GEOLOGICAL DATA AND EVENTS FROM THE ROMANIAN MARAMURES WITH EMPHASIS ON THE PALAEOGENE SYSTEM

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Abstract. The study is essentially a stratigraphical short memoir – regional stratigraphy – of the northern and innermost sector of the East Carpathians: the Romanian province named Maramures. The tectonic setting, then the Jurassic, the Cretaceous and the Mio-Pliocene formations are briefly presented (details are given in some previous articles). The Palaeogene formations are the main object of the study. The central-western basinal area of the province contains turbiditic formations (Eo-Neocretaceous preflysch, Palaeogene flysch and Oligo-Miocene postflysch) deformed by two Alpine tectonic phases, Middle Cretaceous and Middle Miocene, the second being manifestly the folding phase. The peripheral Eastern and Southern zones of Maramures display marginal-neritic Neocretaceous and Palaeogene formations – the postparoxismal cover of the central Crystalline-Mesozoic high uplift. The basement and its cover were affected by deep crustal faults. The ages of the formations at the degree of stage were established by means of the nannoplankton associations (C.M.) and large foraminifers (G.B.). In some cases the sedimentological or petrogenetical conditions or factors, as well as the consequences of the superposition of the recent, nontectonic deformations on the preliminary deformed formations were also debated. An important mass of volcanics is associated with the Mio-Pliocene molasse. Some remarks and comparisons finish the study. The main conclusion of the paper is: the Romanian Maramures represents the South-Eastward continuation of an external zone of the Magura Nappe (West Carpathians) at the inner side of the Central East Carpathians. The morphology of this connection zone (East-West Carpathians) is that of a double basin divided by a central Crystalline-Mesozoic axis.

Résumé. *Données et événements géologique du Maramures Roumain. Examen détaillé du Systhème Paléogène.* Cette étude est une analyse essentiellement stratigraphique – stratigraphie régionale – dans le secteur septentrional et le plus interne des Carpates Orientales, dans la province nommée Maramures (Maramouresh). L'examen des formations du Jurassique, du Crétacé eu du Mio-Pliocène est résumatif (les détails etant donnés dans quelques article antérieurs). La description des formations et des membres du Systhème Paléogène représente le sujet principal du travail. L'aire dépressionnaire, central-occidentale, contient des formations turbiditiques (préflysch éo-néocrétacé, flysch paléogène et postflysch oligo-miocène) qui ont été déformées par deux phases tectogéniques: méso-crétacée et méso-miocène, la deuxième étant manifestement plicative (des nappes-écailles ou écailles chevauchantes). Les zones périphériques du Maramures, orientale et méridionale, comportent des formations de bordure néritique néocrétacée et paléogène. C'est la couverture postparoxismale de la cordillière centrale cristalline-mésozoïque. Le soubassement et sa couverture ont été affectés par une mécanique rupturale profonde (quelques failles crustales). Les datations au degré d'étage ont été établies principalement sur les associations de nannoplancton (C. M.) et de grands foraminifères (G. B.). Dans quelques cas, les conditions ou les facteurs de sédimentation et de pétrogenèse, ainsi que les effets de la superposition des deformations d'origine non-tectonique récente sur les formations préalablement bien déformée, ont été necéssairement pris en discussion. Une importante masse de volcanites est associée à la couverture mio-pliocène d'épaisseur appréciable (mollase poststyrienne). L'étude s'achève avec quelques remarques, comparaisons et conexions. La conclusion principale réaffirme l'idée que d'après les caractères du substrat mésozoïque, autant que ceux des séquences turbidiques paléogènes, le Maramures roumain représente le prolongement vers le sud-est d'une zone externe de la Nappe de Magura de Carpates Occidentales, à l'intérieur de l'axe central des Carpates Orientales, La physionomie de cette zone de raccord entre les tronçons carpathiques oriental et occidental est celle d'un bassin double séparé par une ride médiane, l'axe central cristallin-mésozoïque.

Key words: Romanian Maramures, tectonic setting, regional stratigraphy, Palaeogen, geological evolution

1. INTRODUCTION

The Maramures (Máramaros, Marmarosh) region of Romania is situated at the north-western end of the Eastern Carpathians and occupies a "trans-Carpathian" position, since it is located at the interior of the Central-Carpathian Crystalline-Mesozoic ridge (the Median Dacides, from the official geotectonic standpoint) (Fig.1).

The geological map of the Maramures region shows that most formations present here are of Tertiary age. The central part is filled with Palaeogene turbidite series, whereas the eastern and south-western borders of the region are covered by different Palaeogene marginal facies.

The object of this study is to bring some additions, corrections and details to the data and conclusions published by one of the authors (Bombiță, 1972) about the geology of the Lăpus Mountains (South Maramures).

The pioneering work concerning the Palaeogene of the Maramures region belongs to Zapalowicz (1886). Other geologists studied parts of the same area at about the same time: Pošepný (1862), Gesell (1880, 1881), Primics (1886), Böckh (1897). More recenttly Kräutner (1934, 1938), Pávay-Vajna (1943), Jaskó (1950), Reich (1950) and Strausz (1950) published notes and articles which were sometimes related to the exploration of the mineral ores present in the region. Zapalowicz (1886) as well as Kräutner (1934, 1938) have studied only the Late Cretaceous and Palaeogene formations deposited on

the internal border of the central Carpathian ridge (Borsa and Ruscova paleoembayments) and those covering the metamorphic rocks of the Rodna Mountains.

(1980a, 1980b) and Săndulescu *et al.* (1980-1994).

Since some considerations concerning the general geological evolution of the Maramures region will also be

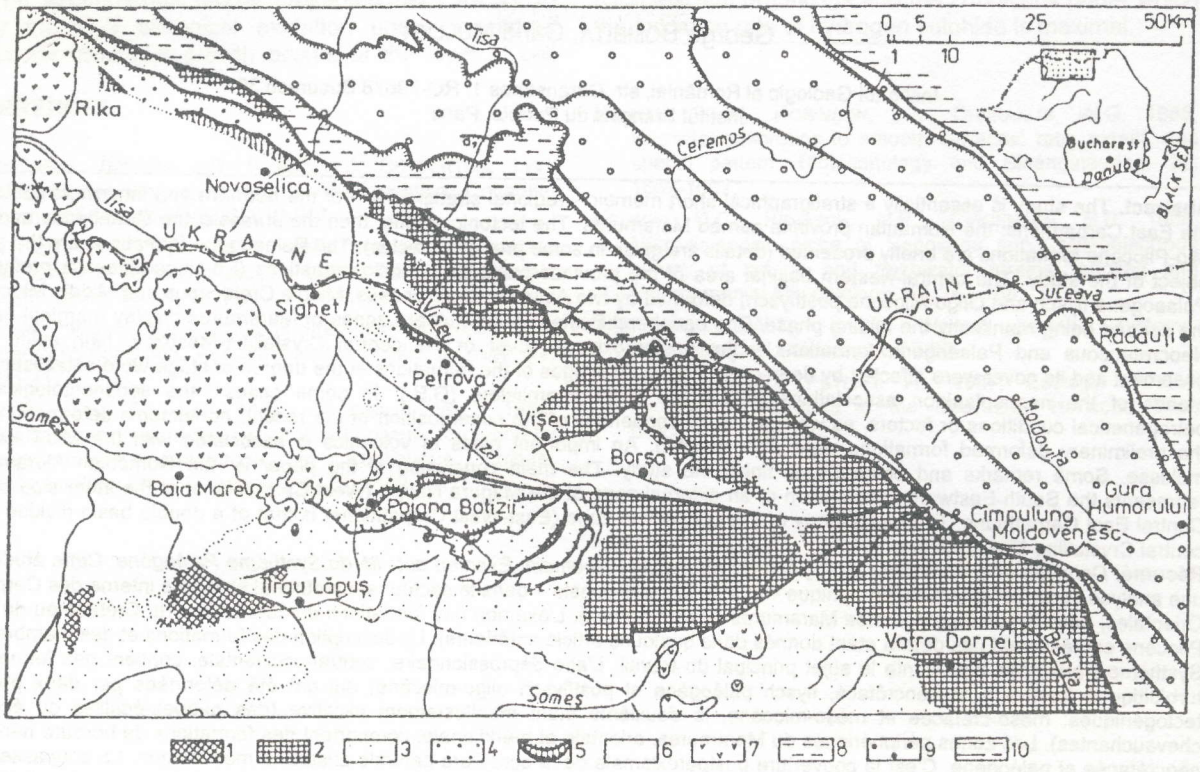


Fig. 1 Position of "Peniny Klippen" in Romanian Maramures. General structural sketch. 1, Inner Dacides, Bihor autochthonous; 2, Middle Dacides, Crystalline-Mesozoic Nappes; 3, post-tectonic cover of the Dacides; 4, Magura Nappe and its equivalent units toward south-east; 5, "Pieniny Klippen" in the Poiana Botizii Village; 6, Neogene molasses; 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.

For all that, at the end of the first half of this century the geology of Maramures was still poorly known. Systematic mapping and research started after 1950, as part of the work for the geological map of Romania (1: 500,000). Subsequently, the Maramures geological formations were studied in even greater detail which was required for the publication of more recent geological maps of Romania on a larger scale 1:200,000 and, in the last years, 1:50,000.

The modern researches of the Trans-carpathian Palaeogene series were made by Patrulius (1954-1960), Mutihac (1955-1990), Atanasiu & Marinescu (1955), Atanasiu (1956), Motas (1956), Dumitrescu (1957) and Ionesi (1959). Detailed stratigraphic and tectonic information is contained in the papers of Dicea *et al.*

discussed within the paper, a summary of the geology of the pre-Palaeogene formations (Middle-Late Jurassic and Cretaceous) proves to be necessary after this Introduction. Also, succeeding the Palaeogene chapter and preceding the Conclusions, the deposits of the transgressive Middle-Upper Neogene molasse formations associated with volcanic materials covering the Palaeogene-Lower Miocene deposits, will be briefly reviewed.

2. OUTLINE OF THE MESOZOIC BASEMENT

The Palaeogene series of the Maramures region are underlain by an pre-Alpine metamorphic basement and by Jurassic-Cretaceous deposits. The latter are known

Fig. 2 Main exposures of the "Pieniny Klippen" rocks at Poiana Botizii. 1, basinal clays with volcanoclastics; 2, cinerites and cinerite sandstones (Callovian); 3, radiolarian jaspers (Callovian-Oxfordian); 4-5, Petricea Formation: 4, limestones with volcanic fragments, 5, calcarenites (Oxfordian); 6-9, Varastina limestones: 6, pelagic limestones with cherts, 7, breccia, 8, *Aptychus* shales and nodular limestones, 9, Ammonitico rosso (Kimmeridgian-Lower Tithonian); 10, Biancone (tectonically placed in member no 6) (Lower Tithonian-Upper Berriasian); 11, olive marls with concretions (Hauterivian-Lower Aptian); 12, couches rouges (Cenomanian-Lower Paleocene); 12a, gray marls with tuffites and tuffaceous sandstones (Cenomanian); 13, variegated silts (Paleocene); 14, Băiut Group, typical flysch (Eocene).


POIANA BOTIZII
Poiana stream
Puntea din Sus
Petricea quarry
Vârdștina brook
Section on the left slope
Section along the brook
Scale III
SW
NE
NW
SE
Sc.V
Sc.IV
Sc.VI
Sc.VII
Sc.VIII
N40-65E/70-80N
N35-50E/45-60N
N50-100E/30-40N
N80-100E/40-45N
N40-65E/40-45N
N40-50E/55-65N
N45E/60-80N
N45E/74N
N35E/80N
N70E/60N
N50E/80N
50m
25
10
5
0

only in some small outcrops near the village of Poiana Botizii (Lăpus Mountains) in the form of several rabotage klippen at the base of the Botiza Nappe. The Mesozoic sequence presents a facies of Pieniny type (well developed in the Slovak and Polish Carpathians) which is basically a condensed suite of pelagic siliceous and carbonate rocks (Fig. 2):

1) Callovian (?) cherry-colored argillites, sometimes silty and apparently agglutinated. Tuffaceous components and pumice blocks are also included.

(2) Callovian (?) yellowish volcanoclastics associated with greenish cineritic "sandstones" of basalt or basalt-andesite composition. Brown cherts (jaspers) and greenish-bluish, more or less silicified argillites are also present. (See detailed descriptions of these two formations in Bombiță & Savu, 1986).

(3) Upper Callovian-Oxfordian banded cherts of greenish-brownish color, sedimentary echo of the volcanics. Interbedded thin layers of limestone and silicified argilites occur in the uppermost part of the sequence. Siliceous microplankton helped to determine the age of these deposits.

(4-5) Oxfordian calcarenites (the Petricea Formation) can be subdivided into two members. The lower one (4) is a coarse light-grey calcarenite in which reworked fragments of ophiolitic rocks (Marcela Dessila-Codarcea in Dimitrescu & Bleahu, 1955) and green oligophiric tuffs in various state of crystallization are included. Red-purple-brown banded cherts, stratiform or cauliflower-looking greenish or red chailles, reddish argillites and volcaniclastics with calcareous matrix are associated with the calcarenites. The upper member (5) is represented by compact calcarenites containing progressively upwards smaller amounts of ophiolitic fragments. Characteristic are bedded or lenticular cherts of variable size. The Petricea Formation occupies the largest area of Jurassic-Cretaceous rocks around the village of Poiana Botizii.

(6-9) Kimmeridgian-Early Tithonian Vărăstina Formation is an Ammonitico rosso facies which is subdivided into several members: (6) pelagic limestones with cherts and marlstones-limestones, more or less silicified; (7) lens-like oligomictic breccias; (8) nodular limestones with red-cherry *Aptychus*-rich shales; (9) nodular, compressed limestones with *Saccocoma* (Ammonitico rosso).

(10) Lower Tithonian-Upper Berriasian-Valanginian milky, micritic, finally fissured pelagic limestones with *Calpionella* of Biancone-Majolica facies. (See detailed descriptions of the formations 3-10 in Bombiță & Pop, 1991).

(11) Hauterivian-Early Aptian Poiana Botizii Formation, represented by dark olive-colored slaby-splintery pelites of Scaglia cinerea type, containing siliceous concretions as well as a characteristic microfauna.

Toward the middle of the Aptian the Meso-Cretaceous phase of the Alpine tectogenesis interrupted the depositional process for some 19-20 million years. Sedimentation resumed during the Early Upper Cretaceous, but from now on with two distinct facies, a basinal and a marginal one. The latter is represented by coarse clastic deposits, while the former, located in the center of the basin, displays a hemipelagic character.

(12) The Early Cenomanian to Early Paleocene basinal sequence is a comprehensive series in Couches rouges (Scaglia rossa) facies: brick-colored silty marls with greenish-bluish spots, rich in microfauna and *Inoceramus* fragments (the Piatra Rosie Formation recording a gradual transition from the Cretaceous to the Palaeogene System).

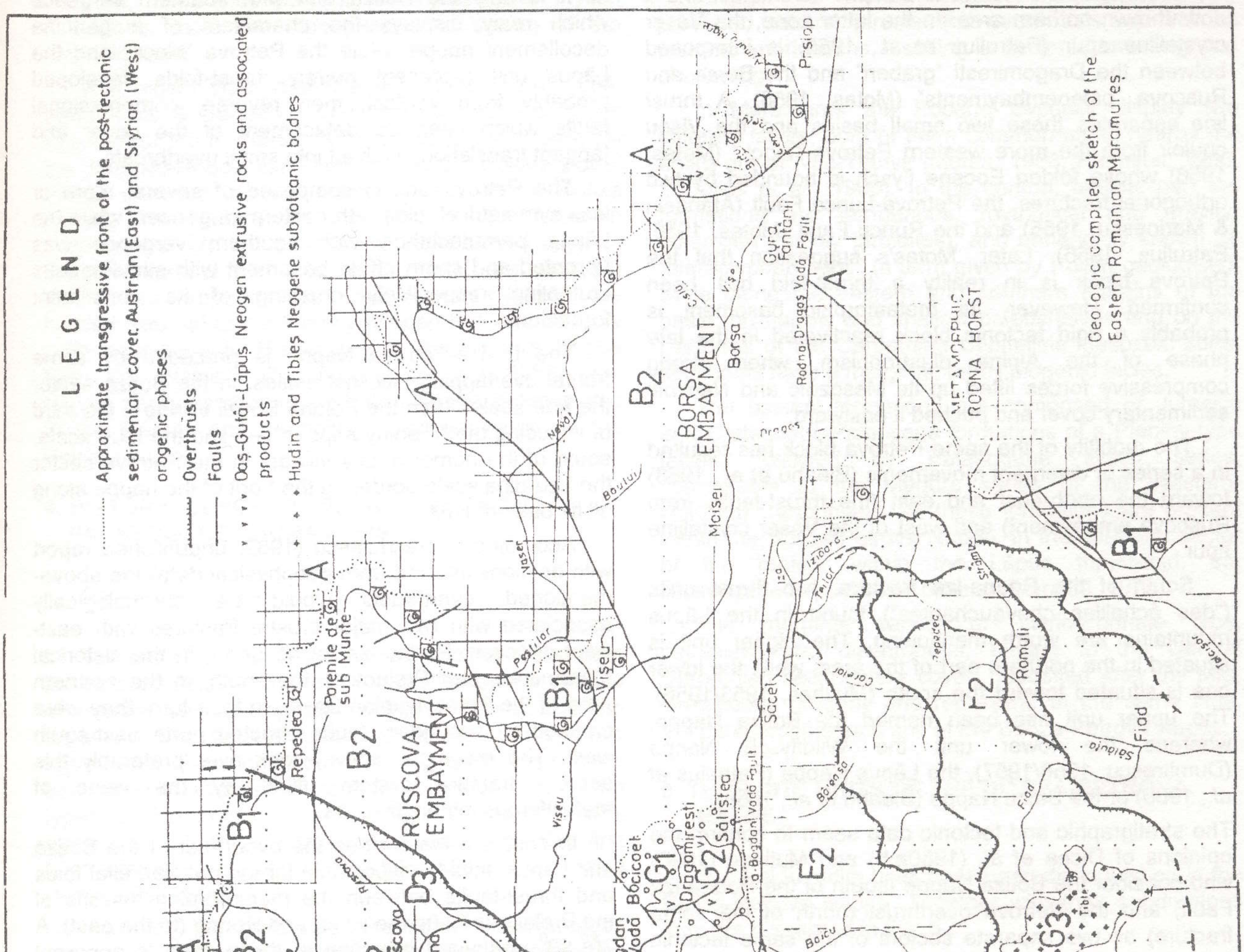
(13) The marginal Late Cretaceous series are situated along the eastern border of the Maramures zone (the Borsa and Ruscova "paleoembayments") and farther north-west, crossing the Romanian boundary into the Ukraine. Zapalowicz (1886), Kräutner (1938), Patrulius (1954, 1955, 1956), Patrulius *et al.* (1960), Iliescu *et al.* (1967, 1968) and Szasz (1974, 1981, 1986) described frequent facies changes and thickness variations of these marginal series. The most important lithological units are: (a) quartz-rich white, yellow or brown conglomerates and sandstones containing *Exogyra columba* (Orlové type) of Late Cenomanian-Early Turonian age (Szasz, 1982, 1986); (b) polymictic Ajmaru Mare conglomerates (Szasz, 1974) with some gray, greenish or reddish marly intercalations containing several species of *Inoceramus* that indicate an Upper Santonian-Campanian age; (c) pelitic red or dark grey marls with *Globotruncana*. In the higher levels of this marly sequence faunas representing the Turonian-Maastrichtian have been identified, while in the uppermost layers a Paleocene microfauna has also been found; (d) the "Orbitoid Beds" (Bombiță, 1966, 1972), renamed the Ungureni Formation (Bombiță *et al.*, 1992), crop out along the south-western fringe of the basin, in the Lăpus Mountains, and are represented by microconglomerates, bio-calcarenites with Orbitoids and Algae, and concretionary marls.The micropaleontological planktonic content indicates the presence of the Middle-Upper Senonian and the Paleocene and even the Lower Eocene. Some short intraformational hiatuses are quite possible.

So far, it is known that the Ungureni Beds have a stratigraphic equivalent in the Bârgău "embayment" near the Cosna village, on the Ciotina valley (Szasz, 1974). More details about the formations 11, 12 and 13 are available in Bombiță *et al.* (1992).

3. GENERAL TECTONIC SETTING (Fig. 3)

Zapalowicz (1886) and Kräutner (1938) were the first to prove the existence along the nothern slope of the Rodna crystalline massif of the important Rodna Fault, susequently renamed the Dragos Vodă Fault (Gherman, 1952, unpubl. report). Strausz (1950) and Pătrut (1952) identified, between the villages of Botiza and Săcel, the Iza fault (so named by Patrulius *et al.*, 1955), also known as the Bogdan Vodă Fault. Pávay-Vajna (1943) and Schréter (1943, *fide* Patrulius *et al.*, 1955) pointed out the existence of some "ample thrustings" on the Iza river.

According to Patrulius *et al.* (1955) and Săndulescu & Bratu (1984) the Dragos Voda and Bogdan Voda Faults are en-echelon faults, while Mutihac (1956, 1990) and Dicea *et al.* (1980b) consider them as two segments of the same single fracture which separate two main compartments, i.e. an uplifted southern area,



Geologic compiled sketch of the Eastern Romanian Maramureș

represented by the Rodna and Lăpus mountains, and a downthrown nothern area. In the latter zone, the Vaser crystalline spur (Patrulius *et al.*, 1955) is interposed between the Dragomiresti "graben" and the Borsa and Ruscova "paleoembayments" (Motas, 1956). A thrust line separates these two small basins and the Viseu couloir from the more western Petrova "block" (Motas, 1956) whose folded Eocene flysch is bounded by two orthogonal fractures, the Petrova-Lunca Fault (Atanasiu & Marinescu, 1955) and the Runcu Fault (Motas, 1956; Patrulius, 1956). Later, Motas's suggestion that the Petrova block is in reality a thrust-fold has been confirmed. However, its metamorphic basement is probably a rigid tectonic block reactivated in the late phase of the Alpine diastrophism, when strong compressive forces lifted up its Mesozoic and Neozoic sedimentary cover and pushed it eastward.

The mobility of the same Petrova block has resulted in a series of divergent movements (Bleahu *et al.*, 1968) toward the north-east and east (the thrust-faults from Ruscova embayment) and west of the Vaser crystalline spur.

South of the Rodna-Iza fracture, two thrust units ("des échailles chevauchantes") found in the Lăpus mountains are worth mentioning. The higher unit is situated in the northern part of the area, while the lower one is situated toward the south (Mutihac, 1953/1956). The upper unit has been named the Botiza Nappe, whereas the lower unit the Wildflysch Nappe (Dumitrescu, 1956/1957), the Lăpus Nappe (Patrulius *et al.*, 1960) or the Baicu Nappe (Bleahu *et al.*, 1968).

