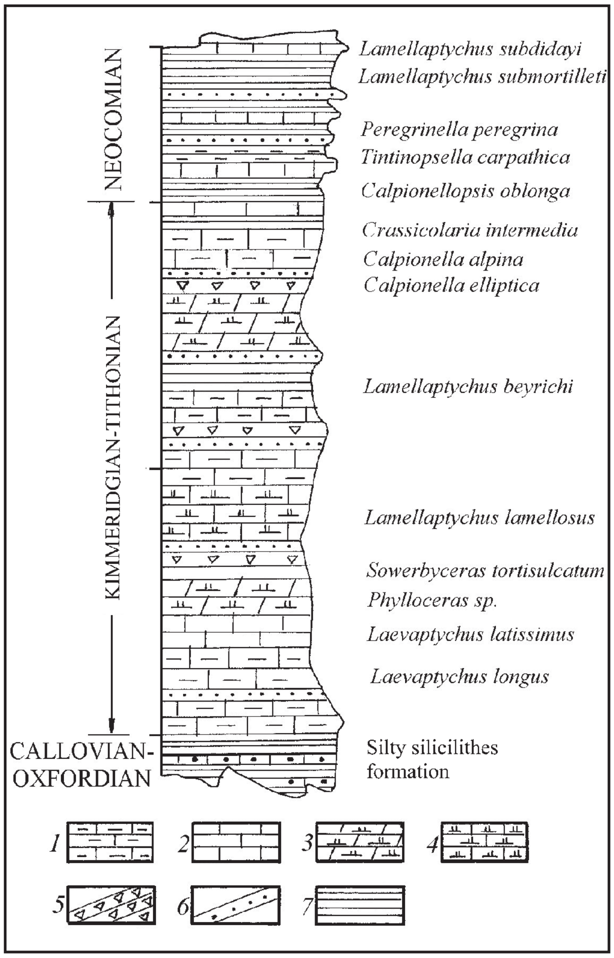

Fig. 10. Synthetic lithostratigraphic column of the Formation with *Aptychus* in Trotuş-Dămuc area: 1 – Red, cherry and green clayey micrites; 2 – micrites and biomicrites; 3 – marly quartz-siltstones; 4 – quartz-silty micrites and biomicrites; 5 – microbreccias; 6 – calcareous litharenites; 7 – quartz-silty-muscovite marls.

turally placed, at the base of the Ceahlău flysch. Currently, it is unanimously accepted, and also proven, that this formation represents the Neojurassic and Eocretaceous of the Bucovinian succession, a partial stratigraphic equivalent of the carbonate succession peculiar for the Hăşmaş Transylvanian Nappe.

In the Hăşmaş Syncline, the *Aptychus* Formation occurs only on the eastern limb and was initially reported by Herbich (1878). The numerous studies that followed were focused, both on its biostratigraphy, through the inventory of its content in aptychi, ammonites and tintinnids, as well as its structural position (Preda and Atanasiu, 1925; Băncilă, 1941; Patrulius *et al*, 1962, 1969, 1976; Dinu, 1971, 1985; Dinu and Matei, 1972; Turculeţ and Grasu, 1965, 1968; Grasu, 1971; Grasu and Turculeţ, 1973, 1978; Săndulescu, 1967, 1969, 1972, 1975).

Briefly, it should be mentioned that, after long discussions, a certain consensus was reached concerning the stratigraphic position of this sedimentary succession, accepting that it includes the Late Jurassic and Neocomian. However, some authors (Patrulius *et al.*, 1969, 1976) considered that there are two lithologically distinct units, but, partly stratigraphically coeval, namely, the *Aptychus* Formation *s. str.* and the Lunca Formation. It seems that there is only one unit, as demonstrated by Grasu and Turculeţ (1973, 1978), the *Aptychus* Formation *s.l.* with a lower member including a red limestone layer of *ammonitico rosso* type, of Kimmeridgian-Tithonian age and an upper member of Neocomian in age, both rich in aptychi type faunas (Fig. 10). While the lower member partly corresponds to the *Aptychu*s Beds *s. str*. of the mentioned authors and host the ammonites, laevaptychi and lammelaptychi from groups A and B, in its lower part and the Tithonian tintinnids associations, in its upper part, the upper member includes the aptychi faunas with evolved, retroversed ornamentation, of groups C and D, the associations of Neocomian tintinnids and specimens of *Peregrinella peregrina*, recovered from the Brateşului Creek-Dămuc area (Grasu, 1971).