The stratigraphic and tectonic data seem to confirm the opinions of Dicea *et al.* (1980a,b) and Mutihac (1990) who consider the Botiza Nappe (south of the Rodna-Iza Fault) and the Petrova overthrust (north of the same fracture) as two separate sectors of the same tectonic unit, the Botiza-Petrova Nappe.The equivalence of both sectors is based on the obvious lithological-paleogeographical relationship as well as on the common lithological scheme of construction. The equivalence would be aserted also by the discovery (Dicea *et al.*, 1980a) of some blocks of Pieniny type in the Tifera hill, west of the Lunca la Tisa village.

The polyphasic reactivation of the Rodna-Iza transcrustal fault (Dragos Vodă and Bogdan Vodă fracture system) has determined the eastward thrust of both compartments, the southern one (in a higher position) advancing some 15 km farther east in comparison with the northern (lower) compartment.

It is only the Botiza unit with southern vergence which realy displays the characters of a genuine décollement nappe, while the Petrova "block" and the Lăpus unit represent merely thrust-folds developed probably from vertical, then reverse, compressional faults which later, by detachment of the cover and tangent translation, evolved into small overthrusts.

The Petrova unit is composed of several more or less symmetrical folds with eastern vergences, while the Lăpus parautochthon with southern vergence was uprooted and shorn off its basement with simultaneous crumpling respectively crushing of its constituent formations.

The Botiza-Petrova Nappe is preceded by some frontal overlapping isoclinal scales: in the Botiza sector the four scales from the Poiana Botizii village – the third of including the "Pieniny Klippen" – and the leud scale, south of the homonymous village; in the Petrova sector the Leordina scale bordering the front of the nappe along all its eastern limit.

According to Săndulescu (1982, unpublished report with opinions inferred from geophysical data) the above-mentioned overthrusts would be chronologically associated with two major crustal fractures with east-west direction: Rodna-Iza to the north, in the historical Maramures, and Preluca to the south, in the northern area of the Transylvanian Basin. In their turn, they were crossed by secundary faults directed north east-south west. The magmatic activity took over preferably this second fracture system, filled by the veins of metalliferous mineralizations.

In southern Maramures the overthrust of the Botiza and Lăpus units is responsible for the quasiparallel folds and thrust-faults between the metamorphic massifs of the Preluca-Inău (to the west) and Rodna (to the east). A 70^0-80^0 northward inflection of these folds is apparent between the Tibles subvolcanic body and the Rodna crystalline massif. A simlar process was active in the northern part of Maramures, where thrust-faults are present in the Ruscova embayement and farther north-west in the Bistra-Rona-Lunca "couloir". In both cases, it is mainly the Oligocene-Lower Miocene series which are involved in folding and thrusting.

It is also worth mentioning that in the upper Sălăuta valley (southern compartment), near the village of Romuli, bright greenish and cherry-red siltstones of Senonian-Paleocene and/or rhytmic suites of Eocene age crop out at the base of several thrust-faults. Such

Fig. 3 Eastern Romanian Maramures, geotectonic sketch compiled after Dumitrescu (1953, unpublished), Patrulius (1955, 1956), Atanasiu (1956), Motas (1956), Mutihac (1956), Bombită (1966, 1972), Dicea, Antonescu, Mitrea *et al.* (1980) and Săndulescu *et al.* (1980-1991). A, Central Carpathians (Middle Dacides). Predominantly Crystalline-Mesozoic forma-tions, Middle Cretaceous nappe system. B, Old posttectogenetic cover. B_1: marginal treansgressive Cenomanian-Eocene formations; B_2: Oligocene-Burdigalian regressive formations in Borsa and Ruscova paleo-embayments. C, Botiza Nappe, Poiana Botizii-Băiut-Botiza sector. The nappe proper with turbiditic formations. The Secu and the Izvoru Vinului formations are separated within the nappe. C_1: Secătura thrust-fold; C_2: Poiana Botizii thrust-folds with Pieniny type Mesozoic klippen; C_3: leud thrust-fold. D, Botiza Nappe, Rozavlea-Petrova-Rona sector with turbiditic formations. The sector is mechanically shifted to the west. The Strâmtura Formation is delimited. D_1: Cornetu thrust-folds; D_2: Leordina thrust-fold; D_3: Ruscova thrust-fold. E, Lăpus bifacial Nappe. E_1: the western sector with shallow water formations; E_2: the eastern sector with turbiditic formations. F, North-Transylvanian bifacial autochthonous. F_1: the western sector with shallow water formations of Preluca type; F_2: the eastern sector (Sălăuta thrust-folds) with turbiditic formations. G, New posttectonic cover. G_1: Badenian-Romanian molasse-like formations; G_2: magmatic rocks and their associated products; G_3: subvolcanic bodies.

deposits, apparently part of the Palaeogene Flysch formations, mark the paleogeographic setting of the turbiditic basin.

In a recent view-point (Săndulescu & Bratu, 1984; Săndulescu & Bădescu, 1994), the general geological structure of the Romanian Maramures is, as follows: (1) the Jurassic-Neocomian klippen from the Poiana Botizii village continue, by the frontal scales of the Botiza Nappe, the Pieniny Klippen Belt of the Western Carpathians; (2) the position of the Botiza Nappe is therefore internal related to the Pieniny Klippen Belt; (3) the Petrova Nappe and the Leordina Scale (Nappe?) are instead external to the Pieniny Klippen Belt and the only units equivalent in Maramures to the Magura Nappe from the Western Carpathians; (4) the "Wildflysch" Nappe, parautochthon of the Botiza Nappe, belongs also to the Pienids and, probably, is an equivalent of the Petrova Nappe.

4. HISTORY, DESCRIPTION AND AGE OF THE PALAEOGENE FORMATIONS

General remarks

The principal data in this central chapter result from the detailed study of the region delimited by the villages of Poiana Botizii, Ungureni, Băiut, Botiza and Săcel situated in the Lăpus Mountains area (Fig.4). It is in this region that the standard lithostratigraphic units have been chosen. Within the aforementioned perimeter both types of formations (basinal and marginal) are well developed, although tectonically juxtaposed. The first posttectonic term of the Middle Miocene is also represented in the region.

However, the area has also some disadvantages from a geological viewpoint. Here, the hydrothermal phenomena are widespread and quite important, producing substantial dissolution and silicification, as a result of a powerful Neogene volcanic activity.

Secondly, the original biologically restrictive pH of the environment, combined with frequent gravity flows (submarine slumps and turbidity currents), have disturbed life processes. As a result, the prevailing microfauna is mostly represented by arenaceous foraminifera grouped into recurrent ecozones and topozones with reduced biostratigraphic significance. Moreover, many forms are redeposited. On that account the equivocal character of some ages.

Finally, the Middle Miocene tectogenesis has produced several thrusts and overthrusts, as well as tectonic imbrications resulting in tectonic shearing and shortening.

In Maramures the Eocene deposits display two different facies, both of them common along nearby the entire rim of Neo-Tethys (Motas, 1956; Patrulius, 1956; Patrulius *et al.*, 1960). In the central, basinal part the formations are terrigenous, rhythmical and gravity-controlled (mainly turbidites), and generically known as "hieroglyphen beds" (a term given by Polish geologists); while along the eastern and southern margins of the basin, on narrow and shallow paleoshelves and on the platforms of the Carpathian Crystalline-Mesozoic zone, sediments have a marginal, partly biogenic facies.

The basinal formations are composed of Jurassic and Cretaceous-Paleocene formations of a Pieniny-type facies, followed by Palaeogene flysch series, comparable to the Magura series of the Western-Northern Carpathians. All these formations are present within the Botiza-Petrova Nappe. In the southern sector of the region, within the Lăpus thrust-fold, the Palaeogene deposits are bifacial (Bombiță, 1972).

The marginal series, of Tatric-Podhale type, ingressive and diachronous, belong to the Central Carpathian sedimentary cover, deposited after the Mid-Cretaceous orogeny and represent, at the same time, the parautochthonous unit of the Botiza-Petrova Nappe.

5. TURBIDITE UNITS OF THE BOTIZA-PETROVA NAPPE

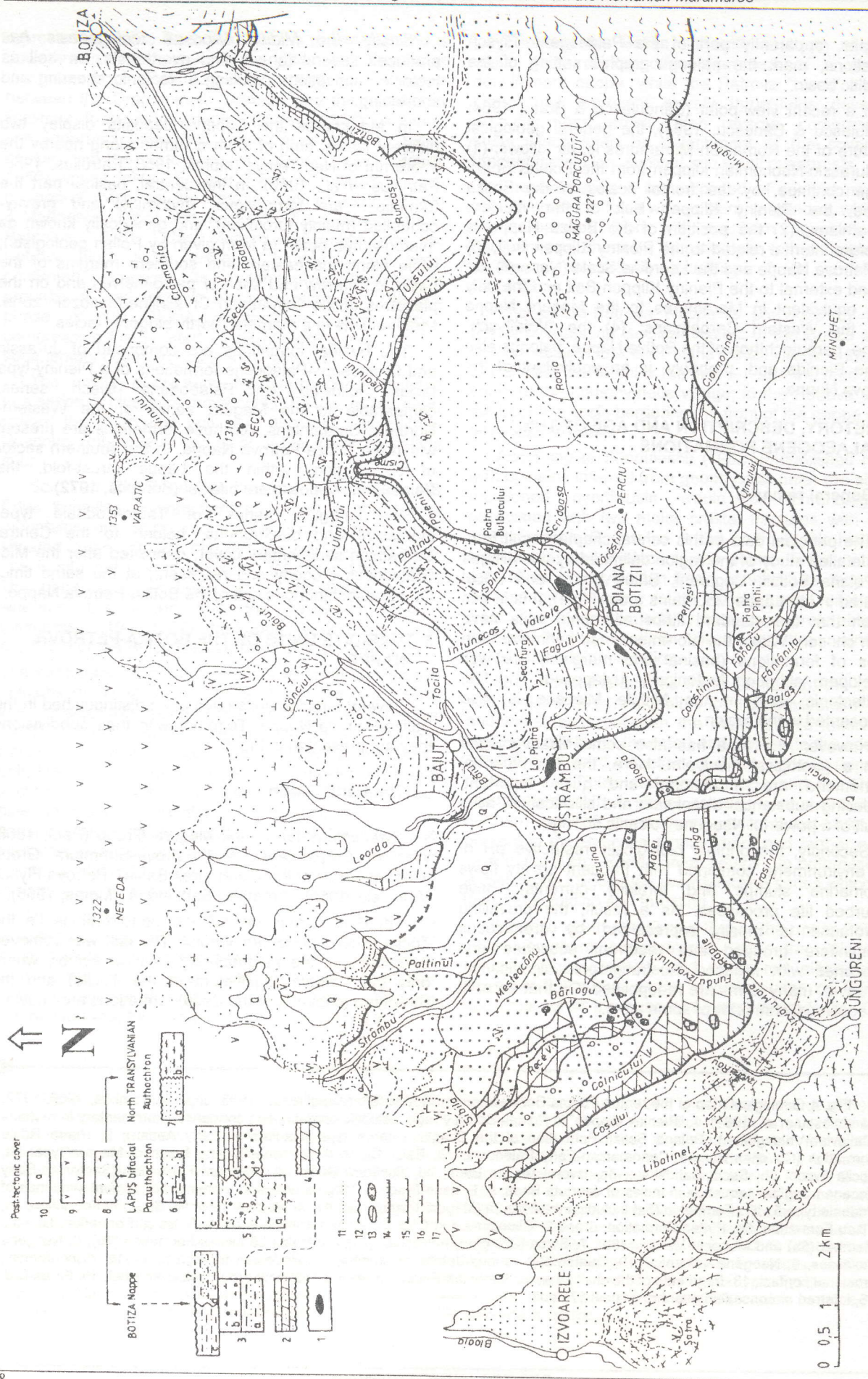
Several turbidite units have been distinguished in the Botiza-Petrova Nappe. Together with their subdivisions they are presented in Fig. 5.

The Băiut Group

Synonimous terms: the Magura Group (Paul, 1868, Western Carpathians); the Petrova-Strâmtura Group (Central sector of the Maramures Basin), Petrova Flysch (Atanasiu, 1956); Strâmtura Sandstone (Motas, 1956).

The Băiut Group consists of three formations, i.e. the Tocila, Secu and Izvoru Vinului. The last was removed by erosion in the neighbouring Petrova sector, where only the Petrova (equivalent of the Tocila) and the Strâmtura (coeval with the Secu) formations are known.

Fig. 4 Geological map of the region Poiana Botizii-Ungureni-Botiza (after Dumitrescu, 1953, unpubl.; Bombiță, 1966, 1972; Săndulescu *et al.*, 1981). 1, "Pieniny klippen" in Poiana Botizii village: volcanic products and condensed sedimentary formations (Callovian-Valanginian). Poiana Botizii Formation of the Scaglia cinerea type (Hauterivian-Early Aptian); 2, Piatra Rosie Formation (Couches rouges, Cenomanian-Early Paleocene); 3, Băiut Group (Paleocene-Eocene flysch of Magura type; 3a, Tocila flysch; 3b, Secul Sandstone; 3c, Izvorul Vinului Beds; 3d, Secătura Beds); 4, Ungureni Formation (Santonian-Early Eocene marginal sequence in facies of Jarmuta Beds; 5, Eocene flysch of Magura type and marginal heteropical sequence of Podhale type 5, Jijia Formation (5a) including the Măgura (Măgura Porcului) lenticular Member (5b); 5c, Strâmbu Formation; 5d, Viseu Formation; 5e, Pintea Formation; 6 and 7, Oligocene and Oligo-Miocene terrigenous beds (6, Baicu Formation: Ursoaia Member (6a) and Muncelu Member (6b); 7, Borsa (-Minghet) Formation (7a) and Valea Lăpusului Formation (7b); 8, Neogene molasses; 9, Neogene volcanics; 10, Quaternary: various detrital sediments; 11, Badenian transgression; 12, disconformity, erosional contact; 13, fragments of the shallow water Senonian-Eocene broken formational group; 14, overthrust; 15, thrust-fold; 16, inferred or concealed overthrust lines; 17, fault.



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The Tocila (Petrova) Formation

Synonimous terms: I. Dumitrescu (1957) named this sequence "normal flysch" and Bombiță (1972) separated it as "the lower horizon of the Tocila-Secu Flysch". Subsequently, Săndulescu & Russo-Săndulescu (1981) and Săndulescu & Bratu (1984) upgraded it to the rank of formation (The Tocila Flysch Formation). It takes its name from the Tocila valley, confluent with the Băiut river between the villages of Băiut and Strâmbu. In places the rocks are strongly affected by hydrothermal processes.

Ionesi (1959) also suggested some possibility of subdividing this formation. Indeed the Tocila flysch can be subdivided into three members i.e. Vâlcele, Scridoase and Crâsmărita (Bombiță, *hic*).

The Vâlcele Member takes its name from the Vâlcele creek which joints the Poiana river in the village of Poiana Botizii. Although the member is known throughout the region, good outcrops are rare. In the southern sector of the region it can be better observed in the thrust-folds near Poiana Botizii (in particular in the Magura Tocilei-Secătura thrust-fold, north of the village), along the Ursu creek (Fundu Botizului) and on the middle course of the Botiza river (Plăiutu creek basin). In the northern part of the region few outcrops can be observed in the neighbourhood of the Petrova and Rona villages (Neagra Mare and Lalu creeks) as well as in the upper reaches of the Porcul creek (Dicea *et al.*, 1980a).

It is difficult to measure the thickness of the member because of frequent thrust-faults and mechanical reductions. It is probably in the order of 30 meters, certainly less than 50 meters (Dicea *et al.*, l.c.). This member is even thinner in the area of Poiana Botizii-Băiut-Botiza.

Lithology. Situated between the Piatra Rosie Formation ("Puchow" *auctorum*, Early Paleocene in Bombiță *et al.*, 1992) and the typical turbidites of the Scridoase Member, the Vâlcele Member is represented by dark-red clays and purple or greenish-gray sandy and micaceous marls. They form centimetric alternances with an incipient rhythmicity. At irregular intervals thin layers of brown-reddish or blackish sandstones with weathered crusts are intercalated.

Fossil content and age. In several permanent exposures on the territory of the Poiana Botizii and Botiza villages a continuous succession can be examined from the Piatra Rosie brick-red marls (Maastrichtian-Early Paleocene) to the Vâlcele Member. Unfortunately almost all samples obtained through repeated colections proved to be sterile.

A sample from the Neagra Mare creek (south of the Bistra village) yielded the only indication of an Early Paleocene nannofossil content, possibly reworked in the Late Paleocene: *Cruciplacolithus tenuis* HAY & MOHL., *Ericsonia subpertusa* HAY & MOHL., and *Ericsonia cava* (HAY & MOHL.) PERCH-NIELS., together with some other redeposited Cretaceous species.

Other smaller and temporary outcrops around Poiana Botizii (the creeks of Vărăstina, Fagu, Vâlcele, Spinu and Paltinu) and near the village of Romuli have yielded a microforaminiferal association where the benthonic agglutinant forms prevail. Among the identified planktonic forms (Bombiță, 1972; Dicea *et al.*, 1980a) are: *Morozovella conicotruncata* (SUBB.), *M. pseudobulloides* (PLUMM.), *Globorotalia crassata* SUBB., *Globigerina triloculinoides* PLUMM., *Glg. linaperta* FINL., *Glg. trivialis* SUBB., *Glg. daubjergensis* BRÖNN. (Early Paleocene microfossil content resedimented in the Late Paleocene as well).

There are also several taxons reworked from the underlying Maastrichtian deposits: *Abathomphalus mayaroensis* (BOLLI), *Globotruncana arca* (CUSHM.) and *Glt. citae* (BOLLI).

The Scridoase Member derives its name from the Scridoase creek, a left tributary of the Poiana stream, 1.5 km upstream the Poiana Botizii village.

In the Poiana Botizii area, outcrops with good reference cross sections can be found following the Poiana stream between the confluence with Vărăstina and Scridoase brooks, then on the right bank of the Poiana valley between the confluence with the Ursu (north) and Fagu (south) valleys, in particular along the Cisme, Măgura Paltinului, Spinu, Vâlcele and Fagu creeks. Within the Petrova sector the same member can be observed along the brooks Seregna (Leordina village), Mârza (south of Petrova), Cornet (south of Rona de Sus) and the Porcul creek basin (north of Oncesti).

The member reaches approximately 400 meters in thickness.

Lithology. The rocks represent the most typical sequence of the Tocila Flysch. They consist of a rhythmical alternance of sandstone beds 10-20 centimeter thick (more seldom 30-40 cm or thicker) and soft, silty marls or clays in binary or ternary sequences. The sandstones are finely grained with muscovite-rich stratification surfaces. The lower part of the sandy beds is compact, well cemented and rich in a large variety of sole marks. The upper part often displays convolute lamination and becomes increasingly shaly and bioturbated upwards. Algal impressions can sometimes be observed. Cross-lamination is seldom present.

The pelitic fraction is gray-greenish in color, quite often with olive and purple strains. Dark siltstones are found throughout the entire sequence, but they appear more frequently in the lower part of the member.

Compared to the Bouma type-sequence the Scridoase turbiditic sequence is often incomplete, since the basal coarse interval (which usually contains large foraminifera) is only rarely present.

This member is mostly affected by the volcanic activity. In the Poiana Botizii-Secu perimeter numerous thermal and especially hydrometamorphic aureoles have been mapped. In these areas the terrain presents steep scarps and cliffs due to the hardness of the resulting hornfels and propylitized skarns. By contrast, in the northern Petrova sector, devoid of volcanites, the relief is much milder with many furrows and ravines, while the slopes are affected by soil creep and slumps.

Fossil content and age. Large Foraminifers. The first but brief profusion of the fauna of Large Foraminifera in Maramures took place in the lower levels of the member. The associations are particularly diverse. Their biostratigraphic significance is unitary – Late Ilerdian-Cuisien, although both the physical state of the tests and

their ratio of the generations A/B indicates they have been transported.

The richest associations were found on the valleys Bloaja Strâmbului (south of the Strâmbu village) and Măgura Paltinului (north of Poiana Botizii village). Both associations were extracted from biocalcarenites seldom interspersed to the rhythmical turbidites towards the base of the member.

Samples from the Bloaja Strâmbului valley yielded the species: *Nummulites pratti* D'ARCH. & HAIME, *N.* ex gr. *nemkovi* SCHAUB., *N. distans* DESH., *N.* ex gr. *exilis* DOUV.- *N. involutus* SCHAUB, *N. planulatus* LAM., *N. aquitanicus* BEN., *N. rotularius* DESH., *N.* ex gr. *archiaci* SCHAUB - *N. pratti* D'ARCH., *N. globulus* LEYM., *N. increscens* SCHAUB., *N. burdigalensis* DE LA H., *N. tauricus* DE LA H., *N. partschi* DE LA H., *N. polygyratus* DESH., *N. praelucasi* DOUV., *N. leupoldi* SCHAUB, *Assilina*, *Operculina*, *Heterostegina* and *Orthophragmina*. From the Măgura Paltinului valley the following species were recorded: *Nummulites* ex gr. *nitidus* DE LA H.- *N. formosus* DE LA H., *N.* ex gr. *burdigalensis* DE LA H., *N.* sp., cf. *buxtorfi* SCHAUB, *N.* cf. *pratti* D'ARCH.& HAIME, *N. distans* DESH., *N. globulus* LEYM., *N. aquitanicus* BEN., *N. planulatus* LAM., *N. exilis* DOUV., *N.* ex gr. *laxus* SCHAUB – *N. nitidus* DE LA H., *Assilina*, *Operculina*, *Orthophragmina* and *Heterostegina*.

On the Ulmoasa and Romanilor valleys, in two erosional windows below the Neogene volcanics of Baia Mare, western Maramures, a ruditic level of the same member includes: *Nummulites* ex gr. *archiaci* SCHAUB -*N. pratti* D'ARCH. & HAIME, *N.* ex gr. *nemkovi* SCHAUB -*N. distans* DESH., *N.* ex gr. *globulus* LEYM., *N.* cf. *rotularius* DESH., *N. burdigalensis* DE LA H., *N.* ex gr. *exilis* DOUV., *N. involutus* SCHAUB - *N. planulatus* LAM., *N.* ex gr. *aquitanicus* BEN., *N. manfredi* SCHAUB, *N. nitidus* DE LA H., and *N. laxus* SHAUB.

From the Spinului valley, north of the Poiana Botizii village, *N. subdistans* DE LA H. and *N. pustulosus* DOUV., were determined while at Gura Leordei, Strâmbu village, *N. pavloveci* SHAUB and *Assilina reicheli* SHAUB occur.

In the basal part of the member, on the Vărăstina creek, an association of arenaceous foraminifera with *Saccaminoides carpathicus* GEROCH has been identified. This species is frequently encountered in the Lower Eocene of the Magura unit in the Polish Carpathians (inf. Ewa Malata).