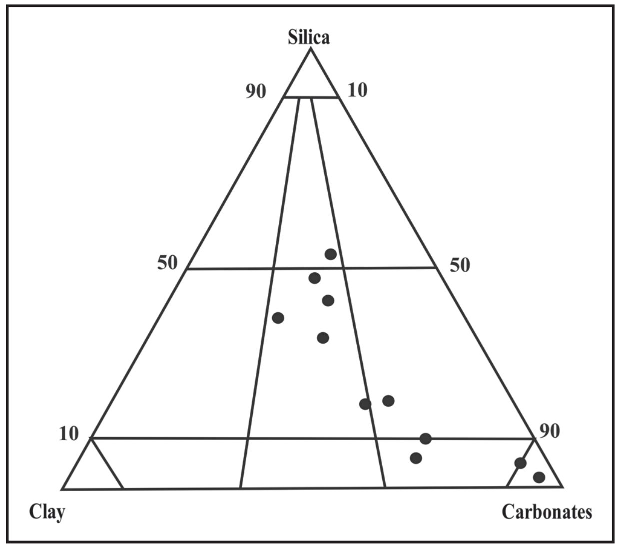

Fig. 11. Carbonate-silica-clay diagram of samples from the lower member of Formation with *Aptychus* (after Grasu *et al.*, 1995).

The lower member. The petrografic background of the basal level of the *Aptychus* Formation consists of massive or bedded, quartz-silty-muscovite marls, showing grey or greenish color; besides the quartz-silty varieties, marls with sandy aspect also occur. The peculiar feature is represented by the cherry-red clayey micrites, transitional from marls to limestone. These rocks are interbedded with marly quartz-siltstones, micrites and biomicrites, microbreccias, and calcareous litharenites. The petrographic heterogeneity of the lower member is well illustrated by the position occupied by some samples from its succession in the carbonates-silica-clay diagram (Fig. 11).

In the studied area, the lower member extends from the Trotuş Basin, through Fagului Saddle, Lupului, Brateşului, Arşiţei, Mâţului (Arşiţa Almaşului) Creeks, up to Piciorului Creek, where it disappears, either due to the erosion prior to the deposition of wildflysch, or to the transgressive character of the latter one.

The fossil fauna recovered from these deposits (Turculeţ and Grasu, 1965, 1968) was found, especially from red or grey silty and sandy marls, and seldom from the limestone outcrops on all the above mentioned creeks, that cut the deposits crosswise (Fig. 9). This fauna includes: *Laevaptychus longus*, *L. latissimus, L. latus* var. *taxopora*, *L. latissimus* var. *pseudoseriopora*, *L. latobliquus*, *L. longobliquus*, *Lamellaptychus beyrichi*, *L. beyrichi* var. *fractocosta*, *L. beyrichi* var. *undocosta*, *L. rectecostatus*, *L.* aff. *cuneiformis*, *L. inflexicosta*, *L. inflexicosta* var. *lata*, *L. carpathicus, L. lamellosus*, *L. sparsilamellosus*, *L. submortilleti*, *L. gillieroni*, *Punctaptychus punctatus*.

From the basal part of the lower member, namely from Mâţului Creek and Şaua Fagului, is known the ammonites fauna reported by Dinu and Matei (1972) and revised by Grasu and Turculeţ (1973), with *Berriasella praecox*, *Ptychophylloceras feddeni*, and *Nebrodites broilli* to which Preda (1973) added *Sowerbyceras tortisulcatum*. Lately, Turculeţ (2004) described *Phylloceras* aff. *barrabei*, *Lytoceras* cf. *montanum*, *Protetragonites quadrisulcatus*, *Pseudolissoceras* cf. *planiusculum, Glochiceras pseudocarachteis, Lytogyroceras* aff. *strictum, Dalmasiceras* cf. *pseudogenitor*, *Dalmasiceras subprogenitor*. The laevaptychi and ammonites fauna indicate that, at least a part of the lower member of the *Aptychus* Formation is Kimmeridgian in age. From its top part, besides lamellaptychi, some tintinnids species have also been described, indicating the Tithonian age. The tintinnids have been studied by Săndulescu (1975) who reports the species *Crassicolaria massutiniana*, *C. intermedia*, *C. brevis*, *Calpionella alpina*, *C. elliptica*. The macrofauna, as well as the microfauna, of the deposits demonstrate that the lower member of the Formation with *Aptychus* belongs to the Kimmeridgian and Tithonian, being the stratigraphic equivalent of the Formation with *acanthycum* and of the Stramberg Limestone from the Transylvanian succession of the Hăşmaş Nappe.

The upper member. With a thickness up to 150 m, it is different of the lower member and relatively monotonous by lithologic (petrografic) point of view, extending from the Trotuş Basin up to the Dămuc Basin. It is characterized by the obvious bedding of silty marls, which either split apart in milimetric laminae or are more massive, greenish or greyish-white in color. They contain rare sublithographic limestone beds (<1 to 6-10 cm thick up to maximum 15-20 cm), that can be seen clearly on the silty marls background, due to their lighter color. Quite often also occur grey-bluish coarse sandstone beds (<1 up to 4-10 cm) showing sometimes a faint grading, with microrudites at their base. The *Peregrinella peregrina* was recovered from the microrudite beds in the Brateşul Creek area (Grasu, 1971). The microfacial and chemical-mineralogic study has shown that the upper member consists of the following petrographic types: quartz-silty-muscovite marls, clayey and clayey-quartz-silty micrites, and calcareous litharenites, as results from the carbonates-silica-clay triangle (Fig.12; Grasu *et al.*, 1995).

The fauna recovered from the upper member includes assemblage of apthychi (Turculeţ şi Grasu 1965, 1968): *Lamellaptychus mortilleti*, *L* cf. *studeri*, *L.* var. *retroflexa*, *L. submortilleti*, *L. submortilleti* var. *retroflexa*, *L. aplanatus*, *L. theodosia*, *L. theodosia* var. *rectangulus*, *L.* aff. *subdidayi*. From the Arşiţei Creek, Turculeţ (2004) also described *Berriasella bebrovensis* and *Tîrnovella berriasensis*. To the aptychi and ammonites a tintinnids association was added (Săndulescu, 1975), including: *Crassicolaria parvula*, *C. alpina*, *C. elliptica*, *Tintinopsella longa*, *T. carpatica*, *Calpionellites darderi*, *Calpionellopsis oblonga*, *C. simplex*.

Both the aptychi and tintinnide faunas indicate the Neocomian age of the upper member, definitely the Berriasian and Valanginian age.

2.5. The Hăşmaş Breccia

For a long time, it was assumed that, in the Crystalline-Mesozoic Area of the East Carpathians, the oldest sedimentary deposits overlying the pre-Alpine metamorphic basement are represented by the quartzose sandstones and conglomerates, initially considered of Verrucano facies and ascribed to the Permian (Herbich, 1878 and Uhlig, 1907). After the discovery of the Azodu Mare fauna from the Tulgheş zone (Atanasiu, 1928), there was palaeontological evidence that they actually belong to the younger stratigraphic division of the Seisian (Early Werfenian). Actually, they represent the deposits of the Alpine cycle, accumulated in a marine shelf area, in the rifting phase of the Carpathian sedimentary basin (the former geosyncline).

It was, however, reported that, at least in the Tisa-Ciuc compartment of the Crystalline-Mesozoic Area and, especially, in the Hăşmaş Syncline, the Seisian conglomerates and sandstones unconformable overlay the bedrock not always represented by metamorphic rocks, but also by a breccia reworking exclusively metamorphic clasts – the Hăşmaş

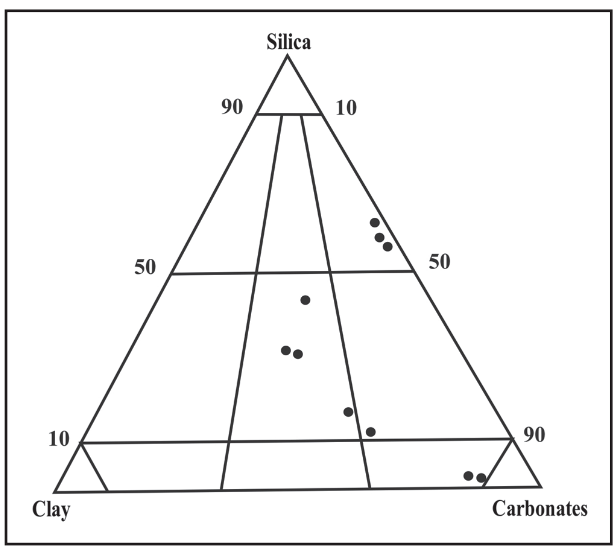

Fig. 12. Carbonate-silica-clay diagram of samples from the upper member of Formation with *Aptychus* (after Grasu *et al.*, 1995).