Along the Neagra Mare valley, south of the Bistra village, there are only slight indications about the presence of the NP 13 and NP 14 nannofossil zones, marking the transition between the Lower and the Middle Eocene.

However, the base of the Middle Eocene (NP 14 zone) is well established at the Poiana Botizii in an outcrop along the lower reaches of the Fagu creek: *Discoaster lodoensis* BRAML. & RIED., *D. kupperi* STRADN., *Coccolithus pelagicus* (WALL.) SCHILL., *Chiasmolithus solitus* (BRAML. & SULL.) LOCK., *C. grandis* (BRAML. & RIED.) RAD., *Discoaster barbadiensis* TAN., *D. sublodoensis* BRAML. & SULL., *D. binodosus* MART.

From the Poiana valley, near the hemp-washing ditches and from the same NP 14 zone, the following forms have been, moreover, identified: *Reticulofenestra* cf. *umbilica* (LEV.) MART. & RITZK., *Coccolithus (Ericsonia) formosus* (KAMP.) WISE, *Sphenolithus moriformis* (BRÖNN. & STRADN.) BRAML. & WILC., *Coccolithus eopelagicus* (BRAML. & RIED.) BRAML., *Discoaster nonaradiatus* KLUMPP, *Chiphragmalithus (Nannotetrina) cristatus* (MART.) BRAML. & SULL.

A second nannofossil association has been found in the Neagra Mare valley, which contains, beside the above-mentioned species, the forms: *Helicosphaera seminula* BRAML. & SULL., *Zygrhablithus bijugatus* DEF., *Cyclococcolithus (Toweius) gammation* (BRAML. & SULL.) ROM., *Sphenolithus radians* DEF., *Zigodiscus (Neococcolithus) dubius* (DEFL.) BLACK and *Discoaster distinctus* MART.

Similar assembladges are present in the Cornet creek, tributary of the Ronisoara valley, as well as in the thrust-sheets at the Romuli village.

In the marly sandstones from a small thrust-sheet in front of the Botiza Nappe (near the Poiana Botizii old school building), a nannofossil association belonging to the NP 14 and NP 15 is represented by *Coccolithus (Ericsonia) formosus* (KAMPT.) WISE, *Discoaster barbadiensis* TAN., *Coccolithus pelagicus* (WALL.) SCHILL., *Reticulofenestra* cf. *umbilica* (LEV.) MART. & RITZK., *Chiasmolithus solitus* (BRAML. & SULL.), *Chiphragmalithus (Nannotetrina) cristatus* (MART.) BRAML. & SULL., and *C. calathus* BRAML. & SULL.

Yet, the benthic agglutinated foraminifera indicate the presence of the Early-Middle Eocene, as well (inf. Ewa Malata).

The deposition of the upper section of the Scridoase Member apparently continued during the first part of the Middle Eocene, as evidenced by the presence of *Cyclammina amplectens* GRZYB. in samples from Poiana Botizii (Vărăstina, Vâlcele and Scridoase creeks) (inf. Ewa Malata).

Remark. As in the case of the Piatra Rosie Formation (Couches rouges), the lithological characteristics of the Vâlcele and Scridoase Members in the Poiana Botizii-Băiut-Botiza perimeter have made possible a sizeable thrust-faulting and imbrication of their deposits. This is why the exposures of the Eocene Tocila flysch observed along the Botiza valley (south of Botiza village) represent only apparently a continous upward sequence. The uniform nannoplankton content of the entire section points possibly toward a repeated imbrication merely of the Scridoase Member.

The Crâsmărita Member is named after the Crâsmărita brook, left tributary of the Roata stream, south-west of the Botiza valley.

Good cross sections are present along the Cisme and the Izvoru Dealului brooks, tributaries of the Poiana river, and in the drainage basin of the Roata stream, tributary of the Botiza river. Although quite complete, the rock sequence is affected by hydrothermal processes. The outcrops from the Fagu valley (tributary of the Poiana stream), those from the Bloaja Strâmbului valley (upstream the decanter) and those from the middle and upper course of the Tocila and Băiut creeks are free of silica-enriching hydrothermal processes.

Besides the aforementioned outcrops present in the Botiza-Poiana Botizii sector, sequences of the member are also found in the Petrova sector: the creek Muntele in the village of Bârsana, the Porcu and Ronisoara

valleys, tributaries of the Iza river, the Seregna and Neagra Mare brooks in the village of Leordina and Bistra respectively.

The member may reach 300-350 meters in thickness.

Lithology. The rhythmicity of the member becomes less obvious, with an increase of the sandy component building strata with a wide range of thickness (up to 2.5 meters). In the Cisme valley, the sandstone layers measure between 0.5 and 2 meters while the pelitic intercalations do not exceed 1 meter. This member does not display the stratonomic characteristic of the Scridoase turbidites, but neither does it represent a thick-bedded arenitic fluxoturbiditic sequence comparable to the formations following it (Secu Formation). Crâsmărita Member becomes thus an intermediate subunit. Graded bedding cannot be observed and the prevailing grey color of the rock shows here and there vaguely blue-greenish shades. Weathering-produced brown-blackish stripes can also be observed.

The base of the strata is well cemented and hard and their soles frequently display various current marks. Toward the upper part of the unit, however, the layers are less cemented and sometimes shaly and slightly convoluted.

The pelitic component is represented by greenish marls or marly clays and in some places by laminated brown to purple siltstones. Rather seldom lens-like beds of whitish limy marls and greentinted marly limestones with algal impressions also occur.

Fossil content and age. If the stratigraphic position is taken into consideration, the nannofossil assembladge of the Crâsmărita Member should belong to the NP 15-17 zones (Middle-Late Eocene). Yet, zone NP 15 is poorly represented in the lower half of the subunit, while zone NP 16 is absent as otherwise throughout the entire Maramures territory.

In the Crâsmărita valley rocks from fresh exposures of the uppermost part of the member, just below the boundary with the overlying Secu Formation, contain *Coccolithus pelagicus* (WALL.) SCHILL., *Discoaster saipanensis* BRAML. & RIED., *Dictyococcites (Reticulofenestra) dictyodus* (DEFL.) STRADN., *Reticulofenestra umbilica* (LEVIN) MART. & RITZK., and *Cribrocentrum reticulatum* (GARTN. & SMITH) PERCH-NIELS.

Along the Vâlcele brook, in the Poiana Botizii village, from stratigraphically roughly equivalent strata, piritized forms of *Chilostomella* have been identified. This genus is often present at the Middle Eocene-Late Eocene boundary or little above in the flysch of the Magura unit, in the Polish Carpathians (inf. Ewa Malata).

In the Cisme valley, tributary of the Poiana river in its upper reaches, in an area with repeated thrusting, a poor nannofossil association belongs to zone NP 17 with *Chiasmolithus* sp., *Reticulofenestra umbilica* (LEVIN) MART. & RITZK., *Dictiococcites (Reticulofenestra) dictyodus* (DEFL.) STRADN., *Discoaster binodosus* MART., *D. saipanensis* BRAML. & RIED., *Sphenolithus moriformis* (BRÖNN. & STRADN.) BRAML. & WILC., and *Cribrocentrum reticulatum* (GARTN. & SMITH) PERCH-NIELS.

The Secu (Strâmtura) Formation

Synonymous term. The "middle horizon" of the Tocila-Secu Flysch separated by Bombită (1972) was elevated to the rank of formation by Săndulescu & Russo-Săndulescu (1981) and by Săndulescu & Bratu (1984). The name derives from the Secu mountain in the Lăpus range.

It is mainly in the Botiza sector that good reference sections can be observed: outcrops provided by creeks flowing northward from the Secu Mountain, i.e. Izvoru Vinului; southward i.e. Băiut, Tocila and Cisme creeks; and eastward, i.e. Izvoru Crâsmărita. In the Petrova sector the same formation is well exposed on the right bank of the Iza valley between the village of Strâmtura and Bârsana.

In the Lăpus Mountains (Botiza raised sector), particularly due to contact metamorphism phenomena, the sandstone is strongly indurated and, as a consequence, erosion has been less effective, so that the Secu Formation is found at an elevation of 1300 meters, while in ther Petrova sector the same formation crops out between 600 and 700 meters.

The thickness of the Secu sandstone reaches 400 meters in the Secu Mountain area, and about 300 meters in the Strâmtura-Petrova sector.

Lithology. The formation represents a sandy sedimentary phase of fluxoturbidite type. The graded transition from the Crâsmărita turbidites to the Secu fluxoturbidites is a rather rapid one in the Crăsmărita brook, while along the Iza valley (downstream the Strâmtura village) the same lithological change occupies a thicker interval.

In the outcrops found in Izvoru Crăsmărita, these turbiditic sandstones, with visible lamination and some graded bedding, change upwards into the mature Secu sandstones, devoid of graded bedding, and with greater bed thickness (from 0.5 meters to 2 or even 3 meters). The layers are separated either by diastems or by thin intercalations of sandy marls and silty clays.

The arenites show a broad grainsize variability within irregularly distributed zones. Sometimes, lens-shaped, coarse, ruditic material is present with a predominance of metamorphic rock fragments.

The dominant color is grey with shades of white-yellow, blue or greenish. Weathering crusts are frequent and quite thick, lending the rock a yellowish-rusty color. At the same time, the rock becomes friable. The sandy outcrops are massive, mostly along weathered cliffs.

The thin pelitic intercalations consist of marly clays of grey, tan or yellowish color. Films of mica and of carbonized vegetal matter are also seldom present.

Close to the lower section, but local toward the upper part as well, the formation contains flysch-like packets where grey-green clay-silt-marl components prevail, alternating with thin layers of sandstone often with convolute lamination.

Fossil content and age. Rare tests of Eocene Large Foraminifera (*Nummulites, Operculina, Assilina* – megaspherical forms), extracted from coarse sandstones in the Secu mountain and Strâmtura narrow path, show all obvious marks of reworking.

The nannoplankton is poorly represented in the area of Mount Secu, while the reworked fossils from the subjacent Cretaceous and Early Eocene formations are numerous. Although anaemical, the *in situ* assemblages found at the base of the Secu Formation (Crâsmărita valley, Mount Secu and stone-quarry north of the Strâmtura village) belong to the NP 17 zone – terminal Middle Eocene: *Coccolithus (Ericsonia) formosus* (KAMPT.) WISE, *C. pelagicus* (WALL.) SCHILL., *C. eopelagicus* (BRAML. & RIED.) BRAML., *Cribrocentrum reticulatum* (GARTN. & SMITH) PERCH-NIELS., *Reticulofenestra umbilica* (LEV.) MART. & RITZ., *Dictyococcites (Reticulofenestra) dictyodus* (DEFL.) STRADN., *Discoaster barbadiensis* TAN., *D. tanii nodifer* BRAML. & RIED., *Sphenolithus radians* DEFL., *S. moriformis* (BRÖNN. & STRADN.) BRAML. & WILC., *Zigodiscus (Neococcolithus) dubius* (DEFL.) BLACK.

After repeated samplings, some more forms have been found in the small outcrops west of the peak of Secu Mountain: *Discoaster saipanensis* BRAML. & RIED., *Ericsonia fenestrata* (DEFL.) STRADN., *Sphenolithus obtusus* BUK., and *Coranulus germanicus* STRADN. (NP 18, Early Priabonian or Late Bartonian).

In the Iza valley, in the exposures just before the entrance in the Strâmtura Gorges and in those of the Slătioara creek (tributary of the Iza), to the already mentioned nannofossil populations one can add: *Sphenolithus predistentus* BRAML. & WILC., *Chiasmolithus grandis* (BRAML. & RIED.) RAD., *Lantemites minutus* STRADN., *Discoaster deflandrei* BRAML. & RIED., and *Zygrhablithus bijugatus* DEFL., belonging to the same NP 18 zone.

Within the Poiana Botizii – Secu Mountain – Botiza perimeter no younger associations have been identified in the upper half of the Secu suite. However, in the Iza river gorges, upstream the Bârsana village, in the rocks forming the trough of the Strâmtura syncline, the following species have been determined: *Ericsonia subdisticha* ROTH., *Helicosphaera compacta* BRAML. & WILC., *Discoaster (Trochastrites) bramletti* MART., *Chiasmolithus oamaruensis* (DEFL.) MOHL. & WADE, *Cyclicargolithus floridanus* (ROTH & HAY) BUK., and *Isthmolithus recurvus* DEFL., belonging to the NP 19-20 zones, Middle-Upper Priabonian.

In our opinion the Secu and the Strâmtura sandstones are isopical formations.

Previous dating. According to Săndulescu & Bratu (1984) the Secu Sandstone "ne dépasse pas le Lutétien supérieur", whereas the Strâmtura Sandstone "revient au moins au Priabonien", possibly reaching the Oligocene. We suppose that for the above quoted authors the heterochrony of the two formations represents a fundamental reason for their "ultra" interpretation of the thrusting in Maramures. According to Dicea *et al.* (1980), the Strâmtura Sandstones belong to the Oligocene (Middle Oligocene), based on a micropaleontological mixture containing dynocysts, nannofossils, Large Foraminifera (*Nummulites* "ex gr. *fabianii*") and the microfauna from the Globigerina Marls.

The Izvoru Vinului Formation

Synonymous term. Bombiță (1972) considered this rock sequence as "the upper horizon of the Tocila-Secul Flysch", while Săndulescu & Russo-Săndulescu (1981) upgraded it to the status of the Izvoru Vinului Formation.

The name comes from the homonymous creek flowing along the northern slope of the Secu Mountain.

The typical cross section is to be found in the drainage basin of the Izvoru Vinului creek. West of the Botiza village, the formation is subjected to a mild process of propylitization produced by the Neogene volcanics, especially pyroxene-rich andesitic lavas (Jereapăn) of Pontian age. The same andesites served as a protecting cover allowing the preservation at the altitude of 800-900 meters of the Izvoru Vinului Formation. By contrast, the formation (or its equivalent) has been completely removed in the Petrova sector (the Strâmtura syncline) by the Plio-Quaternary erosional phase.

The formation measures approximately 250-300 meters in thickness.

Lithology. It is a predominantly marly series, being built by marls and siltstones of green-olive-blue shades, with weathering-generated rusty crusts and with steel-grey or dark-grey zones here and there.

The dry outcrops are of grey-yellow-pinkish color. Thin sheets (2-10 mm) associate themselves in decimetric packets which exfoliate easily along stratification surfaces. Bioturbation marks are present locally.

In large exposures slump surfaces display shiny stress "mirrors" and contorted beds. At the base of the formation, Săndulescu & Russo-Săndulescu (1981) separated on the northern slope of the Secu mountain an intercalation of approximately 20 meters in thickness of purple clays. A second intercalation is present toward the middle of the formation along the Izvoru Vinului creek.

Although rare, lenticular and concretionary marly limestones, as well as hard, grey sandstones are also present.

Dicea *et al.* (1980) claim that the Izvoru Vinului Formations does not exist as clear-cut entity.

Fossil content and age. Its position within the Late Eocene corresponds to the place it occupies in the sequence of sandstones cropping out on Secu mountain. The phytoplankton content bespeaks the same age - Late Eocene - given by rare representatives of the Rhambodinium coronatum association, namely *Rhombodinium draco* (GOCHT) and *Wezeliella articulata* EIS. (inf. N. Baltes).

The microforamineral assemblage is also of Late Eocene significance with *Sphaerammina subgaleata* (WASICEK) - the maximum frequence of the species - if one accepts the correlation with the Magura unit in the Polish Carpathians (inf. Ewa Malata).

The nannoplankton was eliminated apparently through dissolution.

The possibility of deposition continuing into the Early Oligocene cannot be ruled out.

Previous dating. They were made by Săndulescu & Russo-Săndulescu (l.c.) who considered the Izvoru Vinului Formation of Late Eocene age and the approximate isopic correspondent of the leud Flysch. Subsequently, Săndulescu & Bratu (l.c.) lowered its age

to the Late Lutetian with a possible passage into the Late Eocene.

At the front of the Botiza-Petrova Nappe some thrust-folds have been identified by Patrulius (1956),. Dicea *et al.* (1980) and precisely Săndulescu (1981, 1991, 1994), each built by particularly turbiditic formations: Ieud Flysch from Ieud Scale, Secătura Formation from the Secătura-Măgura Tocilei Scale, Voroniciu Formation from the Leordina Scale, Pârâul Mocilnei Formation from Ruscova Scale, Dumbrava and Rozavlea formations from the Leordina Scale, too. Further on the concise presentation of the first three.

The Ieud Formation

The name derives (Bombiță, *hic*) from the Ieud creek and village, located in the upper basin of the Iza river.

The standard section is along the middle course of the Ieud creek, western slope of the Fus hill.

The thickness of the formation is 350-400 meters.

Lithology. The section begins with a horizon of marly and silty shales of red-purple color measuring some 50 meters in thickness. Layers of green-blue color are also present marking zones of chemical reduction. Stratification is masked by some foliation planes (effect of tectonic stresses?).

The largest part of the formation can be considered as a turbiditic-rhythmic sequence (flysch), but a clear graded bedding cannot be observed. The sequence represents a centimetric to decimetric alternance of sandstones and siltstones, or sandy marls of grey-green color. The thickness of the sandstone beds, varying between several centimeters and 1.5 m, can be observed in a large exposure situated at the northern end of the Ieud village. The lower bed surfaces are flat with frequent sole-marks or some bioglyphs and are well cemented. The upper surfaces display convolute lamination and their degree of cementation is reduced, marking the transition toward the pelitic interval. The general aspect of the outcrop is typical of the "hieroglyphic beds".

The last 20 meters of the Ieud Formation represent the litho-biozone informally known as the "Globigerina Marls" (Mutihac, 1955, 1956; Bombiță, 1972; Dicea *et al.*, 1980; Săndulescu & Bratu, 1984), well-known throughout the Carpathian belt. The sequence is basically a marly one with rare, thin but hard sandstone beds. When wet, the grey marls are soft, pasty and sticky and are responsible for generating frequent landslides. When dry, the same rocks break up in thin shingles.

Fossil content and age. Below the "Globigerina Marls" horizon one finds (resedimented?) rare nannoplankton species characteristic of the first part of the Late Eocene (NP 18-19) with *Isthmolithus recurvus* DEFL., and *Dictyococcites (Reticulofenestra) dictyodus* (DEFL.) STRADN. But despite repeated collections of samples at the faciotype, the formation proved to be extremly poor in microfossils. Its age – Late Eocene – is based mainly on its clear stratigraphic position and lithofacies.

It is only within the Ieud thrust-fold that the continuity between Eocene in turbiditic facies and euxinic Oligocene is clearly expressed (Dicea *et al.*, 1980a, 1980b; Săndulescu & Russo-Săndulescu, 1981). The line of outcrops of the Ieud Flysch-Globigerina Marls, along the Ieud river beneath the Fus hill, is interrupted by a large landslide some 50 meters long. Beyond it and immediately beneath the thrust line of the Botiza Nappe, a different kind of rock sequence can be observed.

The general steel grey and bluish color of the Eocene outcrops is replaced by the brown-tan hue, typical for the Oligocene deposits. The rocks themselves are quartzose sandstones of Kliwa type, but hard rather than friable. When frech they are white-grey, but through weathering the color changes to rusty-brown. The meter-thick, sometime convoluted layers of sandstone alternate with bituminous, tan-colored marls which exfoliate into thin sheets.

The nannoplankton identified in the pelitic rocks succeeding the Globigerina Marls horizon and displaying an Oligocene lithofacies seem to point to a corresponding Oligocene age (NP 22 zone): *Dictyococcites (Reticulofenestra) dictyodus* (DEFL.) STRADN., *Coccolithus pelagicus* (WALL.) SCHILL., *Chiasmolithus oamaruensis* (DEFL.) MOHL. & WADE, *Ericsonia fenestrata* (DEFL.) STRADN., *E. subdisticha* ROTH, *Helicosphaera compacta* BRAML. & WILC.

The Secătura Formation

Historical background. In the uppermost thrust-fold at the front of the Botiza Nappe, north of the village of Poiana Botizii, Antonescu *et al.* (1975) and Dicea *et al.* (1980a) have separated a "flysch-like" suite considered to be the equivalent of the Borsa Sandstone (Late Oligocene-Early Miocene). Săndulescu & Russo-Săndulescu (1981) considered this rock sequence of "Oligocene?" age; later, Săndulescu & Bratu (1984) defined and named it as a "sandy flysch with convolute stratification".

The name derives from the Secătura-Măgura Tocilei hill, located immediately north of Poiana Botizei village.

Standard outcrops with typical rocks of the Secătura Formation can be observed along the creeks Fagu, Vâlcele, Spinu, Paltinu and Ulmu, tributaries of the Poiana stream and originating in the upper slopes of the Secătura-Măgura Tocilei-Măgura Paltinului ridge.

Contact metamorphism phenomena have affected the formation north-east of the Măgura Tocilei Mountain, so that pertinent observations can be made only in the Secătura hill, south of Măgura Tocilei. Other exposures are present along the Bloaja Strâmbului creek, tributary of the Lăpus river, and in the Pârâul Intunecos creek, tributary of the Tocila stream.

The formation reaches up to 250 meters in thickness.

Lithology. It is quite variable: fine-grained and mica-rich sandstones, grey-blue in color with yellow weathered aureoles, forming beds of 0.3-0.5 meters; undulated sandstones, sometimes with convolute lamination, showing here and there an advanced degree of limonitic weathering; massive sandstones, well cemented, rich in mica, forming strata of 0.5-1.5 meters in thickness.

The Secătura sandstone builds the divide between the Poiana and Tocila stream, on top of the thrust-folds with Tocila Flysch.

The fine-grained rocks are quantitatively subordinate and consist of thin layers of grey marls, marly clays with green or blue tints, tan or yellow when weathered.

Săndulescu & Russo-Săndulescu (1981) and Săndulescu & Bratu (1984) consider the Secătura Formation as isopic with the "Oligocene (?)" sequence succeding the Eocene turbidites of the leud thrust-fold.

Fossil content and age. From the outcrops in the Secătura hill (Poiana Botizii village) the reworked nannoplankton was identified in zone NP 17 (terminal Middle Eocene with a younging tendency). Samples collected from the headwaters of the Fagu and Vâlcele creeks indicate a Late Eocene age (NP 19-20 zones) and contain: *Coccolithus pelagicus* (WALL.) SCHILL., *Reticulofenestra umbilicata* (LEV.) MART. & RITZK., *Dictyococcites (Reticulofenestra) dictyodus* (DEFL.) STRADN., *Sphenolithus moriformis* (BRÖNN. & STRADN.) BRAM. & WILC., *Discoaster saipanensis* BRAML. & RIED., *D. (Trochastrites) bramletti* MART., *D. tanii nodifer* BRAML. & RIED., *Chiasmolithus oamaruensis* (DEFL.) MOHL. & WADE, *Ismolithus recurvus* DEFL., *Cribrocentrum reticulatum* (GARTN. & SMITH) PERCH-NIELS., *Helicosphaera compacta* BRAML. & WILC., and *Coranulus germanicus* STRADN.

The same age, with possible passage to the Oligocene, is based on the species: *Ericsonia subdisticha* ROTH., *Cyclicargolithus floridanus* (ROTH & HAY) BUKRY, *Cyclococcolithus (Ericsonia) formosus* (KAMPT.) WISE, *Reticulofenestra umbilica* (LEV.) MART. & RITZK., and *Discoaster barbadiensis* TAN (inf. Marieta Dicea).

Reworked Lower Eocene and Cretaceous microfauna has also been foundst.

Some palynofacial elements, found in the perimeter of the faciotype, also indicated the terminal Eocene or the Eocene-Oligocene limit (inf. N. Baltes).

The Voroniciu Formation

Historical background. The Voroniciu Sandstone was first separated and named by Motas (1956). Subsequently, Dicea *et al.* (1980), Săndulescu & Bratu (1984) and particularly Săndulescu *et al.* (1991) named and positioned the formation within the Leordina thrust-fold.

The name derives from the Voroniciu valley from the north end of the Rozavlea village.

Reference outcrops can be observed along the Voroniciu valley, on top of a suite named the "Rozavlea Flysch" by Săndulescu *et al.* (1991).

The estimated thickness is around 200 meters.

Lithology. Motas (1956) described the formation as a sequence of quite coarse, thick-bedded, polygenous sandstones, of grey-yellowish color, containing large foraminifera and bivalves. However, in the Voroniciu valley itself the fluxoturbiditic often massive aspect of the rocks is subordinated. It is clearly expressed though in the hill east of the valley.

Another rock type worth mentioning is a grey micaferous sandstone with convolute bedding, exfoliating in broadly ondulated sheets. Traces of coalified organic matter are present, as are frequent calcitefilled veins, perpendicular to the bedding and brown crusts of oxidation-type weathering.

The pelitic component is represented by grey marls vaguely bluish, rich in mica, forming thin interlayers, and by marly clays dull and pasty with a lithology resembling the well-known Globigerina Marls of the Carpathian Range.

Fossil content and age. After several samplings of the formation faciotype (Voroniciu valley), the (resedimented?) nannoplankton indicates a terminal Middle Eocene age (NP 17-18?) with: *Discoaster saipanensis* BRAML. & RIED., *D. barbadiensis* TAN, *Cyclococcolithus (Ericsonia) formosus* (KAMPN.) WISE, *Dictyococcites (Reticulofenestra) dictyodus* (DEFL.) STRADN., *Cribrocentrum reticulatum* (GARTN. & SMITH) PERCH-NIELS., *Coccolithus pelagicus* (WALL.) SCHILL., *Reticulofenestra umbilica* (LEV.) MART. & RITZK., and *Chiasmolithus grandis* (BRAML. & RIED.) RAD. However, in a sequence along the Cruhli-Seregna valley, tributary of the Viseu river near the Leordina village, sequence approximately equivalent, by strike continuity, to that from the Voroniciu valley, the nanoassemblage is certainly of Late Eocene age with: *Discoaster saipanensis* BRAML. & RIED., *D. barbadiensis* TAN, *Dictyococcites (Reticulofenestra) dictyodus* (DEFL.) STRADN., *Reticulofenestra umbilica* (LEV.) MART. & RITZK., *Cribrocentrum reticulatum* (GARTN. & SMITH) PERCH-NIELS., *Coccolithus (Ericsonia) formosa* (KAMPN.) WISE, *Coccolithus pelagicus* (WALL.) SCHILL., *Sphenolithus moriformis* (BRÖNN. & STRADN.) BRAML. & WILC., *Discoaster tanii nodifer* BRAML. & RIED., *Chiasmolithus grandis* (BRAML. & RIED.) RAD., *Chiasmolithus oamaruensis (Defl.) Mohl. & Wade*, *Ismolithus recurvus* DEFL.

The large foraminifera, mentioned also by Motas (1956), are very rare. In the sandstones cropping out in the Voroniciu valley, only two megaspherical shells belonging to the *Nummulites chavannesi* DE LA HARPE species (Later Priabonian) were found.

Previous dating. Dicea *et al.* (1980) considered the Voroniciu Sandstone as equivalent to other two fluxo-turbiditic formations, namely the Strâmtura and Secu Sandstones, all of ambigous "Late Eocene-Early and Middle Oligocene" age. Săndulescu & Bratu (1984) considered the Voroniciu Sandstone as the equivalent of the upper part of the Strâmtura Sandstone (Priabonian-Early Oligocene). Later, Săndulescu *et al.* (1991) confined the age of the Voroniciu Formation to the Oligocene.

The Eocene flysch of the Ruscova thrust-sheet, which developed east of the Leordina thrust-fold between the Iza valley to the south and the Ruscova valley to the north, displays a facies close to that of the Secătura and Voroniciu formations. These strata were recently named the Pârâul Mocilnei Beds (Săndulescu *et al.*, 1991) and described as "hieroglyphic beds with red clay intercalations" of Lutetian-Priabonian age. In the Cucu valley, east of the Leordina village, these beds contain nannofossils from the NP 19 (Middle Priabonian) zone with: *Sphenolithus moriformis* (BRÖNN. & STRADN.)

BRAML. & WILC., *Coccolithus pelagicus* (WALL.) SCHILL., *Dictyococcites (Reticulofenestra) dictyodus* (DEFL.) STRADN., *Cribrocentrum reticulatum* (GARTN. & SMITH) PERCH-NIELS., *Reticulofenestra umbilica* (LEV.) MART. & RITZK., and *Isthmolithus recurvus* DEFL.

6. FORMATIONS BELONGING TO THE LĂPUS NAPPE (PARAUTOCHTHON)

The Eocene lithological content of the Lăpus Nappe is bifacial, i.e. a turbiditic deep-water facies, developed toward the east, reaching the Săcel village (Bâleasa, Bistrita and Carele valleys), and a marginal shallow water facies in its western half, reaching the Strâmbu and the Ungureni villages. The indentation between the two facies can be observed along the Roaia creek, an area which marks probably the boundary between the paleoshelf and the continental paleoslope (Bombiță, 1972).

TURBIDITE FORMATIONS

The Jijia Formation

The name (Bombiță, *hic*) derives from the Fundu Jijiei pass, which marks the crossing from Transylvania into Maramures, between the Măgura Porcului mountain (west) and the heights of Covetele-Cârligătura (east).

Areas of good outcrops are present in the upper course of the Roaia, Botiza (between the Izvoru Detunatului creek and the Izvoru Cârligătura), Ieud (south of Izvoru Muncelului), Baicu (south of the confluence with the Idisoru brook) and Bâleasa valleys.

The thickness is evaluated at about 550 meters but with sizeable variations.

Exposures and reference sections can be examined (from east to west) in the upper reaches of the Bâleasa, Baicu, Ieud and Izvoru Jijiei brooks.

Lithology. The formation belongs to the group of "hieroglyphic beds", where hard, indurated marly shales and siltstones of grey-greenish color predominate. Two or three intercalations of purple color are present in the upper part. Also frequent are transitional terms from siltstones to finely micaceous marly sandstones displaying on their bedding planes carbonized vegetal matter and brown-black weathering crusts. The sandstones are usually thin (around 0.5 m) with frequent solemarks.

Age. The Jijia Formation proved to be devoid of fossils in all sampling points. We subscribe to the opinions of Dicea *et al.* (1980) and Săndulescu & Bratu (1984) that it is possible that east of the Roaia river, this unit could include at its base, here and there, strata older than the Bartonian.

The Măgura Member (Măgura lens-shaped conglomerate) (Böhm-Bem, 1944; Méhes, 1944; Dumitrescu, 1957; Bombiță, 1966, 1972) was named (Bombiță, *hic*) from the Măgura Porcului Mountain located between the Fundu Jijiei pass and the Roaia valley.

Its rocks are well exposed along the brooks flowing from the Măgura Porcului eastward (Izvoru Jijiei and Izvoru Detunatului), north-westward (Roaia Mare) and south-westward (Izvoru Ciormolina).

The member measures some 200-250 meters in thickness.

Lithology. It is composed mainly of conglomerates with poor size-sorting, gradation and stratification, containing lenses and tongues of sandstone with variable grainsize and degree of cementation. When the cement is carbonatic the conglomerates are hard and harsh. Conversely, a sandy-marly matrix leads to friable, crumbling rocks. There is no internal organization of pebbles, imbrication is absent but the degree of roundness is moderate. Marked heterometry and poor sorting suggests a proximal source area. The conglomerate clasts are made of gneiss, quartzite, dolomite, biotite-rich para-gneiss, micaschist and quartz-sericite schist. There are some rare Mesozoic-looking limestones, but their microfacies has not yet been studied.

In the western sector of the Lăpus Nappe the conglomerates were identified in the Roaia, Ciormolina and Izvoru Jijiei basins. To the east they were identified in the Măgurita mountain (upper reaches of the Ieud river), up to the Arcer creek (tributary of the Baicu stream). Farther east the conglomerates are missing. Recent cartographic imagery (Bombiță, 1972; Săndulescu & Russo-Săndulescu, 1981) suggests a lens-like character of the Măgura Member.

The paleogeographic picture of the conglomerate lenses is one of a series of submarine fans aligned in an east-west direction, along a paleoridge ("transanticline") linking the Rodna crystalline massif to the Preluca metamorphic core (Motas, 1956; Dumitrescu, 1957; Bombiță, 1972). The coarse material of these submarine fans prograde laterally into arenites. If this interpretation is accepted, the whole of the Jijia Formation should represent a proximal coarse turbidite unit.

Age. The faciotype has not furnished any fossil material. Given its stratigraphic position and its lithological resemblances, the Măgura Member may be correlated with the (?) Prislop and Viseu rudites, but as a proximal facies.

The Strâmbu Formation

Synonymous terms: "Grès carpatique" *pars* - Boué & Lilienbach, 1833; "Karpathen-sandstein" (*pars*) - Hauer & Stache, 1863; Primics, 1886; "Facies de cordilerã" (*pars*) - Dumitrescu, 1957; Strate de Valea Lăpusului (*pars*)- Bombiță, 1972; Gresia de Borsa (*pars*) - Dicea *et al.*, 1980; "Gresii masive" - Săndulescu in Borcos *et al.*, 1980; Săndulescu *et al.*, 1981; Săndulescu & Bratu, 1984).

The name of the formation (Bombiță, *hic*) taken from the Strâmbu village located at the confluence of the Băiut stream with the Strâmbu valley.

Reference sections are to be found west of the Roaia stream, in recent cuts made by logging truck roads along the banks of the following valleys: Iezuina, Mesteacăn, Matei, Bloaja Strâmbului (right bank, downstream the decater), Poiana and Roaia (between the confluence

with the Ciormolina and Roaia Mică-Roaia Mare brooks). East of the Roaia stream exposures are present along the road linking Botiza and Grosi villages, more precisely between Fundu Jijiei and Izvoru Jijiei. Other interesting outcrops can be studied in the collecting basins of the Ieud stream (upstream Izvoru Muncelului) and Baicu stream (upstream the Idisoru brook), as well as along the Bâleasa creek.

The thickness varies from 300 meters west of the Roaia stream to 700-800 meters east of this stream.

Lithology. The general look of the sequence is that of a pararhythmic fluxo-turbidite, in which grey sandstones with rare reddish zones prevail. The medium grain-sized arenites are finely micaceous, with a carbonate cement and with bed-thicknesses varying between 1-3 meters and rarely 4-5 meters with diasthems for interlayers. In the latter case microconglomeratic intercalations are often present. When observed in large exposures the rocks and their structure suggest sand flows and slides.

East of the Botiza river the sandstones are massive and the tributaries flow through canyon-like valleys. West of the Roaia stream (Mesteacăn and Iezuina creeks, near Strâmbu village) the stratonomy is not so harsh and massive. In many cases the cement has been leached leading to a milder, ruiniform landscape. Weathering produced rusty colors and white, powderish salt precipitation. The proximity of the land is apparent through the presence of small coal pockets.

Quite large mecanoglyphs are often present on the sandstone sole, while their upper surfaces are broadly undulated and even convoluted. The layers of marly shales or grey-greenish siltstones are constantly subordinated to the sandstone.

Several recurrences of "hieroglyphic beds" are present at the upper part of the formation in the form of 3-7 meters-thick sequences of thin sandstones (10-20 centimeters), rhythmically alternating with grey-green-bluish siltstones. The sandstones do not show graded bedding, have mica-rich surface with breach resembling cakes of soap, often weathered and of brown-black color. A few bioturbation phenomena can be observed. The last of the "hieroglyphic beds" sequence includes the typical mark-level Globigerina Marls (Mutihac, 1955, 1956; Dicea *et al.*, 1980), so widespread throughout the East Carpathians.

Fossil content and age. Large Foraminifers. The association of *Nummulites* contains many forms of the upper part of the Middle Eocene obviously redeposited together with representative species of the Late Eocene.

At the confluence of the Iezuina creek with the Lăpus river occur: *Nummulites millecaput* BOUB. (dominant species), *N. fabianii* (PREVER) particularly frequent, *N. puschi* D'ARH., *N.* cf. *biarritzensis* D'ARCH. & HAIME, *N. striatus* BRUG., *N. lunae* BOMB., *N.* aff. *chavannesi* DE LA H. (ancestor), *N. perforatus* (MONTF.), *N.* ex gr. *meneghini* D'ARCH. & HAIME - *N. biedai* SCHAUB, *N.* cf. *tavertetensis* REG. & CLAV., *Assilina* and *Operculina*.

A second similar rich population was found at the confluence Poienii stream-Lăpus river ("Gura Poienii") with: *N.* ex gr. *millecaput* BOUB.-*maximus* D'ARCH., *N.* ex gr. *crassus* BOUB.,- *N. meneghini* D'ARCH. & HAIME, *N. fabianii* (PREV.), *Assilina* and *Orthophragmina*.

Mixed associations Middle and Late Eocene were also found at the confluence Bălas creek-Poienii river (south Poiana Botizii village): *N. fabianii* (PREV.) and *N. striatus* BRUG.; in the Gura Poienii quarry: *N. lunae* BOMB., *N.* aff. *chavannesi* DE LA H., *N.* aff. *budensis* HANTK., *Operculina* sp.; on the Bârlogului creek, Ungureni village: *N.* ex gr. *perforatus* (MONTF.), *N. fabianii* (PREV.), *N.* cf. *chavannesi* DE LA H.; at the confluence Rasca and Corostina creeks-Poiana river: *N. fabianii* (PREV.); on the Poienii river between the confluence with Iezuina and Valea Lungă creeks: *N. millecaput* BOUB., and *N. striatus* BRUG.

An important but single "clean" Late Eocene association is that found on the Bistrita brook, south of the Săcel village, in the passage interval from the Jijia flysch to the base of Strâmbu Formation with: *N. fabianii* (PREV.), *Operculina alpina* DOUV., *N. chavannesi* DE LA H., *Spiroclypeus granulosus* BOUSS., and *Heterostegina reticulata* RUTYM.

Nannoplankton. At the confluence of the Iezuina and Valea Lungă creeks with the Lăpus river (Strâmbu village) small nannoplankton associations have been identified. They contain a mix reworked forms from the Cretaceous, Late Paleocene and Middle Eocene.

At the confluence of the Bloaja Strâmbului creek and Lăpus river one adds: *Sphenolithus moriformis* (BRÖNN. & STRADN.) BRAML. & WILC., *Discoaster tanii nodifer* BRAML. & RIED., *D. barbadiensis* TAN, *Lantemithus minutus* STRADN., *Chiasmolithus oamaruensis* (DEFL.) MOHL. & WADE and *Coccolithus eopelagicus* (BRAML. & RIED.) BRAML.(NP 18 zone).

In the Botiza-Grosi pass (Fundu Jijiei) the Strâmbu formation has supplied an association belonging to the NP 19 zone (Late Eocene) with: *Isthmolithus recurvus* DEFL., *Cyclococcolithus (Ericsonia) formosus* (KAMPN.) WISE and *Reticulofenestra umbilica* (LEV.) MART. & RITZK.

Planktonic foraminifera. From the lower part of the formation, in the Valea Lungă creek, an association of planktonic foraminifera has been determined from the Middle (-Late) Eocene (zones P 12, P 13 and P 14) with *Globorotalia densa* (CUSHM.), *Glr.* ex gr. *cerroazulensis* (COLE), *Globigerina eocaena* (GÜMB.), *Glg. corpulenta* SUBB., *Glg. frontosa* SUBB., *Glg. hagni* GOHRB., *Glg. senni* (BECKM.), *Glg. linaperta* FINL. and *Globigerinoides higginsi* BOLLI (inf. Ewa Malata).

From the samples collected around the headwaters of the Ulmu creek (confluence with the Roaia river) we identified *Globorotalia cerroazulensis* (COLE), *Globigerina corpulenta* SUBB., *Glg. oachitensis* HOVE & WALL., and *Globigerinatheka index* (FINL.) (Late Eocene, inf. Ewa Malata). The forms are all poorly preserved. As concerns the biocontent of the Globigerina Marls horizon which top the formation, it is represented (Dicea *et al.*, 1980) by *Globigerina corpulenta* (SUBB.), *Glg. apertura* CUSHM., *Glg. eocaenica* TERQ., *Glg. varianta* SUBB., *Glg. inflata* D'ORB., *Glg. officinalis* SUBB. etc., indicating a "terminal Eocene" age.

Palynology. The samples from "Gura Iezuinii" (Strâmbu village) and from the Fânaru valley (east of the Piatra Pintii hill) contain the Rhombodinium coronatum dinoflagllate association (Late Eocene): *Rhombodinium draco* (GOCHT), *Wetzeliella articulata* EIS., *W. condylos* WILL. & DOWN., *W. reticulata* WILL. & DOWN., *Deflandrea*

robusta DEFL. & COOKS., *Chiropteridium dispersum* GOCHT and *C. lobospinosum* GOCHT.

The samples from the Paltinu and Mesteacănu valleys have provided species from the Deflandrea leptodermata association pointing toward the Late Eocene-Early Oligocene boundary with: *Deflandrea phosphoritica* EIS., *D. heterophlycta* DEFL. & COOKS., *Cordosphaeridium cantharellum* (BROS.) and *C. funiculatum* MORG. (inf. N. Baltes).

The Baicu Formation

Synonymous terms: "Grès carpatique" (*pars*) - Boué & Lilienbach, 1833; "Karpathen-sandstein" (*pars*) - Hauer & Stache, 1863; Primics, 1886; "Flis Oligocen-Aquitanian" – Dumitrescu, 1957; Strate de Valea Lăpusului - Bombiță, 1972; Gresia de Borsa - Dicea *et al.*, 1980a; Gresie de tip Borsa - Săndulescu in Borcos *et al.*, 1980a; in Săndulescu & Russo-Săndulescu, 1981.

The name (Bombiță, *hic*) comes from the Baicu stream, confluent of the Iza river at the Dragomiresti village.

Reference sections as well exposed in the brooks descending from the Muncelu mountain, wesward into the Botiza valley and eastward into the Ieud river. The same formation is known in the Lăpus and Tibles mountains, between the villages of Strâmbu and Băiut to the west and Sălistea de Sus to the east, particularly along the Poienii, Roaia, Botiza, Ieud and Baicu valleys and their tributaries.

The upper part of the Baicu Formation is hidden, in the western sector, under the Botiza Nappe. In the eastern sector it is complete and measures approximately 1000 meters in thickness.

Mutihac (1956) distinguished within the Baicu Formation two subunits here named: the lower one – Ursoaia Member, the upper one – Muncelu Member.

The Ursoaia Member takes its name after the homonymous creek, tributary of the Ieud stream.

One can examine this member along the lower course of the Petreasa creek (eastern tributary of the Poiana river, 1,5 kilometers downstream Poiana Botizii), in the Izvoru Detunatului brook (in the Botiza valley basin, north of Fundu Jijiei) and in the upper course of the Izvoru Cârligăturii creek (western tributary of the Ieud river).

Thickness is about 150 meters.

Lithology. Mutihac (1956) sketched the lithology of the Ursoaia member as a "stack of sandstones interspersed with sandy clays...containing *Clupea* fish scales of Early Oligocene age". In fact, the sandstones are subordinated, thin-bedded, with fine granulation and faintly convoluted. The prevailing rocks are mudstones or marly clays, dark grey or even black, slightly bituminous. Sometimes they are quite friable (little plates or "splinters"), micaceous and sandy, other times they are hard and compact. Weathering produced rusty crusts and salt crystals.

In some places tan and brown thinly laminated rocks contain fish scales (Petreasa creek); in others (Bloaja Strâmbului valley) the marls are silicified ("menilitic" rocks). It is possible that the Ursoaia Member may represent the quasi-heteropic equivalent of the Valea Carelor Formation.

Fossil content and age. Above the springs of the Ulmu creek (tributary of the Roaia valley) and along the lower course of the Petreasa valley (south of the Poiana Botizii village), the lithofacial aspects are not so easily recognizable. In the nannoplankton association the following forms have been identified: *Dictyococcites (Reticulofenestra) dictyodus* (DEFL.) STRADN., *Helicosphaera compacta* BRAML. & WILC., *Coccolithus pelagicus* (WALL.) SCHILL., *Reticulofenestra umbilica* (LEV.) MART. & RITZK., *Cyclococcolithus (Ericsonia) formosus* (KAMPN.) WISE, *Zygrhablithus bijugatus* DEFL., and *Helicosphaera seminula* BRAML. & SULL. dating from the Rupelian.

Muncelu Member. The name comes from the Muncelu Mountain situated between the Botiza and Ieud valleys.

The member is thicker (approximately 800 meters) and was described by Mutihac (1956) as "coarse sandstones in thick strata of Late Oligocene-Aquitanian age".

Lithology. The outcrops display massive sandstones of fluxoturbiditic type with layers 0.5-3 meters thick, usually separated by diasthems. The sandstones are of a grey color with yellow-tan weathered surfaces and with many irregular joints. Locally, through the loss of cement, the rock becomes soft and powderish. Large sole marks are often present and convolute bedding is quite common. Concretions are also observed in some points.

The lutitic terms are mainly muddy marls, finely micaceous and slightly bituminous, thinly sheeted and brittle when indurated.

There are also some intermediate lithological terms, i.e. sandy marls in beds 0.5 meters thick, of a dark color, with mica-rich faces, bituminous and with coalified vegetal matter.

A general observation refers to the pelitic components which are the most useful in separating the Eocene from the Oligocene rocks, since the turbiditic arenites are approximately the same.

Fossil content and age. The palynological association identified in the samples from the Petroasa valley indicates the presence of the Rupelian with: *Deflandrea phosphoritica* EIS. div. ssp., *D. arcuata* VOZZ., *D. cygniformis* BALD. In these samples *Pentadinium laticinctum* GERL. and *Vozzhennikovia* sp. appear for the first time. Very seldomly one encounters *Cordosphaeridium fibrospinosum* DAV. & WILL., and *Wetzeliella eocaenica* BALT. (inf. N. Baltes).