Breccia (Mureşan, 1970). This breccia is better represented on the internal limb of the syncline, starting with Balint's Creek, a southern tributary of the Olt River. The breccia is clast-supported and consists of disorganized angular clasts of metamophic rocks, with very small amount of matrix. The clasts reworked represent, both medium and low-rank metamorphics, such as: micaschists, paragneisses, ocular gneisses, gneissose granites, gneissose diorites, sericite-chlorite schists, sericite-graphite schists, sericite quartzite etc.

The angularity of clasts, lack of sorting, and the coarse detrital matrix, indicate a continental sedimentary environment of a material resulted through by the denudation processes and short transport (Mureşan, 1970). Consequently, the breccia represents a colluvial deposit, accumulated before the Seissian transgression, very likely during the Permian time. This Permian breccia is also exposed along the external limb in the Lunca anticline and 'Creasta Dămucului'. In our study area, the Hăşmaş Breccia is exposed on the Guşei Creek, and we identified it, lately, on Frunţii Creek (Fig.13).

The outcrop on the Frunţii Creek shows several features that request an explanation. In this outcrop the Triassic dolomites directly overlie the Hăşmaş Breccia (Fig.13), while the sandstone-conglomerate unit, Seissian in age, lacks. This situation is not unique, because there are more others lineaments where the basal clastic succession of the Alpine cycle lacks. The situation is explained as a break in sedimentation, correlable with the detachment of the dolomites from their metamorphic basement (Săndulescu, 1975). We think this interpretation is a logical one, considering the contrast in competence between dolomites and the more plastic metamorphic substrate represented by the Tulgheş Group. Moreover,

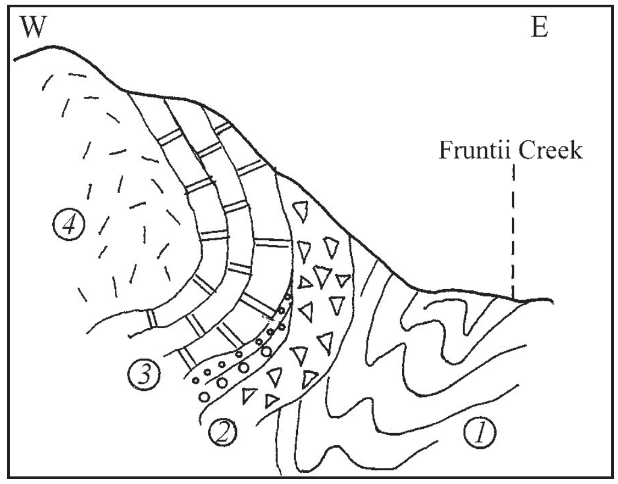

Fig. 13. Geological cross-section along Frunţii Creek: 1 – Bretila Group; 2 – Hăşmaş Breccia (Permian); 3 – Triassic dolomites; 4 – Wildflysch (Barremian-Albian).

the outcrops on Frunţii Creek, but mainly the new artificial exposures on Piciorului Creek, along the newly built forest road, show that in 'Creasta' Dămucului area, the metamorphic basement, the Triassic dolomites and, even, the lower member of the *Aptychus* Formation (Fig.14) slightly overthrust the Wildflysch Formation. Actually, it is an opposite, westward, vergence of the structures, including the Central-Carpathian Fault, *i.e.* the overthrust plane of the Crystalline-Mesozoic Area over the flysch zone, showing this *à rebours* feature (Săndulescu, 1975). The situation on Piciorului Creek clearly confirms this structure. The interpretation is that this structure was the result of the Laramian, maybe Miocene, post-paroxysmal tectogeneses, that resulted in refoldings, includ-