In the same valley, 1.7 km upstream the confluence with the Poiana river, and less clearly in the spring zone of the Muncelu brook (right tributary of the Botiza river), the nannoplankton indicates the presence of the Late Oligocene (NP 25), represented by *Coccolithus pelagicus* (WALL.) SCHILL., *Helicospaera recta* HAQ, *Pontosphaera enormis* LOC., *Zygrhablithus bijugatus* DEFL., and *Reticulofenestra lockeri* MULL. Reworked Cretaceous forms are also present.

The upper horizons, sampled in some points in the neighborhood of the Strâmbu and Poiana Botizii villages, have evidenced a palynofacies with Diatoms and palm

pollen determined only generically, but quite rich and easy to recognize in Maramures and northern Transylvania in the transitional interval Oligocene-Lower Miocene (inf. N. Baltes).

For the time being, these are the only data confirming the continuous deposition of the Baicu Formation across the Palaeogene-Neogene boundary.

Remark. One must also mention here three lithostratigraphic turbiditic units about which we have not clear idea wheather they have or have not the attributed formational degree (in Săndulescu *et al.*, 1991; Săndulescu & Bădescu, 1994).

In the Ruscova Scale, on the middle course of the Viseu river, the Pârâul Mocilnei Beds would be a Lutetian-Priabonian hieroglyphic beds-type formation with red clays intercalations.

In the northern Maramures, in the Rona de Sus village, on the Dumbrava (*recte* Stejeret-Dubrovătea) and Cornet valleys, the Dumbrava Beds would be a Maastrichtian-Paleocene sandy-marly flysch, similar to the "Inocerams Beds" of the Magura Nappe, continued by the Rozavlea Paleocene-Eocene Flysch of "hieroglyphic beds" type. The latter would contain frequently intercalations of red shales but, in a quaint manner, associated with black shales of dysodile type and black limestones of "Oligocene facies" (Săndulescu & Bădescu, 1994).

Shallow water formations

(Figs. 4 and 5)

The Pintea Formation

Synonymous terms: "Lithothamnium reiche Nummulit-Kalksteinschollen auf den Karpathensandstein gelagert" - Pošepný, 1862; Hauer & Stache, 1863; Primics, 1886; Hoja Schihten:..."graulich-weißer oder gelblicher Kalk ist sandig oder enhält auch größere Quarzgerölle...umhüllt von organischen Reste ...besonders viele Lithothamnien-Knollen und kleine Nummuliten" - Koch, 1894; ..."lentile de calcare detritice cu nummuliti" – Dimitrescu & Bleahu, 1955; "calcare recifale cu *Lithothamnium* si numuliti" - Dumitrescu, 1957; "Orizontul calcarelor detritice" - Bombiță, 1966, 1972; "...klippe sedimentare (Lutetian?, Priabonian?)" - Săndulescu in Borcos *et al.*, 1980a; in Săndulescu & Russo-Săndulescu, 1981).

The name (Bombiță, *hic*) is taken from the Piatra Pintii (Stanii Pintii) hill, some 2 kilometers south of the Poiana Botizii village.

Reference cross-sections can be observed in the Piatra Pintii hill, some 2 kilometers south of the Poiana Botizii village.

The thickness is probably around 50 m.

Lithology. As a whole, the formation is represented by nummulitic bio- and lithoclastic limestones. It can be that throughout the Lăpus Mountains most of the Eocene marginal facies contains either epimetamorphic clasts ("impure" limestone), or is richer in bioclastic micrite. The former type occupies the lower part of the Pintea Formation, while the "pure" limestone is found mainly in the upper part. Accordingly, the Pintea formation could be subdivided into Lower Piatra Pintii Member and Upper Oblazã Member.

The Piatra Pintii Member marks the transition between the subjacent Viseu Formation (weakly and temporarily outcropping here) and the Oblazã Member. Good exposures can be examined in the Piatra Pintii hill, 2 kilometers south of the Poiana Botizii village. As mentioned, in this lower member the microconglomeratic limestone is abundent and its lithoclasts are made mainly of quartz, quartzite and micaschist. Their degree of roundness varies and some clasts stick out of the rock due to the partial dissolution of the surrounding carbonate cement.

In the Pintea hill the clastic limestones form a giant bar of hard, incompetent rock, tectonically intruded in or extruded of the soft cover and removed by erosion. Due to the tectonic stresses coming from the north, the limestone layers, together with all the Neocretaceous-Palaeogene pile, were broken ("broken formational group"), fragmented and upturned into their present position.

The probable thickness is 40 meters.

This lithological type changes gradually through disappearance of the metamorphic clasts and of the *Nummulites*. For instance, in the Gura Poienii quarry, the limestones still have some angular polycrystalline quarz fragments, but are mainly bioclastic in nature (calcarenites rich in rhodophytic Algae and foraminiferal detritus). North of the Ungureni village, the alluvial deposits found in the creeks flowing from the Obcina hill (in particular the Izvoru Mare brook) are rich in huge clasts (some tens to hundreds cubic meters) of biogenic calcarenites and algolithes, sometimes impure or recrystallized, but more often containing fragments of Solenoporae and rhodophytic Algae (phytal environment), corals, worms, bryozoans and mollusks.

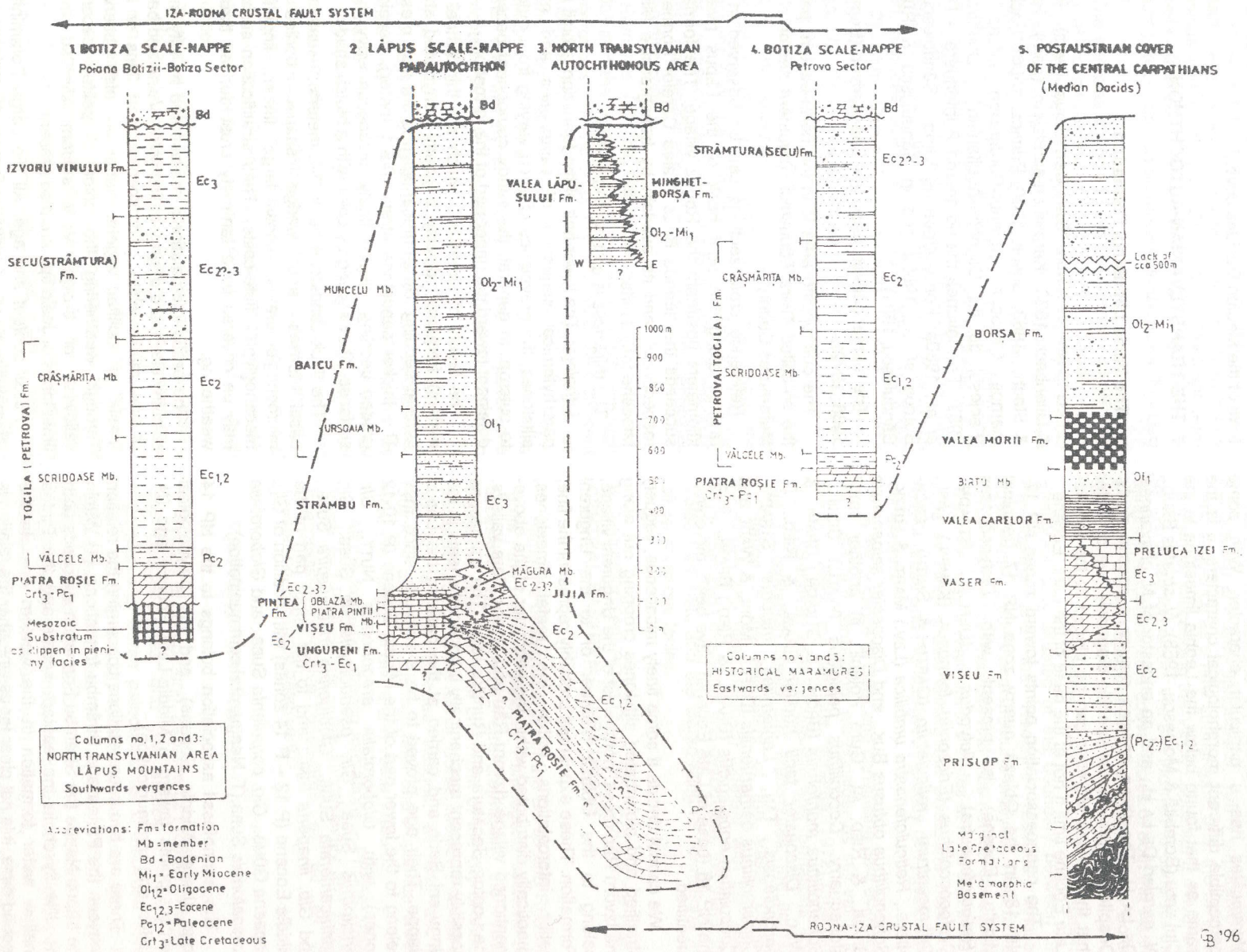
Fossil content and age. Following the field work of Primics (1886) and the diagnosis of the nummulites by Vutskits, Koch (1894) concluded that the limestones from Dealu Pintii are Hoia Beds (Early Oligocene) with *Nummulites intermedius-fichteli*, unconformably overlying the "Karpathensandstein" of Cretaceous-Tertiary age.

Beside the Algae population, three species of *Nummulites* from the Biarritzian-Bartonian stage are prevalent in these bioclastic limestones: *N. millecaput* Boubée with large diameter of the test (B) and large diameter of the megasphere (A), *N. perforatus* (Montf.) and *N. striatus* Brug. There are also a morfa *N.* ex gr. *striatus* Brug.-*N. boulangeri* Schaub and many thin and waved *Orthophragmina.*

The Oblazã Member can be examined in the small Oblazã quarry, along the road to Poiana Botizii. Here the limestones display an obviously nodular structure and are of dark grey color when fresh, light grey or rusty yellow when weathered. The limestones alternate with grey-bluish silty marls. The probable thickness of the outcrop is 4-5 meters, for the whole subunit is 20 m.

Fig. 5 Synthetic lithostratigraphic columns and their structural relation in the Romanian Maramures

SYNTHETIC LITHOSTRATIGRAPHIC COLUMNS AND THEIR STRUCTURAL RELATION IN THE ROMANIAN MARAMUREȘ



These pure limestones can also be observed in the Poiana Botizii-Ungureni area, as many broken and displaced blocks.

Fossil content and age. The little fauna of *Nummulites* has a particular character. With some perceptible different morphological characters, it is the same as that found below the Leghia limestone in the Cluj area (Bombiță & Moisescu, 1968): *N. striatus* BRUG., *N. garnieri* DE LA H., and an ancestor of *N. chavannesi* DE LA H. The three species require a special study. Despite this provisional specific diagnosis, we consider that the Oblază Member can be placed at the Middle-Late Eocene limit if not at the base of the Late Eocene.

The nannoassociation points toward zones NP 17-NP 18. In the Oblază quarry zone NP 17 (terminal Middle Eocene) is present with *Dictyococcites (Reticulofenestra) dictyodus* (DEFL.) STRADN., *Cyclococcolithus (Ericsonia) formosus* (KAMPN.) WISE, *Cribrocentrum reticulatum* (GARTN. & SMITH) PERCH-NIELS., *Reticulofenestra umbilica* (LEV.) MART. & RITZK., *Sphenolithus obtusus* BUK., and *Discoaster saipanensis* BRAML. & RIED. At "Gura Poienii", in another small stonequarry, *Coccolithus pelagicus* (WALL.) SCHILL., *Sphenolithus moriformis* (BRÖNN. & STRADN.) BRAML. & WILC., *Discoaster tanii nodifer* BRAML. & RIED., *D. barbadiensis* TAN, *Lanternites minutus* STRADN., *Chiasmolithus oamaruensis* (DEFL.) MOHL. & WADE and *Coccolithus eopelagicus* (BRAML. & RIED.) BRAML., from the NP 18 (base of Late Eocene) have been, moreover, identified.

We cannot decide if some finely micaceous, vaguely stratified and bioturbated siltstones cropping out along the Izvoru Rău creek, north-west of the Ungureni village, belong to the Oblază Member or to the Ungureni Formation. These exposures probably represent the fine, pelitic intercalations within the reefal limestones, chaotically distributed within the perimeter of the above-mentioned village (Izvoru Rău and Izvoru Mare valleys, the Lorilor, Secătura and Ruptilor hills). The limestones possibly represent mechanically introduced sheets in the Ungureni Beds and carried at the base of the Lăpus Nappe. Their age proved to be a surprise, since they belong to the lower part of the Middle Eocene (P 10-12 zones) with *Globorotalia aragonensis* NUTT., *Glr. lensiformis* SUBB., *Glr. pseudotopilensis* SUBB., *Glr. pentacamerata* SUBB., *Globigerina inaequispira* SUBB., and *Glb. linaperta* FINL.; and to the upper part of the Middle Eocene (P 12 – P 14 zones) with addition of *Glg. eocaena* GÜMB., *Glg. corpulenta* SUBB., and *Globorotalia crassaformis* SUBB.(T. Neagu, oral communication).

The nannofossil association belongs to the NP 14 zone (basal Middle Eocene), and the palynological content points toward a Middle-Late Eocene age (N. Baltes, oral communication).

There are two interpretations concerning the relation between the Pintea and Strâmbu formations: (1) Within the Lăpus Nappe the Strâmbu Formation succeeds both the Jijia flysch in the eastern sector and the Pintea shallow water formation in the western one. In the second case, it is not clear for us wheather the relation is stratigraphical or mechanical. (2) In this area of shallow water sedimentation it would have been possible the existence of a soft Late Eocene formation (member) succeeding the Oblază Member soon removed by the erosive ingression of the Strâmbu detrital formation.

The Pintea Formation seems to be, at the same time, a constitutive unit of the Lăpus thrust-sheet, but also a term of the Median Dacides cover.

7. THE TRANSYLVANIAN AUTOCHTHON

The Valea Lăpusului Formation

Synonymous terms: "Grès Carpatique" (*pars*) - Boué & Lilienbach, 1833; "Karpathen-sandstein" (*pars*) - Hauer & Stache, 1863; Gesell, 1880; Primics, 1886; "Faciesul marnos Oligocen superior-Burdigalian inferior" or "Faciesul de flis Oligocen-Aquitanian" - Dumitrescu, 1957; "Formatiunea marno-grezoasă inferioară" - Dicea *et al.*, 1980a; Formatiunea de Vima - Săndulescu (in Borcos *et al.*, 1980a and in Săndulescu & Russo-Săndulescu, 1981).

The name derives from the Lăpus river (Bombiță, 1966, 1972).

The outcropping area is in the north-eastern part of the so-called "Tara Lăpusului" (southern sector of the Maramures County).

Reference cross-sections can be observed in the ravines along the right bank of the Lăpus river, 2 kilometers upstream the Rogoz village. The formation succeeds the Ileanda Beds (Valea Carelor Formation, respectively), and its overlain by transgressive Middle Miocene formations.

The thickness is around 600 meters.

Lithology. The lower half of the formation is built by a pararhythmical sequence of sandstones and marly siltstones, the prevalence of each varying from outcrop to outcrop. In general, the sandy component becomes dominant toward the upper part of the formation.

The layers of sandstone which are thin (under 0.5 meters) frequently display a poorly convoluted shaly-laminar bedding. Small mecanoglyphs are also present. The thicker sandstone strata (0.5-1 meter), devoid of graded bedding, display finely micaceous wavy upper surfaces. They show grey color with a bluish shade.

The thick sandstone beds (1-2 meters), usually with basal lenses and wedge shaped bodies of microconglomerates, show large linear, linguiform mecanoglyphs (flute-casts). Their stratification surfaces may be covered by a tan-rusty crust derived through weathering.

The pelitic intercalations, represented by silty marls or marly clays, are of grey-bluish color. Veins and bands of pink marls, white efflorescenses and films or little "nests" of coalified vegetal matter are also observed. Through weathering the color of pelites becomes yellowish or brown. Very seldom silicified marly limestones of Jaslo tipe are also present.

Fossil content and age. All the Large Foraminifers (*Nummulites* ex gr. *aturicus-perforatus*, *N. millecaput*, *N. beaumonti*, *N. fabianii*, *N.* cf. *budensis*, *Assilina*, *Orthophragmina*, *Orbitoides* etc.) are reworked. Fossiliferous outcrops are also found on the valleys

Strâmbu, Glodu and Paltinu in the south-western sector of the Maramures province.

There are few autochthonous nanno-plankton forms, but the reworked ones are numerous. The samples from the ravines around the Rogoz village (the faciotype) contain Early Miocene species, such as *Coccolithus pelagicus* (WALL.) SCHILL., *Discolithina (Pontosphaera) desueta* (MÜLLER) PERCH-NIELS., *D. (P) multipora* (KAMPT.) ROTH. and *Cyclicargolithus abisectus* (MÜLLER) WISE.

The samples collected from the Minghet hill (Roaia-Minghet interfluve) and from the Izvoru Cosului valley (north-west from the Ungureni village) display a Middle Oligocene palynological content with *Deflandrea phosphoritica* EIS. (N. Baltes, oral communication).

That the time of deposition of this formation corresponds to the Late Oligocene-Early Miocene is also attested by its certain lateral passage to the Vima Marls which contains, on the northern rim of the Transylvanian basin, nannoassociations of Early Miocene age (zone NN 2) with: *Coccolithus pelagicus* (WALL.) SCHILL., *Discolithina (Pontosphaera) desueta* (MÜLLER) PERCH-NIELS., *D. (P) multipora* (KAMP.) ROTH, *Helicosphaera carteri* (WALL.) KAMPT., *H. ampliaperta* BRAML. & WILC., *H. euphratis* HAQ and *Reticulofenestra pseudoumbilicata* GARTN. The analysis of the planktonic foraminifera association (Popescu, 1975) has established the Oligocene-Miocene boundary in the upper third of the Vima Formation, separating the Globigerina ciperoensis + Glb. angulofficinalis zone from the Globigerinoides primordius zone.

Remarks. (a) The Valea Lăpusului Beds (Bombiță, 1966) and the Vima Marls (Lăzărescu, 1957) although synchronous are, heteropically speaking, two different formations and thus they cannot be synonymous as claimed by Săndulescu (in Borcos *et al.*, 1980; Săndulescu & Russo-Săndulescu, 1981). The Vima Marls are synonymous only to the "Aquitanische Schichten, thonige Tiefseefacies" defined by Hofmann (1881, 1887).

The Valea Lăpusului Formation, whose stratonomy and lithology were described in the previous paragraphs, is markedly different from the Vima Formation as exposed at the Vima village. The latter is represented by a 300 meter-thick sequence of grey dull-coloured compact marls, sometimes siltic, either resembling cakes of soap and displaying a concretionary-concentric lithification, or as long chips with conchoidal faces and clear-cut edges. Sandstones are extremely rare, usually friable and partly or thoroughly weathered through oxidation.

Both the Valea Lăpusului and the Vima formations are situated at the top of the Palaeogene stratigraphic column of marginal facies, comparable to the Palaeogene succession framing the Preluca and Inău "crystalline islands". All the above-mentioned facies are much more similar to the Austrian Schlier Formation (Early Miocene) than to a "flysch-like (shaly flysch) turbiditic sequence" (Săndulescu *et al.*, 1981, p. 80).

(b) Immediately south of the thrust line of the Lăpus Nappe and all along its trajectory between the Libotinel creek (north of the Ungureni village) and the Hudin-Tibles Mountain, a suite of massive and coarse sandstones has been mapped. Their outcrop area widens from west (Lăpus Mountains) to east (Tibles Mountains). Dicea *et al.* (1980) considered this arenitic sequence an equivalent of the Borsa Sandstone, stratigraphically succeeding the Valea Lăpusului Formation. Săndulescu (in Borcos *et al.*, 1980; in Săndulescu & Russo-Săndulescu, 1981) separated the same sequence as a new stratigraphic unit, the Minghet Sandstone, succeeding the Valea Lăpusului but overlain by the Borsa formation. We are inclined to consider the Minghet Sandstone as a coeval facies of both the south-western Valea Lăpusului and the north-eastern Borsa formations.

(c) The correlation between the formations stratigraphically situated at the boundary between the Palaeogene and the Neogene requires detailed stratigraphic studies and structural analysis. Their faunal content is poor or reworked and thus not too conclusive. Moreover, their involvment in a series of folds and thrust-folds or thrust-sheets linking the crystalline horsts of Rodna (east) and Preluca (west) greatly complicates the correlations.

In the absence of clear and convincing new evidence for a different correlation, we consider as still valid, for the time being, the previous scheme (1972) regarding the synchronicity of the Oligo-Miocene formations from the Transylvanian Basin and Maramures: the Ileanda Formation is the equivalent of the Valea Carelor Formation (the Birtu included) together with the Valea Morii Formation (menilites and dysodyles); the Vima, the Valea Lăpusului and the Borsa-Minghet formations are all synchronous facies.

8. PALAEOGENE POSTTECTONIC COVER OF THE CENTRAL-EASTERN CARPATHIANS

Along the eastern margin of the Borsa and Ruscova "gulfs", the following principal Palaeogene sections are accessible and important stratigraphically: the Prislop Pass, the perimeter east and north of the city of Viseu, the surroundings of the Săcel, Borsa, Moisei, Poienile de sub Munte and Repedea villages, as well as the outcrops along the Bistra, Luhei and Toplianca creeks near the villages of Bistra and Valea Viseului.

All the following Eocene formations – Prislop, Viseu, Vaser and Preluca Izei – are successively and zonally transgressive-ingressive eastwards as far as the Crystalline-Mesozoic basement.

The Prislop Formation

Historical background. Zapalowicz (1886) considered the conglomerates and sandstones bordering the Ruscova and Borsa paleogulfs as Cretaceous *sensu largo*. Kräutner (1938) circumscribed their age to the Cenomanian. Patrulius *et al.* (1955, 1960), however, were inclined to attribute to the Eocene all the conglomerate and sandstone sequences following the Orlové-type formation with *Exogyra*. The age of conglomerates was also vague to Böckh (1897), Pávay-Vayna (1943) and Schréter (1943, *fide* Patrulius *et al.*, 1955).

Recent paleontological data (Szasz, 1974) have shown that approximately the first 200 meters of the Prislop conglomerates and sandstones belong, even at the type-locality, to the Turonian-Maastrichtian interval and possibly to the Paleocene as well. This basal stack of rocks was named by Szasz the Ajmaru Mare Formation. Iliescu *et al.* (1967, 1968) belive that a similar age correction should also be applied to some "Vaser marls", generally considered by Patrulius to be of Eocene age as well.

The Prislop Pass, which links the provinces Maramures and Bucovina, is at the origin of this formation name (Patrulius *et al.*, 1955, emend., Szasz, 1974).

Reference cross sections can be examined along national highway Borsa-Prislop Pass-Iacobeni, east of the Gura Fântânii hamlet.

The average thickness of the formations is around 300 meters (Szasz, l.c.) but with wide variations (200-500 meters) along the frame of the Borsa and Ruscova paleoembayments.

Lithology. Above the disconformity with the Late Cretaceous Ajmaru Mare Formation, the Prislop Formation begins with massive, non-graded, disorganised beds composed of isolated pebbles and blocks devoid of roundness. The chaotic polygenetic coarse breccias or boulder beds are here poorly sorted, surrounded by sandy-gravely matrix, fine-grained debris or sandy-marly matrix of black or reddish color with a vague or without signs of stratification (deposits of debris avalanche?).

The clastic elements belong to various basement rocks: micaschist, paragneiss, quartzite, chlorite-sericite schist, graphite-sericite schist, limestone, dolomite. The amount of cement is small.

Toward the upper part of the formation the clasts are increasingly better rounded and the intercalations of coarse massive sandstone become more frequent. Mica-rich sandstones with lens-like accumulations of coalified vegetal matter are also present. The megaclasts become rare and scattered in a thick noncohesive sandy-gravely matrix. Some reverse and normal gradings seem to be the products of dense turbidity currents of dense submarine fan-dense suspension wanting - at less apparently - sedimentary tractional structures.

In the uppermost part of the formation, marly sandstones or marly-silty shales prevail in para-rhythmic alternance with calcareous sandstones. No lenses or layers of shallow water rocks or other structures and textures of shallow-marine environments were observed.

With these sedimentary specific features it is not sure, in our oppinion, that the microbiocontents of the Prislop Formation are *in situ*. In the Gura Fântânii hamlet, in an outcrop along the highroad, the Prislop Formation is followed by marly limestones of Vaser type.

Remarks. 1. What Patrulius *et al.* (1955) described, *grosso modo*, as the Prislop Conglomerates represents three distinct formations: the Ajmaru Mare Conglomerates (Late Cretaceous-Early Paleocene), the Prislop Conglomerates and the Viseu Formation. The last two units belong to the Upper Paleocene (?) – Eocene depositional cycle, but only the Viseu Formation contains Large Foraminifers.

Approximately 3 km east of the Gura Fântânii hamlet, samples collected from dark marls, probably belonging to the upper part of the Ajmaru Mare Formation, contain nannoplankton of the NP 2 zone (Lower Paleocene) with *Zigolithus sigmoides* BRAML. & SULL., *Cruciplacolithus tenuis* HAY & MOHL., and *Ericsonia subpertusa* HAY & MOHL. It is not possible to say whether this nannoplankton is *in situ* in the upper part of the Ajmaru Mare Conglomerates, or whether it represents fossil material at the base of the conglomerates from Gura Fântânii. On the Viseu map (1: 50,000) Săndulescu *et al.* (1991) mentioned limited outcrops of "grey marls and siltic marls of Paleocene (?) age" deposited directly on the crystalline basement north of the Viseul de Sus town, between the Vaser and Vinului valleys.

2. No large Foraminifers were found in the Prislop Conglomerates *stricto sensu*. The nummulitic assemblage of Early Eocene, mentioned by Tătârâm *et al.* (1969) at the far end of the Ruscova paleoembayment, the headwaters of the Iza river or the Teilor valley, probably belongs to formations situated higher in the stratigraphic column and thus needs a revision.

The Viseu Formation

Historical background. Kräutner (1938) distinguished this formation as "Littoral-detritische Facies". Patrulius *et al.* (1955) individualized it as "grès et microconglomèrats quartzitiques (avec)...des enclaves à *Nummulites perforatus*". At the Poiana Botizii village, in Pintea hill, Dimitrescu & Bleahu (1955) and Dumitrescu (1957) considered the large Nummulites from these conglomerats as reworked. Săndulescu *et al.* (1991) appended the name Viseu Formation for the succession of "marls, sandstones and conglomerates with *Nummulites*".

The formation takes its name from the river and city of Viseu.

Reference cross sections are present along the creeks descending the western slopes of the Arsita Sasului and Hâgii hills, north of the city of Viseu. Here the Viseu Formation is situated between the Prislop Conglomerates and the Vaser Marls. The same series can also be examined in the Tolpiciorul hill, near the sources of the Iza river, south-east of the Săcel village. In the neighbourhood of the Poiana Botizii village ("Piatra Pintii" or "Casa Pintii") and north of the village of Ungureni (along the Izvoru Mare and Izvoru Rău creeks), the formation appears in isolated outcrops where it is not very typical.

The formation reaches 350 meters in its type-locality (Săndulescu *et al.*, 1991), but in the area of the Iza springs the thickness diminishes to no more than 50 meters. The formation is thinner still near the Poiana Botizii and Ungureni villages (25-30 meters).

Lithology. Good outcrops can be observed on the slopes of the Topliciorul hill, east of Săcel. Here the most widespread rock is a bioclastic rudite, quite hard, of a dark grey color and with abundant carbonate cement.

Among the bioclasts Algae, Corals, Bivalves, Bryozoans, Echinoderms, but mostly large Formanifers can be recognized.

Epimetamorphic lithoclasts are present either as part of the matrix, or as layered ruditic intercalations. Most of the metamorphic clasts are quartz or quartzite.

In the Poiana Botizii-Ungureni area the terrigenous component is more important. Beneath the large limestone layers (at Piatra Pintii), several ravines expose lenses or layers of microconglomerates and conglomerates composed of metamorphic clasts and abundant bioclasts: Algae, Mollusks, large *Nummulites*. In some outcrops calcarenites are present, showing Large Foraminifers and other bioclasts embedded in a matrix made of fine terrigenous or biogenous sand.

Fossil content and age. A rich and varied Nummulitic fauna was obtained from outcrops of coarse and hard quartzitic sandstones in the Topliciorul hill: *Nummulites brongniarti* D'ARCH. & HAIME as marker species associated with *N. perforatus* (MONTF.), *N. discorbinus* (SCHLOTH.), *N. beaumonti* D'ARCH. & HAIME, *N. meneghini* D'ARCH. & HAIME, *N. gizehensis* (FORSK.) and *Orbitolites* sp.

The basal ruditic part of the Piatra Pintii section (two crags south of the Poiana Botizii village) yielded: *Nummulites millecaput* BOUB., *N.* ex gr. *millecaput* BOUB.-*N. dufrenoyi* D'ARCH. & HAIME -*N. maximus* D'ARCH., *N. perforatus* (MONTF.), *N. aturicus* JOLY & LEYM., *N. meneghini* D'ARCH. & HAIME, *N.* ex gr. *sordensis* HERB & SCHAUB -*N. herbi* SCHAUB -*N. brogniarti* D'ARCH. & HAIME, *N. biedai* SCHAUB., *N.* ex gr. *striatus* BRUG., *N.* cf. *pretauricus* SCHAUB, *N. cyrenaicus* SCHAUB, *N.* ex gr. *gizehensis* (FORSK.)-*N. lyelli* D'ARCH. & HAIME, *Orthophragmina*, *Assilina*, *Alveolina* and *Inoceramus* (reworked fragments). The biostratigraphic significance is Late Middle Eocene (Biarritzian-Bartonian).

In some other outcrops (Strâmbu village, northern area of the Ungureni village etc.) the equivalent levels of the basal Viseu Formation supplied *N. millecaput* BOUB., as leading species in association with *N. lunae* BOMB., *N.* cf. *striatus* BRUG., *N. puschi* D'ARCH. etc.

The Vaser Formation

Historical background. Zapalowicz (1886) considered the formation named "Mergelschifer", together with the present Preluca Izei Formation, as a carbonate-rich group belonging to the Early Eocene. Kräutner (1938) included the Vaser Formation within a more comprehensive sequence, the so-called "Gura Fântânii Series" of Middle Eocene age. Patrulius *et al.* (1955) gave it the present name and described in some detail several types of the Vaser Marls.

The formation takes its name from the Vaser stream which discharges its waters into the Viseu river.

Reference cross-sections can be studied along the creeks flowing down the western slopes of the Arsita Sasului and Hâgii hills, north of the city of Viseu. In these localities the Vaser Formation surmounts either the Viseu Beds or, directly, the Prislop Conglomerates and is ovelain by the Valea Carelor Formation (Săndulescu *et al.*, 1991). Mutihac (1955, 1956), Patrulius *et al.* (1955), Patrulius (1956) and Szasz (1974) have mentioned the ingressive-transgressive relation of the Vaser Marls (as well as that of the Preluca Izei Limestones) onto the metamorphic basement. Patrulius *et al.* (1955) precisely observed that in some areas the Vaser Marls "occupy the entire stratigraphic interval between the metamorphic basement and the base of the Oligocene". Finally, the Vaser Formation can precede but also substitute the Preluca Izei Formation.

Other good outcrops are located at the confluence between the Vaser and Viseu rivers in the city of Viseu de Sus ("Gura Vaserului").

The thickness reaches some 200-250 meters at the type locality, but only 50 meters in the surrounding regions.

Lithology. The lithotype from "Gura Vaserului" is represented by silty marls of grey-bluish color when fresh. Through weathering the color lightens. The layers are thick and homogeneous. The stratification surface are harsh and obliterated by schistosity. Some sandy well-cemented intercalations are also present. Patrulius *et al.* (1955) mentioned some other rock types such as dark grey limestones, marly sandstones or marly-sandy limestones with Foraminifera, as well as red-purple marls with grey and green stains. A few centimetric layers of micaceous sandstones with bulbous mecanoglyphs are also present.

At Gura Fântânii hamlet the basal part of the formation is represented by grey-bluish marly limestones succeeding directly the Prislop Conglomerates.

Fossil content and age. At the type-locality (Gura Vaserului) the nannoplanktonic association collected from the base of the formation belongs to zone NP 17 (terminal Middle Eocene) with *Cyclococcolithus (Ericsonia) formosus* (KAMPN.) WISE, *Sphenolithus obtusus* BUKRY, *S. radians* DEFL., *Discoaster barbadiensis* TAN, *D. tanii nodifer* BRAML. & RIED., *Reticolofenestra umbilica* (LEV.) MART. & RITZK., and *Dictyococcites (Reticulofenestra) dictyoda* (DEFL.) STRADN.

Two Nummulites found on the Prihodului hill, north-west of the Viseu de Sus locality, *N. striatus* BRUG., and *N. lunae* BOMB., besides *Operculina* sp., and *Orthophragmina* sp., with some marks of wear by transport in the littoral zone, have the same biostratigraphic significance: Middle-Late Eocene boundary. We have no sure proofs on the Late Eocene, but it can be accepted considering the obvious and directly stratigraphic succession.

A synchronism with Oblazã Member of the Pintea Formation is probable.

The Preluca Izei Formation

Synonymous terms: "Nummulites und Brachiopoden-kalk" (Zapalowicz, 1886); "Nummulitenkalke, Littorale Riff-Fazies" (Kräutner, 1938); "Calcare nummulitice si coraligene" (Patrulius *et al.*, 1955; Patrulius, 1956).

The formation name (Bombită, *hic*) comes from the homonymous large grade situated close the Iza river headwaters.

Thickness measures approximately 50 meters.

Lithology. Even more than the Piatra Pintii Limestones, the Preluca Izei Formation displays the typical features of a biogenic littoral facies, originating through the accumulation of micritic oozes on a stable platform under a subtropical climate. Some clastic supply is also present as well as a certain organic building activity.

The rock is basically a grey organoclastic limestone with Algae, Corals, Bryozoans and a diverse microbenthos (mainly Miliolids and Large Foraminifers). Locally, concentrations of usually broken (sedomly intact) Mollusks are present (*Chlamys, Spondylus, Pecten, Venericardia, Pycnodonte*).

Fine sandy limestones, marly limestones and nodular limestones can also be observed, less frequently though.

The stratification is good, marked quite frequently by thin shaly layers. When exposed to weathering, the limestone bedding faces are corroded through dissolution. The circulation of the waters through fractures have formed dolinas and caves.

In thin section the limestone is either a recrystallized bioclastic micrite with numerous microforams, or a biogenic calcarenite with macroforams included in a bioclastic groundmass resulting from the crushing and trituration of Foraminifera and red Algae. The rock contains many quartz grains; in some cases their frequency changes the calcarenite into a carbonate sandstone.

Being ingressive on the north-western corner of the Rodna massif, the Preluca Izei Formation rest unconformably on the metamorphic basement.

Fossil content and age. At the type locality five Large Foraminifers are present, all markers for the Priabonian: *Nummulites fabianii* (PREVER), *N. incrassatus* DE LA H., *N. pulchellus* HANTK., *N. chavannesi* DE LA H., and *Operculina alpina* DOUV. In the Izioara valley, east of Săcel, the Preluca Izei Formation, rich in Mollusks (*Chlamys, Pecten, Spondylus*), Algae and microbenthos (Miliolids), also contains *Nummulites budensis* HANTK.

The Mollusks and varied Large Foraminifers fauna is often refound as reworked in clayey pockets in the overlying Valea Carelor Beds, as well as in lens-shaped detrital beds belonging to the Borsa Sandstones of the Săcel village (Noth, 1885, in Böckh, 1897; "Schréter layer" in Patrulius, 1955, 1956).

The last few meters of the Preluca Izei Formation cross probably the Eocene-Oligocene boundary. At the eastern end of the Borsa paleogulf (Gura Fântânii) the thickness of the formation is reduced to 5-6 meters of marly, shaly limestone of bluish-grey or whitish color. The nannofossil content here is Rupelian (zone NP 22) with: *Lantemithus minutus* STRADN., *Dictyococcites (Reticulofenestra) dictyodus* (DEFL.) STRADN., *Reticulofenestra umbilica* (LEV.) MART. & RITZK., *Ericsonia subdisticha* ROTH and *Coccolithus pelagicus* (WALL.) SCHILL.

Previous dating. The Preluca Izei Limestone was first considered by Zapalowicz (1886) as Early Eocene in age, while Kräutner (1938) places the formation in the Middle Eocene. Finally, Schréter (1943 in Patrulius *et al.*, 1955) and Patrulius (1955-1956) brought proof for a correct Late Eocene age.

The Valea Carelor Formation

Historical background. Zapalowicz (1886) distinguished the sequence of bituminous shales succeeding the Nummulitic Limestones as "Ober-eocener...strzolkaartige Schichten und Birtiu (*recte* Birtu) Sandstein". The last term was mentioned also with the synonymous "Scerisioara (*recte* Scărisoara) Sandstein".

The present name of the formation was given by Patrulius (1954) after the valley which joins the Iza river in the Săcel village.

Reference cross-sections are along the homonymous valley in the Iza river basin, upstream the Preluca Izei glade and along the Izioara and Teilor creeks.

Thickness can reach 250 meters.

Lithology. Patrulius (1954, 1960) considered the Valea Carelor Formation as a turbiditic sequence ("flysch") containing Eocene redeposited material ("wildflysch").

At the type locality the formation consists of marginal-littoral boulder clays, more seldom siltic, marly clays of a dark color, dull or shiny. Originally, the deposits were sapropelic muds, pure or sandy, probably lagoonal, changed through diagenesis into black clays. Stratonomically the rock is compact or stratiform and only seldom lamellar or foliated. When compact glittery stress surfaces can be observed quite often. In the second case one must notice the brown-rusty zones of alteration, ankerite lens, dysodile shales and salty exudations.

Associated with the black clays are lenses of hard, fine-grained sandstones, devoid of sole marks. In the southern sector, especially in the faciotype area (Carele, Izioara, Teilor, Sălăuta and Fiad valleys), the rocks are strongly deformed, bent, curved, contorted and with a boudinage-type structure. The cracks are either open or filled with calcite.

West of the Rodna horst the formation includes medio- and microbreccias with mainly Priabonian blocks from its immediate substrate, i.e. Algal nodules, Corals, Bryozoans, all kinds of benthic organisms (Mollusks, Crustaceans, Large Foraminifers). These redeposited blocks and boulders, which sometime reach appreciable sized, belong not only to the Preluca Izei Limestones, but also to the Prislop Conglomerates, to the Late Cretaceous red or green siltic shales, mechanically squeezed, and to the metamorphic rocks. They all resulted from the collapse of paleocliffs, undetermined by erosion. The Eocene carbonates were probably only partially lithified at that time, so that their petrogenesis continued and ended in the new, Oligocene, habitat.

The peculiar facies of the Valea Carelor Formation is the result of two cumulative processes: (1) Around the village of Romuli strictly tectonic causes, active during the Middle Miocene and leading to the thrust-folds. These structures are devoid of their reverse limb, have a south-eastern vergence and moved over a soft, lubriacting sole of Senonian, Paleocene and Eocene lutites. (2) Non-tectonic causes, such as recent superficial deformation of a gravitational collapse-type, produced in areas of Setrev pass and Carelor valley

where the thick cover of the Borsa Sandstone was removed through erosion. One may thus consider the Valea Carelor Formation as a semitectonite.

Paleontological content and age. The fossil inventory is poor and heterogeneous (Maastrichtian, Eocene and Oligocene), and its stratigraphic value was uncertain from Zapalowicz (1886) to Patrulius (1954), Patrulius *et al.* (1960).

The *in situ* fossil assemblage reflects an anoxic, anaerobic environment, rich in H_2S emissions, with algal overpopulation. The Mollusks and Crustacean fauna (Mutihac, 1955; Bulgaru, 1966; Iliescu & Iliescu, 1966), as well as the Microforams (Antonescu *et al.*, 1975, 1977) are of reduced significance age-wise.

The lithofacies and, in particular, the biofacies (frequent fish skeletons) of the formation led to its correct correlation with the Rupelian lagoonal-euxinic Ileanda formation, known in north-western Transylvania.

The Eocene organisms (Large Foraminifers, Mollusks and Mammals) (Patrulius, 1954, 1960) are detached through the desaggregation of the parent limestone and subsequently transported and dumped into the Oligocene lagoon.

Initially Patrulius (1955) claimed an Oligocene age for the Valea Carelor Beds, since all previous authors attributed them to the Eocene. Subsequently, however, Patrulius reconsidered their age and placed them into the Eocene, claiming that their fauna was *in situ.* Nowadays, the age equivalence between the Valea Carelor Formation and the papyraceous Rupelian Ileanda Beds from Transylvania is firmly established.

Patrulius (1955) also mentioned that in the Borsa paleogulf there are places where these beds occupy the entire stratigraphic interval between the Preluca Izei Limestones and the Borsa Sandstones.

The Birtu Member. The Birtu Sandstone ranks as a member of the Valea Carelor Formation. It is situated either toward the upper part of the Valea Carelor Formation or represents the capstone of those beds (Zapalowicz, 1886; Patrulius, 1955).

The name derives from Birtu creek, a northern tributary of the Viseu river, downstream the Gura Fântânii hamlet.

Reference cross-section can be examined along the south-western tributaries of the Borsa river, between Gura Fântânii (east) and the Moisei monastery (west).

Thickness exceeds 400 meters in the Ruscova embayement (Săndulescu *et al.*, 1991), but is reduced to only 200-300 meters in the eastern and southern sectors of the Borsa paleogulf.

Lithology. The Birtu Sandstone is a relatively coarse quartz-arenite of medium hardness. In most outcrops, the rock is grey in color with mica-rich bedding surface which are frequently but weakly undulated. Microconglomeratic lenses are also present. Bed thickness can reach 2 meters. The clear subsidiary pelitic fraction is similar to the Valea Carelor Beds (dark marly clays).

The Birtu Sandstone is not accepted as an individual unit by the petroleum geologists (Dicea *et al.*, 1980). They attach this member at the base of the Borsa Formation, as the reservoir of a small oil accumulation in the region.

The Valea Morii Formation

Historical background. The term has recently been introduced by Săndulescu *et al.* (1991) for the formation separated by Zapalowicz (1886) under the name of "Smilno-(Menilit) Schiefer" and by Patrulius (1955, 1956) as the "Menilitic series", including the "Misica Marls". Dicea *et al.* (1980) used exclusively descriptive terms ("Marls and marly limestones with menilites, dysodiles and spherosiderites") for the same formation.

Future studies should determine whether the Valea Morii Formation is really an independent unit marking the transition from the Valea Carelor Beds to the Borsa Sandstone, or only a lateral facies variation (like the Birtu Sandstone) of the upper part of the former.

The name originates from the homonymous valley, a right bank tributary of the Viseu river, 1.5 kilometers downstream the village of Viseu de Jos.

Cross-sections can be seen in the eastern sector of the Ruscova embayment; then within the perimeter of the Rozavlea, Sieu and Dragomiresti villages and, more to the north, in the neighbourhood of the Rona, Bistra and Viseu valleys.

Thickness measures between 200 and 300 meters.

Lithology. The Valea Morii Formation is a bituminous series comprising quite a variety of rock types, such as marly limestones, tan and white or dark brown and black; more or less silicified marly limestones, some of Jaslo type (a Polish name), other genuine menilites; shaly marls of a grey, tan or yellow color; clays in laminate, leafy layers, brown, grey or black.

It appears that in the Borsa paleoembayment and along the western rim of the Rodna metamorphic horst, the Valea Morii Formation contains an increased amount of thin bituminous shales (dysodiles) with salt exudations, gypsum crystals, spherosiderites and lens-shaped bands of sideritic limestones and ankerites.

Fossil content and age. The macrofauna collected by Draghindă (1952, unpublished report) in the surroundings of the Telciu and Romuli villages (Strâmba valley particularly) includes: *Polymesoda convexa* (Brogn.), *Crassostrea* ex gr. *cyathula (Lmk.), Tympanotonos labyrinthum* (Nyst.), *Pecten arcuatus* (Brocc.), *Hexaplex (Muricantha) deshayesi* (Nyst.), *Gemmula* aff. *koninckl* (Nyst.) and *Chlamys biarritzensis gravesi* (D'Arch.) (up to date taxinomic nomenclature by A. Rusu), representing a mixture of stenohaline and eurihaline forms of (Early?) Rupelian.

The most widespread microfaunal forms are *Globorotalia membranacea* (Ehr.) and *Glr. menardii* (D'Orb.), while *Deflandrea phosphoritica* (Eis.) is representative for the microflora (Dicea *et al.*, 1980).

Misica Marls Member. On the northern rim of the Ruscova paleogulf, more specifically on the eastern slope of the Misica hill in the vicinity of the villages of Repedea and Poienile de Sub Munte, Patrulius (1956) identified a succession of lutites, measuring 150 meters in thickness, which he named the Misica Marls.

They are inserted in between the Valea Morii Formation and the Borsa Sandstone and are represented by lead-grey marls, marly clays criss-crossed by calcite-filled veins, as well as by black shales, green marly clays and brown shales, all alternating with sandstones with frequent poor convolute bedding.

The Borsa Formation

Historical background. It was Zapalowicz (1886) who separated and named this formation from the more comprehensive "Grès carpatique" (Boué & Lilienbach, 1833) "Karpathensandstein", respectively (Hauer & Stache, 1863; Gesel, 1880; Primics, 1886). Magóra Sandstein (*pars*) and Scărisoara Sandstein (in Zapalowicz, l.c.) are other two synonyms.

The formation name derives from the locality and the river Borsa, the latter flowing north of the Rodna crystalline massif.