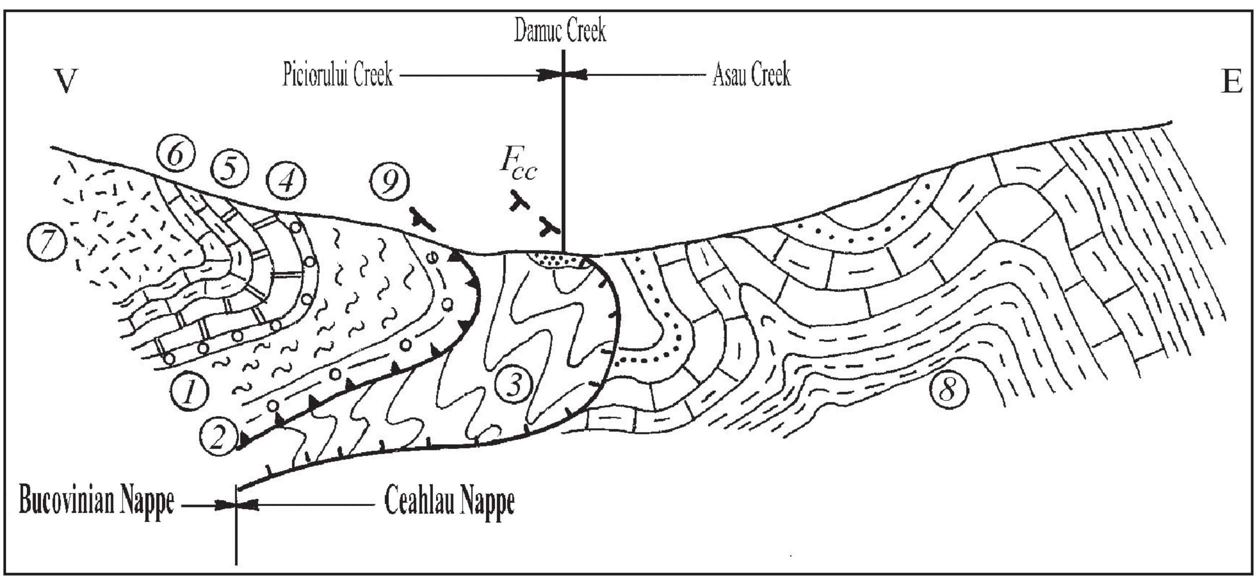

Fig. 14. Geological cross-section along Piciorului Creek – Asău Creek, indicating the *à rebours* character of the deposits from the eastern limb of the Hăşmaş Syncline and of the Central Carpathian Fault (F_{cc}): **Bretila-Rarău Group:** 1 – garnet-bearing micaschists; 2 – gneisses; 3 – **Tulgheş Group**; 4 – conglomerates and sandstone (Seisian); 5 – dolomites (Campilian-Anisian); 6 – Formation with *Aptychus* (Kimmeridgian-Tithonian); 7 – Wildflysch; 8 – **Ceahlău** Nappe (Sinaia Formation).

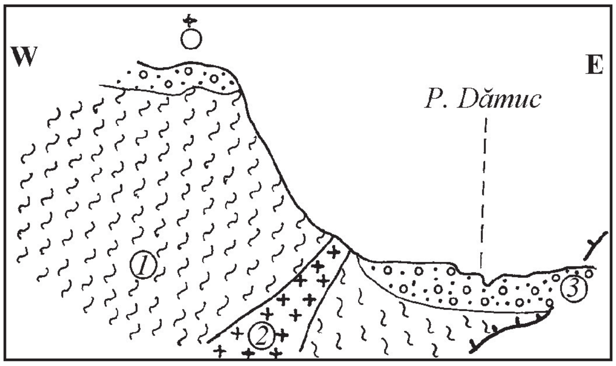

Fig. 15. Geological cross-section on Dămuc Creek, upstream of its confluence with Frunţii Creek, indicating the position of the basalt dyke that intrudes the basement of the Bucovinian Autochthonous (after Grinea, 1998): 1 – Tulgheş Group (undivided); 2 – basalts; 3 – Quaternary (terrace and main river bed alluvial deposits).

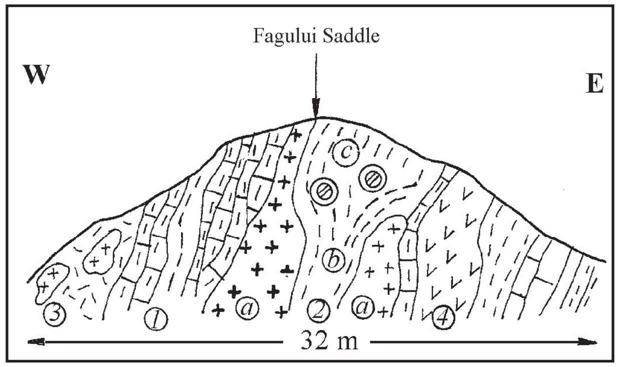

Fig. 16. Detailed geological cross-section in the pyroclastic-tuffogenous complex from Fagului Saddle, included in Formation with *Aptychus*: 1 – Lower member of Formation with *Aptychus* (Kimmeridgian-Tithonic); 2 – pyroclastic-tuffogenous complex; a – diabases and green, red or black siliciliths (opalites); b – quartz-silty or sandy marls affected by thermal metamorphism; c – silicified logs and cones of conifers + cycadae; 3 – wildflysch with dolerite olistoliths; 4 – covered area.

ing that of Central Carpathian Fault, which explains why, on certain lineaments, this major thrust shows segments with backthrusting.