Reference cross sections. Along the right bank tributaries of the Borsa river some good outcrops are exposed particularly between the village of Borsa and Moisei. Other exposures can be examined in the cuts along the railroad following the Iza valley, north of Săcel.

Thickness can reach 2,000 meters (Patrulius, 1956).

Lithology. As far as thickness and areal distribution are concerned, the Borsa Sandstones are by far the most important of all Maramures formations.

The faciotype is a turbiditic arenite, seldom fine and convolute but usually lacking size-sorting, building layers of decimeters-to-meters thickness. The color of the rock is generally grey with a bluish shade when fresh, but tan, rusty or yellow when weathered, with iron oxide-rich crusts. Sole marks are frequent and varied, usually large and linear (flute casts). Also present are layers of breccias, some of them containing Algal crusts and nodules, as well as reworked Large Foraminifers and Mollusks shells as fragments. The bed of coarse sands remarked by Noth (1885 in Böckh, 1897) was named "Schréter Bed" by Patrulius (1955, 1956).

The carbonate cement, once dissolved and leached, leaves the rock outcrops taking a "ruiniform" aspect.

The pelitic part is represented mainly by mudstones and marly clays of grey-brown, often displaying laminae. "Black" bituminous shales, spherosiderites and lenses of menilites are seldom present. Some vegetal remains and even thin intercalations of coal can also be observed.

In the lower third of the formation the sandstone layers are thinner (0.5-1 meters) with frequent convolute bedding; they alternate with marly strata of approximately equal thickness.

The maximum thickness of the Borsa Formation is registred in the eastern areas of Maramures (upper basin of the Sălăuta river, the Borsa and Ruscova paleoembayment) where the erosion was mild. In the western area, much more affected by erosion caused by the Middle Neogene transgression, the thickness is reduced to less than 1000 meters.

Between the Grosii Tiblesului village and the Târlisua creek (southern Maramures), above the Borsa Sandstone, Dicea *et al.* (1980) have mapped an "upper marly-sandy formation". It consists of a predominantly lutitic sequence with subordinated strata of slightly bituminous shales and sandstones. Patrulius (1956) also observed an "upper bituminous complex" associated with the Borsa Sandstones located in the Ruscova "gulf".

The Borsa Formation served as a reservoir-rock for the small oil bearing anticlinal structure Săcel-Săliste-Dragomiresti (Tietze, 1878; Gesel, 1880; Böckh, 1897; Strautz, 1950), which has been reexplored in the 50's, when some petroleum was extracted.

Fossil content and age. All the macropaleontological material of Eocene age found in the Borsa Formation is reworked from the Preluca Izei and Viseu formations. In the environs of Săcel village, at the confluence of the Larga brook with Iza river and in the Highis hill, the "Schréter Bed" represents a coarse sandy biodetritus poorly consolidated, resulting from the reworking and trituration of some Eocene faluns in the littoral zone (Mollusks, Algae, Bryozoans) and littoral microbenthos (in particular Foraminifers). The formation is also "fossiliferous" south of Bistra village.

By its stratigraphic position and due to its lithological characters, the Borsa Sandstone has been considered of Late Oligocene age since its first separation as an entity (Zapalowicz, 1886). The principal *in situ* fossils, *Globigerina ciperoensis* BOLLI and *Globigerinoides trilobus* REUSS, are markers for the Late Oligocene and Lower Miocene, respectively (Dicea *et al.*, 1980).

The marly sandstones near the village of Grosi display a Burdigalian nannoplankton (zone NN 2) with *Dictyococcites (Reticulofenestra) dictyodus* (DEFL.) STRADN., *Zygrhablithus bijugatus* DEFL., *Cyclococcolithus (Ericsonia) formosus* (KAMPTN.) WISE, *Pontosphaera multipora* (KAMPTN.) ROTH, *Cyclicargolithus floridanus* (ROTH & HAY) BUKRY, *Reticulofenestra umbilica* (LEV.) MART. & RITZK., *Transversopontis zigzag* LOCK., and *Helicopontosphaera kamptneri* HAY & MOHL.

The upper levels of the formation, sampled in the area Borsa-Moisei-Săcel, have provided a characteristic palynofacies with diatoms and palm tree pollen, similar to the palynofacies of the Muncelu Member (Baicu Formation, Lăpus thrust-sheet). This palynofacies association is easily recognizable throughout the Late Oligocene-Lower Miocene series in Maramures and northern Transylvania (N. Baltes, oral communication).

9. THE PROBLEM OF THE MARAMURES "WILDFLYSCH"

Some lithostratigraphic units from Maramures were lebeled as "typical wildflysch".

(1) In our oppinion Dumitrescu (1957) and Săndulescu (1980-1984) lumped wildflysch heterogenous series, comprehensive in age, including the Ungureni Beds (Middle Senonian-Early Eocene with some probable stratigraphic gaps), the Prislop Conglomerates (redefined by Szasz, 1974), the Piatra Pintii and Oblază Limestones (Biarrizian-Bartonian) and the Strâmbu Sandstone (Priabonian). The entire group ("wildflysch"..."intensely dislocate" in Dumitrescu, 1957) is present in the western sector of the Lăpus Nappe,

north of the Ungureni village, between the Sibila creek (to the west) and the Roaia valley (to the east).

(2) Patrulius & Popescu (1960) have considered as wildflysch the Valea Carelor Formation (Rupelian blacks clays, localy including prevalently Eocene blocks), displaying good exposures south of Săcel village, along the valley with the same name. According to the aforementioned athors, the red marls, also present as narrow bands and lenses within the formation, are of allochthonous origin, representing gravity slumpings of Senonian age included in an Oligocene formation.

Finally, Antonescu *et al.* (1975, 1977) and Dicea *et al.* (1980a) consider all the formations from point (1) as equivalent and synchronous to the Valea Carelor Beds (2), and thus a "wildflysch".

In our view the use of the term wildflysch to desingnate the formations just mentionad is improper.

The initial notion of wildflysch (Kaufmann, 1870-1872; 1886, in Boussac, 1912, p. 508-510) had no clear genetic connotation. Boussac translated Kaufmann's detailed description so that French geologists at the beginning of the past century could get "une idée assez exacte de cette curieuse formation".

Later, the notion of wildflysch, otherwise like the notion of flysch itself, acquired also a genetic significance (Trumpy, 1960; Broquet, 1978, 1986 etc.). Indeed, we believe that the term wildflysch should be associated with an Alpine-type orogenic environment characteristic of the deposition of the flysch facies (Lombard, 1972; Winkler, 1988), although the former lacks the typical rhythmicity of the latter. The wildflysch cannot be something else than a particular facies of the alpine flysch, that is a flysch with olistostromes. Ignoring the flysch-wildflysch relationship could lead only to confusion, since all kinds of deposits labeled as diamictites, tilites, tilloids, breccias and megabreccias, boulder beds, broken formations or even some of ordinary conglomerates may be included in the term of wildflysch.

The advent of Global Tectonics changed the meaning of the concepts of wildflysch: similar if not identical facies were considered to be associated with subduction processes in marginal trenches.

Hsü (1974) concluded that most chaotic, disrupted deposits belong genetically to either a (tectonic) mélange *sensu* Greenly-1919, or to a (sedimentary) olistostrome *sensu* Flores-1955. In some cases existing olistostromes may be further tectonized in a third type of mélange. The field is still largely controversial (Hsü, 1968; Raymond, 1984a,b; Raymond & Terranova, 1984).

In the case of the Maramures series considered to represent a wildflysch facies, none of the descriptive or genetic characteristics of a mélange or wildflysch fit.

Two fundamental premises exist in the problem:

(1) Prior to presume the genesis, the diagnosis of a wildflysch should be based on observable clear litho- and biofacial criteria; (2) the petrogenesis of chaotic poly-lithologic rock bodies implied processes of fragmentation and mixing, leading to exotic blocks in autochthonous matrix (imbricated-penetrative matrix) (Raymond, 1984a).

The "wildflysch" north of the Ungureni village does not contain exotic redeposited blocks, but local rock material belonging to the shallow water facies nearby. No Jurassic limestones (Dumitrescu, 1957) or any oyher pre-Senonian sedimentary rocks were identified. Within the collection of diverse rocks types scattered as blocks of various sizes (from small to huge), the fossil content can easily be determined and it represent the marginal facies of some different Senonian or Eocene formations.

The dislocation of these marginal terms and their scattered, disorderly, mosaic-like distribution is a direct result of the push and pressure exerted by the motion of the Botiza Nappe from north to south against a supposed buried basement sill (haut-fond), the so-called Preluca-Rodna transanticline (Motas, 1956; Dumitrescu, 1957; Bombiță, 1966, 1972), covered by some incompetent, brittle deposits (Late Cretaceous and Eocene conglomerates, marls and limestones), easy to uproot, dislodge and fragment.

Therefore, the "wildflysch" near Ungureni is not a shaly basin fill of "geosynclinal-type" deposit including allochthonous blocks (Dumitrescu, 1957; Săndulescu, 1980-1984), but a marginal-littoral quadri-formational suite of rocks, completely autochthonous, but detached and crushed by tectonic stresses of the Botiza Nappe against the marginal formations fronting it. It is, in our opinion, *a broken formational group* (? a sort of tectonite *auctorum*).

The Valea Carelor Formation, with the faciotype near the village of Săcel (the homonymous valley), has been considered to be a wildflysch due the local presence either of exotic elements from the basement and of littoral type (metamorphic rocks, Neocretaceous or Eocene conglomerates and limestones embedded in sapropelic black shales), or of "slices" of red-green Late Cretaceous-Palaeogene marls and flysch-like sequences of Tocila type; all these in a peculiar tectofacies (Patrulius & Popescu, 1960). It is worth mentioning that there are two types of red beds. The first is characterized by well-indurated marls and siltstones of vivid brick-red color with white-bluish stains of Late Cretaceous-Paleocene age ("Couches rouges"). The second type is represented by indurated or relatively soft sandy or silty marls and clays of dark red and purple color of Paleocene-Eocene age.

As far as the peculiar tectofacies of the Valea Carelor Beds is concerned, two different situations and causes must be taken into consideration: tectonic and non-tectonic causes.

In the upper Sălăuta valley (village of Romuli, east of the Setrev pass), careful mapping (Mutihac, 1956; Patrulius, l.c.) shows the existence of several thrust-folds with east and south-east vergence. Their base is represented by frequently crushed sheets of Late Cretaceous greenish or reddish marly limestones and of Eocene flysch. These dislocated, highly stressed rocks are followed by compressed but coherent and undisturbed Valea Carelor Beds and by a thick sequence of clastic Oligo-Miocene deposits (Borsa Sandstone). Clearly, this area has essentially been subjected to the effects of the Styrian tectonic phase.

However, in other neigbouring western sectors (upper basin of the Carelor valley and Setrev pass are typical), where the Valea Carelor Formation is not

followed and protected by the Borsa-type sandstone (presumably subjected to erosion), a second situation can be observed. Here a disordered, dismembered and chaotic aspect is obvious within the Valea Carelor Beds. Such aspects are not the result of tectonic or ancient gravity-induced processes but, in our opinion, represent recent, local and superficial hydroplastic deformation, generating slumps and flows of collapse type (Goguel, 1952). The pelites were contorted and churned, while the sandstones were bent and fissured. The fissures either remained open or were filled with recrystallized calcite. It is possible that the Pleistocene uplift of the Rodna crystalline horst is responsible for the slopes along which slumping and bed distortion took place.

Thus, the "wildflysch" aspects displayed by the Valea Carelor Formation are the result of two completely different processes, Middle Miocene thrusting and dislocation (in some places), and Pleistocene gravitational deformation and sliding (in other).

The possibility of an orogenic terminal Cretaceous phase (Săndulescu, in Debelmas *et al.*, 1980; Săndulescu *et al.*, 1981), producing relief and slopes along which sheets and fragments of rocks could slide into the Rupelian lagoon (Patrulius & Popescu, 1960) is not supported by our own data and field observations. Facies distribution and the uninterrupted sedimentation of the basinal formations between the Cenomanian and the Burdigalian, for some 80 million years, prove that the Maramures basin functioned as a paleogeographic unit for all this time-span, without any major interruption in the depositional process. Since the broken deposits are known only along the basin's border, it is illogical to assume their gravitational transport from the deeper depo-center toward the shallower periphery.

In the absence of the protective cap of the Borsa Sandstone, the older deposits now exposed could bend, glide and flow along the slopes of the new topographic surface during recent times.

10. OUTLINE OF THE MIDDLE MIOCENE-PLIOCENE SEDIMENTS AND THE ASSOCIATED VOLCANICS

The Neogene transgression started in Maramures some 13-14 million years ago, following the Styrian phase of the Alpine orogeny.

Our direct and detailed data (Bombiță, 1972) concern particularly the confines of the villages of Botiza, Ungureni, Strâmbu, Băiut and Poiana Botizii. In this perimeter the first terms of the Middle Miocene, belonging to the Badenian stage, are well developed. The formations intersect and partly cover the two thrust lines, one marking the superimposition of the Botiza Nappe over the thrust-fold of Lăpus, and the second representing the thrust of the latter (parautochthonous) on the marginal autochthonous deposits of the Transylvanian facies.

Good outcrops of Badenian rocks can be examined north of the Ungureni village in the Luncuta hill, as well as in the upper basin of the Strâmbu valley. Lithologically, the subhorizontal beds are represented mainly by shales and rather coarse calcareous, biodetrital and tuffaceous sandstones.

Within our samples, G. Popescu has identified a microfaunal association typical of the Late Badenian: *Globigerinita glutinata* (Egg.), *Globigerina concinna* Reuss, *Glg. bulloides* D'Orb., *Globigerinella obesa* (Bolli); then *Elphidium fichtelianum* (D'Orb.), *Pulenia bulloides* D'Orb., *Melonis pompilioides* (Ficht, & Moll.), *Florilus boneanus* (D'Orb.), *Cassidulina globosa* Brady, *Cibicides lobatulus* (Ficht. & Moll.), *Cibicidoides laevis* (Rzeh.), *Uvigerina brunnensis* Karr., *Eponides repandus* (Ficht. & Moll.), and *Sphaerogypsina hemisphaerica* (Pop.). The microfauna represents the top of the Kossovian substage (P 10-12, NP 6-7), the so-called Konkian, according to the established Eastern Paratethys nomenclature (Popescu, 1979) equivalent to the Early-Middle Serravalian in the standard Mediterranean nomenclature. It is whort mentioning that during the Konkian time the marine, stenohaline Badenian fauna reaches its maximum development in the Carpathian and Pannonian areas (Popescu & Gheta, 1984).

East of the village of Izvoarele, sandy limestones with bioclastic layers (Algae, Miliolids, fragments of Corals and Mollusks) of Badenian age as well as some gypsum blocks were also found.

Along the Paltinu creek (4-5 km north of the village of Strâmbu) the Badenian rocks are mainly basal microconglomerates, microbreccias and calcareous-tuffaceous soft sandstones of different colors (light grey, greenish, yellowish), sandy limestones with *Pecten, Chlamys, Venus, Ostrea, Pycnodonte* measuring some 30 meters in thickness, followed by *Ervilia* marls (2.5 meters) and calcareous sandstones with volcanoclastic material and containing Mollusks, Bryozoans, Algae and Foraminifers (Edelstein *et al.*, 1971; Bombiță, 1972; Kovacs *et al.*, 1984).

The Sarmatian is brackish from the base. The sequence begins with 250-300 meters of dark-grey marls with *Ammonia, Asterigerina, Elphidium* and the biomarker *Anomalinoides dividens* Luczk.; further upsequence *Ervilia, Cardium, Syndesmia, Cryptomactra, Mohrestemia* and *Donax* are found. The Sarmatian is capped by hydrothermally metamorphosed sandstones.

North of Băiut village, Pannonian sediments (Dragu & Edelstein, 1968) were identified such as fine muscovitic marls and yellowish sandstones containing several species of *Congeria.*

The most common Pannonian deposits are conglomerates, quartzitic sandstones, coarse sands and marls with *Congeria, Melanopsis* and *Limnocardium.*

The Pontian stage was also located with quartzitic sandstones, shaly siltites, tuffs, marls and sands.

The above-mentioned deposits represent the marginal-coastal, ingressive and diachronous facies. In the central, basinal zone, west of the Viseu river, the synchronous colmatant deposits are much thicker and include reworked material: 700-800 meters of the complete Badenian suite and 1000 meters of Sarmatian sediments (Motas, 1956; Năstăseanu, 1956). According to the geophysical data the thickness of the Neogene deposits is approximately 3500 meters.

In the central-eastern sector of the Maramures Miocene area three (out of the four) Badenian formations, well known in the Transylvanian Basin and

the Subcarpathians, have been recognized: the *Globigerina* tuffs and marls, the Salt Formation and the "Spirialis marls" (Năstăseanu, 1956; Antonescu *et al.*, 1981). Within the Globigerina marls and tuffs, the zones with *Praeorbulina glomerosa* and with *Orbulina suturalis* were identified. The zone with *Velapertina iorgulescui* has been separated within the "Spirialis marls" (G. Popescu, pers.inf.).

The important well-known large and relatively tabular area of the Baia Mare volcanics is superimposed over some deeper magmatic bodies (polyphasic plutons) that are responsible for both volcanism and metallogenesis. Gephysical research has also outlined a complex fracture system that had probably the fundamental role for the evolution and the control of the general magmatic activity (Borcos *et al.*, 1993, unpubl. report).

The volcanic activity can be subdivided into three cycles (Borcos *et al.*, 1980b): the first Late Badenian-Sarmatian, the second Sarmatian-Pontian (Serravalian-Messinian in the Tethyan terminology) and the third Upper Pontian-Pleistocene.

Very important metalogenetic processes are associated with the second cycle, resulting in ore deposits that were and still are mined.

East of the Lăpus Mountains three subvolcanic bodies have been exhumed by erosional processes: the Hudin subvolcano, the Hudiesu body and the Tibles mountain.

11. FINAL REMARKS (G. Bombiță)

The geological evolution of the Maramures: an overview (Fig. 6)

The Romanian Maramures, as a small Carpathian sector of the Tethyan Ocean northern active margin, is characterized by sedimentary sequences quite similar to those of other peri-Mediterranean Alpine ranges – Alps, Apennines, even the Betic Cordilleras. Thus, no major diffrences in the general geological evolution of these Tethyan sectors appear to exist (Ricou *et al.*, 1986).

In Poiana Botizii village all sedimentary sequences succeed to some volcanogenic formations distributed in two magmatic cycles.

The first cycle includes ophiolitic rocks of spilitic type found in blocks of small to medium size within the Oxfordian Petricea Formation.

I suppose that originally the basaltic lava was injected during a distensive phase along a spreading center. We have no data to affirm whether the initial volcanics were Triassic or Early-Middle Jurassic. But this stage marks anyhow the emplacement of the initial oceanic lithosphere. Subsequently, slabs of ophiolitic rocks reached possibly a subduction zone where they became part of a mélange. Later still, the mélange complex was brought to or near the surface and subjected to erosion, so that the spilitic fragments were incorporated into Oxfordian sediments.

The second cycle of igneous activity – logically subsequent effect of the subductions – is represented by rocks found in situ at the base (Callovian?) of the whole Mesozoic stratigraphic sequence. Here, porphyritic tuffs, basaltoid andesites and oligophyric rocks, as well as some medium-sized blocks with porous pumice are found. This volcanoclastic suite of Middle-Early Late Jurassic age represents an island arc assemblage generated during a supposed compressional phase which was also responsible for the obduction and scraping of the first cycle ophiolites.

The presence of the above-mentioned igneous rocks offers some information about the early evolution of the former domain before its closing and suturing. The Maramures area, as a futher flysch and molasse basin, would be subsequently superimposed upon this older suture line.

As concerns the evolution of the sedimentary process in Maramures, one can distinguish successively five bodies of Tethyan-Paratethyan deposits: a primary thalassogen-biogene and condensed Malm-Neocomian corp; a second intermediate biogene-progressively detritogene (preflysch) from Neocomian to Paleocene; a third turbiditic *stricto sensu* Paleocene-Eocene-Early Oligocene (flysch); a fourth intermediate flysch-molasse Late Oligocene-Early Miocene in age (postflysch); and a fifth molasse infill of Badenian-Pannonian age.

The oldest sediments identified are radiolarites and jaspers deposited near the Dogger/Malm boundary. They cover the island arc volcanics which, in turn, rest therefore either on a sialic metamorphic basement, or on ocean floor rocks.

The radiolarites and jaspers are followed by the Petricea Formation, a sequence of turbidite-rich clastic limestones, deposited on a shallow carbonate platform. It is in these calcarenites of Oxfordian age that ophiolitic pre-Callovian rock fragments are found.

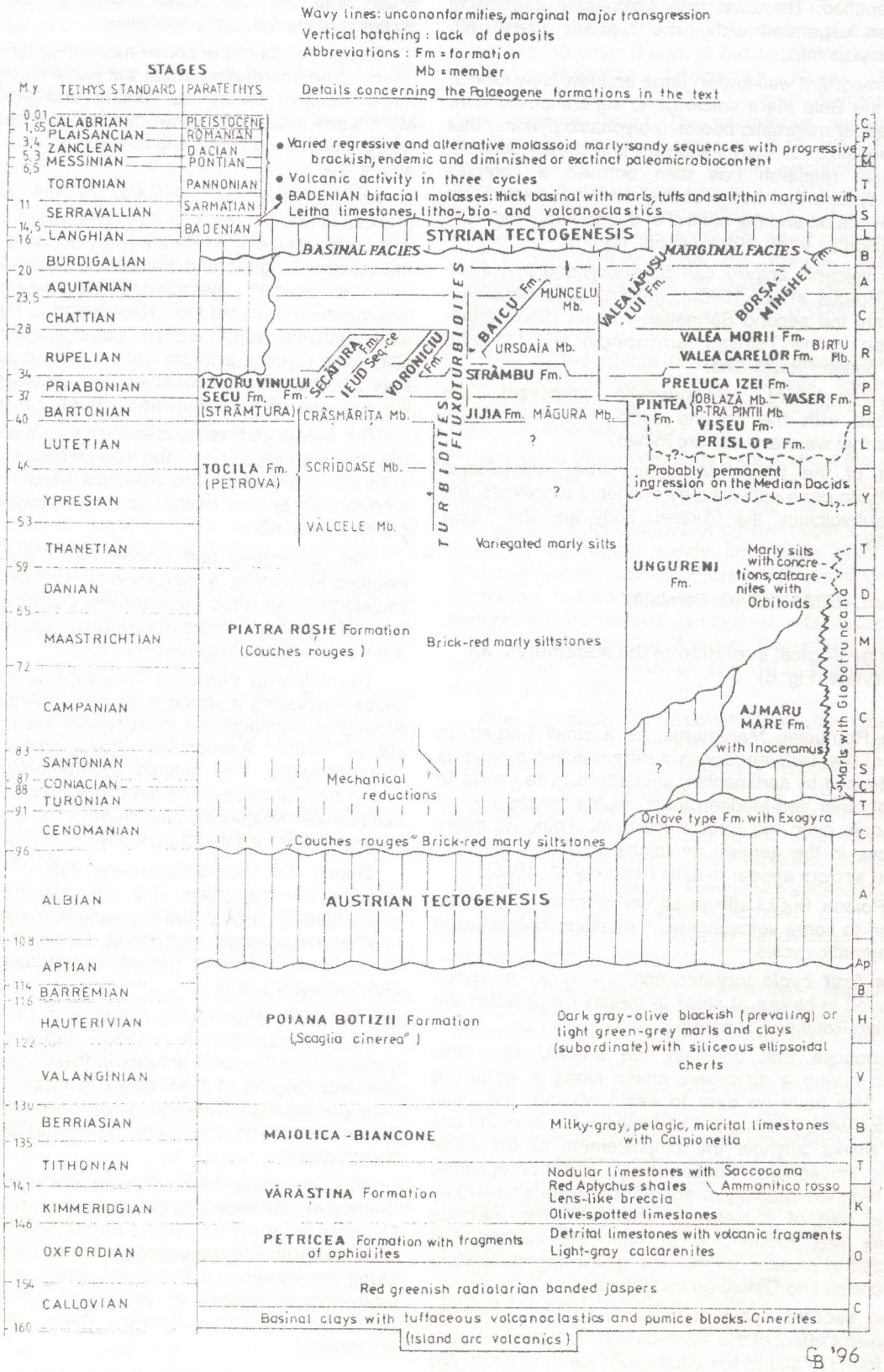
The following Vărăstina Formation is of a different facies, displaying a strong composite pelagic character. Among its members the most typical are red *Aptychus* shales and Ammonitico rosso-type limestones (Kimmeridgian). The pelagic sedimentation continued during the Tithonian-Berriasian with micritic *Calpionella* Limestones (Majolica) identified in a small outcrop belonging to an eroded thrust-fold.