2.5. Autochthonous basic magmatites

The Hăşmaş area hosts the scarce autochthonous basic magmatic rocks from the Crystalline-Mesozoic Area of the East Carpathians. These are found on the external limb of the Hăşmaş Syncline and include the basalt dykes from the Dămuc Valley, upstream the junction with Frunţii Creek (Fig. 15) and the pyroclastic-tuffogenous complex from the Fagului Saddle, linking the Dămuc with Valea Rece (Fig. 16). The basalt dyke intruded in the Tulgheş metamorphic rocks was initially reported by Ianovici and Ionescu (1966) and was studied in detail by Grinea (1998). The pyroclastic-tuffogenous complex, included in the Lower Member of the *Aptychus Formation* (Late Jurassic) was initially described by Băncilă and Papiu (1962) as diabasic agglomerates and tuffs, associated with siliciliths (jaspers) (Fig.16). The debris of silicified conifers and cycadae recovered from this magmatic complex indicate a subaerial effusive magmatic activity. Both basalts, and the volcanogenic complex represent a within plate basic magmatism related to the opening of the East Carpathian rift basin (Outer Dacide Trough), both being coeval with the Azuga magmatic series of the Sinaia Formation.

3. CONCLUSIONS

The area of the Bicaz Gorges – Hăşmaş National Park, includes the limestone and dolomite massifs of Licaşul, Suhardul Mic, Cupaşul and Bardosul, in the north, and Hăşmaşul Mare, Piatra Singuratică and Fratele, to the south, belonging, mainly, to the Hăşmaş Transylvanian Nappe. However, several scientific, geologic, geographic-geomorphologic and biological objectives, respectively, recommend the neighboring area between Municelu-Surduc and Fagului Saddle, more precisely, the so-called „Creasta" Dămucului, to be included in the protected are or, at least, to become a buffer zone of the National Park.

Several of the most important places from the area with exceptional scientific value recommended to be included in the Bicaz Gorges – Hăşmaş National Park have been presented in detail:

1) The Munticelu-Surduc limestone massifs, large tectonic outliers of the Hăşmaş Nappe, with the other important sites associated, namely: the Şugău Gorges with the only travertine accumulation from this mountains, the Munticelu Cave, the only real cave in area, with its special speleological heritage, the olitstolith of *Aptychus* „Beds" from Criminiş, and the quarry of the cement factory, the only place in the East Carpathians where the overthrust surface of the Jurassic limestones onto the Cretaceous wildflysch can be seen in outcrop;

2) the Sub-Bucovinian tectonic klippen from Gura Dămucului with one of the most complete stratigraphic successions of this structural units in the East Carpathians, ascribed to the Tirassic, Dogger and Neocomian, based on paleontological criteria;

3) the *Aptychus* Formation, between Fagului Saddle and Piciorului Creek, representing the Malm successions in pelagic facies of the Bucovinian Autochthonous, with rich faunas of aptychi, ammonites and tintinnids, that served to establish the stratigraphic correlation with the calcareous succession of the Transylvanian Allochthonous;

4) the exotic sedimentary klippen from Piatra Luciului, reworked in the Cretaceous Wildflysch Formation, with their fauna assemblages indicating the Werfen type Triassic, the Liassic, Dogger and the Tithonian in Stramberg limestones facies; the richest fauna of the Cretaceous wildflysch was described from the same area;

5) the Permian Hăşmaş Breccia from Guşei and Frunţii Creeks, scarcely exposed in the East Carpathians but with a remarkable paleogeographic significance;

6) the within plate autochthonous ophiolites, very scarcely exposed in the East Carpathians, representing the result of the basic magmatism related to the opening of the East Carpathian rift (Outer Dacide Trough) at the end of the Late Jurassic; it is the basalt dyke on the Dămuc Valley, included in the Tulgheş Group, upstream the mouth of Frunţii Creek and the pyroclastic-tuffogenous formation, extrusive, associated to the *Aptychus*-bearing deposits in Fagului Saddle.

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