During the Valanginian-Lower Aptian most of the deposits are marly and silty with ellipsoidal siliceous concretions (Poiana Botizii Formation), marking probably another paleogeographic change, namely the breakup of the carbonatic platform, generating gradually deepening depressionary zones.

During the Middle-Late Aptian and Albian, the Mid-Cretaceous compressive phase produced the first generation of Alpine structures in the Carpathian realm. The tectonic unit of the Eastern Carpathian crystalline core (the Median Dacides), which also represents the Maramures Basin basement, is the result of Austrian deformations.

In Cenomanian-Paleocene times, the still dominantly marly and silty series, such as the foraminiferal pelagic Couches rouges (Piatra Rosie Formation) are recurrently asociated with fine terrigenous influxes. Simultanerously, along the Maramures Basin rim, several transgressive-ingressive sequences of shore and neritic type were deposited (Orlové, Ajmaru Mare and Ungureni formations).

STRATIGRAPHIC UNITS IN THE ROMANIAN MARAMUREȘ
ATTEMPT OF SPATIAL AND TEMPORAL CORRELATION



As everywhere in the Alpine area, in the second half of the Late Cretaceous the general recrudescences of the erosion processes become manifest in emergent zones, sills, ridges and cordilleras, and thus, by "high-density turbiditic currents", supplied clastic material to the adjacent troughs.

Within the Maramures Depression, the Cretaceous sedimentation continued into the Palaeogene with slightly pararhythmic deposits of pre-flysch type (Vâlcele Member), followed by typical rhythmical flysch series (Tocila-Petrova Flysch), succeded in turn by fluxo-turbidite sequences (the Secu-Strâmtura Sandstones) and by some local turbidite-like formations (Secătura, Ieud, Voroniciu, Jijia). The Izvoru Vinului Beds, capping the Secu Sandstones, represent a flysch-like recurrence.

The planktonic forminiferal population of Upper Priabonian age, identified in the latest horizon of the Strâmbu Formation from the eastern sector of the Lăpus Nappe (Mutihac, 1956; Dicea *et al.*, 1980), points toward a short but general extension of open-sea conditions. Thus, the Late Eocene marks the maximal extension of the marine neo-Tethyan realm in the Carpathian area during Palaeogene times.

The numerous stratigraphic gaps claimed initially for the marginal-littoral facies belonging to the Lăpus Nappe and to the sedimentary cover of the Median Dacides (the Borsa and Ruscova paleo-embayments) have substantially been reduced both in number and hiatus time as result of detailed biostratigraphic studies. The Ungureni Beds were deposited, with some possible interruptions, during the Campanian-Early Eocene time-span. The Middle Eocene is represented mostly by the Prislop, Viseu and Pintea formations, while the Preluca Izei biogenic limestones are of Late Eocene age.

In littoral environments, the Eocene sedimentation starts with coarse clastic rocks which progressively change upwards into finer detrital series, and then into a suite of carbonaceous platform with phytal, reef and bioclastic rocks.

The postflysch facies (Contescu, 1968) is the dominant lithology of the Oligocene epoch. It is a massive sandstone facies with important euxinic-bituminous shaly episodes. As a general trait, the Oligocene formations are regressive and quasi-isopic, whether basinally deposited or representing a marginal facies, which probably reflects the advanced stage of basin filling (the Baicu, Valea Carelor, Valea Morii and Borsa formations).

The whole sedimentary detrital assemblage defined in Maramures as the succession preflysch-flysch-postflysch, between the Austrian and Styrian inversions, totalizes 3000-3500 meters in thickness and was built in approximately 80 million years.

The area occupied by the Oligocene and Oligocene-Miocene deposits within the Maramures is larger than the one covered by Eocene series, in particular in the region situated between the Preluca crystalline (west) and the Rodna mountains (east), as well as in the Borsa and Ruscova paleo-gulfs.

Fig. 6 Stratigraphic units in the Romanian Maramures. Attempt of spatial and temporal correlation

The west- to east- paleocurrent directions prevail in most Palaeogene litho-stratigraphic units, pointing toward the presence of a western supply area within the Transylvanian territory (the so-called "Pannonian-Transylvanian median massif") (Contescu *et al.*, 1968; Jipa *et al.*, 1973). This would suggest that during the Palaeogene period the Central-Carpathian crystalline ridge, representing the backbone of the East Carpathian belt, was submerged at least in this area and thus did not supply (?) detrital material to the Maramures basin.

The entire sedimentary sequence was subject to a second, Middle Miocene, subsequent of the Styrian geotectonic phase, which resulted mainly in décollement processes, made easier by the presence of several incompetent formations – the Piatra Rosie and Tocila – with lubricating levels. These deformations mark the end of the major orogenic activity in the region.

The Middle-Late Miocene and the Pliocene witness the filling of the depression by an important and variable molasse; simultaneously an intense volcanic and subvolcanic activity of island arc type, preceding the final uplift above sea level of the entire Maramures region.

The major dislocations in the area, the Iza and Dragos Vodă transcrustal faults, were repeatedly activated until the end of the Neogene. As a result, the Botiza-Petrova Nappe was fragmented into two principal compartments, subjected to a strike-slip displacement of about 12 kilometers.

Comparisons, similarities and connections

The main problem concerning the general structure of the Romanian Maramures is its attribution to a certain paleogeographic entity and a tectonic unit of the Carpathian orogen.

Andrusov (1933) was the first to express the opinion that the Pieniny Klippen Belt and its south-east prolongation represent an internal Carpathian unit, while the Maramures sector of the Central Carpathian Cordillera, including its Cretaceous-Palaeogene cover and its north-western extension into the Ukrainian Carpathians, occupied a more external position. Such an assumption contributed to a change in the conceptual thincking concerning the paleogeographic position of the Maramures area. Instead of considering this unit as a gulf of the Transylvanian Basin (Uhling's old idea), the Maramures unit became part and parcel of the East Carpathian orogen.

In 1943, Anton rediscovered rocks of Pieniny facies in the northernmost part of Transylvania, and considered them as the direct extension into the Romanian territory of the Pieniny Klippen Belt of Slovakia and Poland. The idea was accepted not only in Romania, but also by the Slovak and Polish geologists, athough later Andrusov expressed some reservations; at first in 1938 (p. 77:..."la zone des klippes du Marmaros présente beaucoup de caractères communs avec la zone des klippes piénines. Toutefois elle ne constitue pas le prolongement de cette dernière"), then approximately in 1965 during the visit to the outcrops from Poiana Botizii (*fide* Patrulius).

Among the Romanian geologists, Patrulius (1956) was the first to mention the similarity and the equivalence between the Maramures flysch series and

those of the Slovak-Polish-Ukrainian Magura unit ("Magura Sandstein", C.M.Paul, 1868).

Nowadays, it is clear that in Maramures the tectonic relationship between the Pieniny-type facies and the Magura unit is exactly reverse to the one observed in the Western Carpathians. Here, the Pieniny Klippen Belt overthrusts the Magura zone, while in Maramures the Pieniny-type formations are situated underneath the Botiza-Petrova (Magura) Nappe.

In previous papers a Pieniny type basement was inferred for the region (Bombiță, 1972, p. 87), although it was considered doubtful that it would represent the direct extension of the Pieniny Klippen Belt itself from Slovakia, Poland and Ukraine. The author underline then two ideas: (1) The depositional area of Pieniny-type facies should not be restrained to the tectonic belt where it is well-known today; and (2) the same facies, covering a much broader paleogeographical area between the Tatra and the Rodna mountains can be involved in more than one tectonic unit of different ages and types.

According to Mutihac (1987, 1988) the klippen from Poiana Botizii are not the prolongation of the Pieniny Klippen Belt from the Western Carpathians. They would mark the Transylvanian Suture, subsequently hidden by the North Transylvanian Fault. The name "Transylvanian Klippen" would be due to some lithofacial resemblances with the sedimentary sequences of the Transylvanian Nappes from the Central Carpathians.

Săndulescu (1972, 1979; in Săndulescu & Bratu, 1984) advocates the *direct* extension of the Pieniny Klippen Belt (Pieniny-Kysuca) all the way to Poiana Botizii where it appears as the frontal thrust-sheets of the Botiza Nappe. To explain the reverse structural relationship mentioned before (i.e. in the Western Carpathians the Pieniny Belt overthrusts the Magura Nappe, whereas in Maramures the Pieniny-type Klippen are found at the base of the same nappe), Săndulescu modifies the current view and imagines a large-scale allochthonous relationship - an ultra-charriage - suggesting some ample, spectacular, mechanical processes comparable to those from the French-Italian Alps.

According to this concept, the Botiza Nappe, with a more internal initial position and which is not equivalent of the Magura Unit, moved over the Petrova Nappe (the only equivalent in Maramures of the Magura unit in Săndulescu's opinion) and came to rest over the Lăpus ("Wildflysch") Nappe.

S. Kruglov from Lvov simply negates the possibility of any extension of the Magura Nappe into Maramures, and considers as fortuitous the resemblance of some of the facies belonging to the units Magura and Botiza-Petrova (personal communications, 1992-1993). On the other hand, the same author claims that two outcrops of Pieniny facies in the Ukrainian Carpathians are practically "identical" to two facial zones belonging to the Slovak-Polish Pieniny Klippen Belt: in the Priborjavsky stone quarry, near the village bearing the same name, the lithologic succession is similar to the Pieniny sequence proper, whereas in the Bolshoy Kamenetz quarry (village of Novoselitza), the closest point to the Ukrainian-Romanian border, the Czorsztyn facies is cropping out (Kruglov, 1974, 1986).

Comparing the Poiana Botizii and Novoselitza sequences (Fig. 7) several observations come to light:

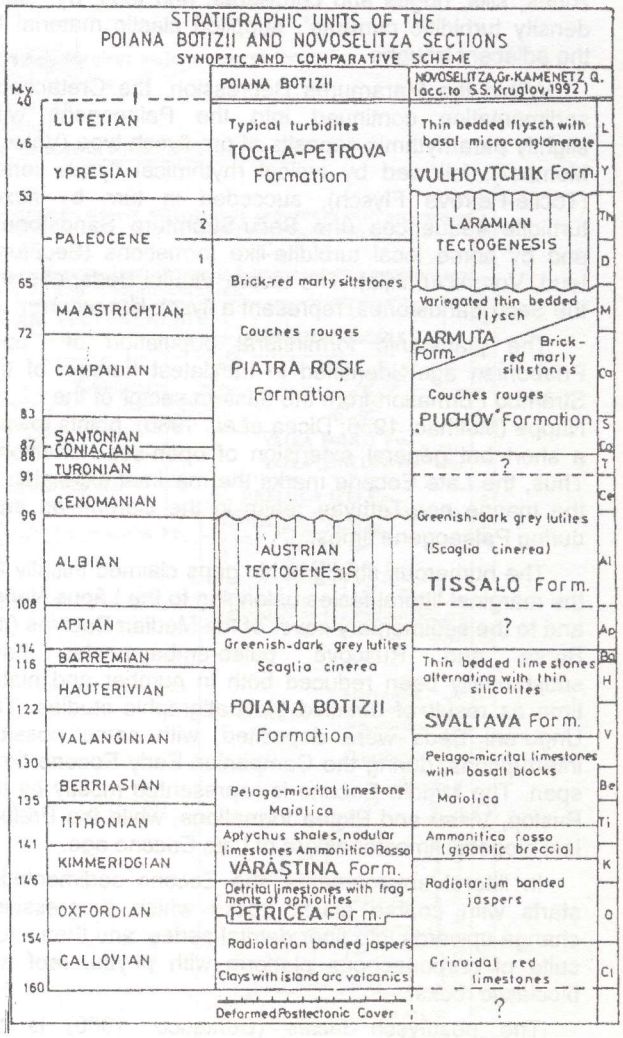


Fig.7 Stratigraphic units of Poaina Botizii and Novoselitza sections. Synoptic and comparative scheme

(1) the Callovian-Oxfordian volcanic rocks (of ocean floor and island arc-type) present at Poiana Botizii are missing at Novoselitza; (2) the Early Cretaceous formations (succeeding the *Aptychus* shales and the Ammonitico rosso limestone) present at Kamenetz are considered younger than the corresponding facies at Poiana Botizii; (3) the Svaliava Formation appears to mark the lithological transition between the Majolica and Tissalo Formation; (4) the gap between the Jarmuta Formation (Campanian-Maastrichtian-Early Paleocene) and the Vulhovchik Formation (Eocene) appears to be minor, the result not of a Laramic deformation but possibly of submarine erosion by local currents. The hiatus, marked by a bed of microconglomerates, is intra-Paleocene because the rock samples collected from the layer immediately beneath the disconformity provided the marker nannofossil *Chiasmolithus danicus* (NP 3).

According to Birkenmayer (1985a, b; 1986) the Mesozoic outcrops at Poiana Botizii are similar to those belonging to the Grajcarek subunit, the most internal subunit of the Magura Nappe in the Polish Carpathians.

Our interpretation comes close to the Birkenmayer's hypothesis, although the stratigraphic columns (Grajcarek and Poiana Botizii) are not similar (Bombiță *et al.*, 1992). In my opinion, the Poiana Botizii klippen belong not to an internal, but to an external subunit of the Magura Nappe. Such outcrops seem to be known so far only at the two extremities of the Pieniny arc: near Vienna – St. Veit Klippen Zone – Ybbsitz Kieselkalk Zone (Prey, 1975; Mišik, 1992) and in Romanian Maramures (Poiana Botizii village).

In this same sector of the Romanian territory, the crystalline basement, buried under younger formations in the Northern-Western Carpathians, rises to the surface and forms the backbone of the East Carpathian range ("the Crystalline-Mesozoic Zone"). The sedimentary cover of the East Carpathian metamorphic core belongs to two domaines with different rock formations and different paleogeographic and paleotectonic evolution, i.e. the Bucovinian normal cover of the crystalline basement and the allochthonous Transylvanian sequences (Transylvanian Nappes). Neither of the two sedimentary sequences displays similarities with the suite of rocks belonging to the Poiana Botizii klippen.

Structural similarities between the Poiana Botizii klippen and the Pieniny Klippen of the North-Western Carpathians are hard to equalize. The former are outer klippen (klippes de rabotage) cropping out along the front of the Botiza Nappe and are represented by Tithonian-Neocomian rocks, plucked out from a probably former Austrian structure; subsequently, during Styrian tectogenesis, they were brought to the surface and pushed southward and eastward over the younger flysch or flysch-like deposits. Against it, the Pieniny klippen from Slovakia and Poland are large bodies of hard rock of Triassic, Jurassic and Early Cretaceous which, out of overthrusting process *stricto sensu*, are mechanically-vertically uplifted over the surrounding Cretaceous-Palaeogene plastic mantle, less resistent against denudation.

Precisely because of its peculiar complicated structure, the Pieniny Klippen Belt was considered by Andrusov to be "l'enfant terrible de la tectonique des Carpathes" (1938), "ein geologisches Wurder der Natur" (1968) or "a tectonic unit...unique among the fold mountains of the world" (1974).

The recently drawn cross-section along the traverse Krakow-Zakopane (Birkenmayer, 1985a) shows the Pieniny Klippen Belt as a set of formations in a vertical-subvertical position, squeezed between two major structural units, i.e. the Inner Carpathian to the south (including the Central Carpathians Block as its main element) and the Outer Carpathians to the north (with the Magura Nappe as the closest unit to the Klippen Belt).

On the Romanian territory, close to the Romanian-Ukrainian border, the Late Cretaceous and Palaeogene formations, representing the post-Middle Cretaceous sedimentary cover of the Central Carpathian Ridge, are overriden by the Flysch series belonging to the Leordina-Petrova thrust-sheets. In particular, this flysch has been thrust toward the north-east over the Oligo-Miocene Borsa Formation which fills the Ruscova paleo-gulf.

As in the past (Bombiță, 1972), I consider that these thrust lines extend into the Ukrainian Carpathians, marking the same tectonic relationships between the Flysch units (with or without the Pieniny-type klippen present at their base) on the one hand, and the Neocretaceous-Palaeogene sedimentary cover of the plunged Central Cordillera on the other hand.

To sum-up, my hypothesis rest as follows:

(1) At Poiana Botizii the Mesozoic rocks of Pieniny facies do not belong to the Pieniny Klippen Belt proper, but represent a segment of the lower part of the Magura Unit. These rocks are part of a new subfacial and sub-tectonic unit, *the Poiana Botizii Unit,* with specific stratigraphic and tectonic characteristics and occupying an external position to the genuine Pieniny Klippen Belt.

(2) The south-eastern extension of the Pieniny Klippen Belt and the prolongation of its contact with the Magura Nappe should be situated somewhere to the west of the Poiana Botizii meridian, possibly offset by a deep crustal fault oriented ENE-WSW. As result, the continuation of the Pieniny Klippen Belt from Slovakia and Poland is now buried beneath the transgressive Neogene deposits and the volcanics of the same age from the Baia Mare region.

Another problem that requires unequivocal answer is: beyond the Romanian-Ukrainian border, and further in Poland and Slovak Carpathians, where and how did the external major units – the Median and Outer Dacides with their Cretaceous-Palaeogene cover – vanish successively?

Using logic as argument, Mutihac (1993, in press) considers that in the Tisa area the units delimited on the Romanian territory by the Pieniny Belt to the south-west and by the Outer Flysch to the north-east (the Inner Flysch Zone, the Central East Carpathian Ridge, the Substratum of the Botiza-Petrova-Magura Nappe and the Transylvanian Suture) are either consumed by subduction or tectonicaly imbricated and laminated. Anyhow, all these would form the basement of the Botiza-Petrova-Magura Nappe.

Săndulescu & Bădescu (1994) have recently announced the discovery of two tectonic windows, Bârsana and Poiana Porcului, in the Bârsana-Valea Stejarului-Costiui-Rona de Sus area, northern Maramures.

These two windows would be, firstly, a proof of the important allochthony that, in the author's opinion, is characteristic, on the whole, of the structural Transcarpathian turbiditic units. Secondly, it was thus changed the rank of the frontal Leordina scale in an independent nappe, the epiglyptic Leordina Nappe, with peculiar lithostratigraphic sequence. The position of the new unit would be above the Median Dacides Cover and below the Petrova Nappe.

The peremptory arguments would be: (1) an outcrop of the Borsa Formation in anticlinal structure under the Leordina and Petrova Nappes in the Bârsana Window; and (2) the outcrop of the Rozavlea Formation (flysch) under the Petrova Nappe in the Valea Porcului (Valea Stejarului) Window.

These windows would also be the south-eastermost ones from all the alignment of tectonic windows of the Magura Group in Slovakia and Poland. The conclusion: "This fact emphasised once more that from Maramures in south-east up to Eastern Slovakia and Poland in north-west, the Magura Nappe overthrusts obliquely several major units covering tectonically the whole inner structures of the East Carpathians" (Săndulescu & Bădescu, 1994).

After the examination of the two windows, I am not convinced that what was designated as "sandy micaferous flysch" to the Bârsana village, on the Căsile Valley, is really Borsa Sandstone, neither there is obvious evidence on its anticlinal structure. My supposition is that the "massive, molasse-like sandstone of Upper Oligocene-Lower Miocene age" is, in fact, along the brook, an Eocene monoclinal sequence of an abrupt, episodic and coarse debris flow within the Petrova turbidites, like a dense poor-sorted material, carried by gravitated currents and deposited during some local and incidental but active circulation, possibly in a sort of marginal fan or channel; but on the left slope of the brook, possibly siliciclastic nonfossiliferous Badenian deposits unconformably lye on the Eocene flysch thrust-sheets.

In accordance with the nannofossil content of the enclosing formation (Tocila-Petrova Flysch sampled upstream and downstream of the unfossiliferous "Borsa" outcrops), the coarse detrital lens would be placed between Middle and Late Eocene in base of: *Cyclococcolithus (Toweius) gammation* (Braml. & Sull.) Rom., *C. (Ericsonia) formosa* (Kampt.) Wise, *Coccolithus pelagicus* (Wall.) Schill., *Chiasmolithus grandis* (Braml. & Ried.) Rad., *Sphenolithus radians* Defl., *Discoaster lodoensis* Braml. & Ried., *D. nonaradiatus* Klumpp., *Chiphragmalithus (Nannotetrina) cristatus* (Mart.) Braml. & Sull., and *Helicosphaera seminula* Braml. & Sull.; respectively *Coccolithus pelagicus* (Wall.) Schill., *Cribrocentrum reticulatum* (Gartn. & Smith), *Dictyococcites (Reticulofenestra) dictyodus* (Defl.) Stradn., *Reticulofenestra umbilica* (Lev.) Mart. & Ritzk., *Discoaster barbadiensis* Tan and *Chiasmolithus oamaruensis* (Defl.) Mohl. & Wade.

On the other hand, upstream the church of Valea Stejarului village, on both tributaries of the Porcului brook, Săliste and Poieni, I found no provable outcrop for the emitted idea (Valea Porcului Window). At present, the Săliste valley is completely filled by slided rocks.

The structure imagined for the Magura Nappe is interesting, logical and plausible but, for the time being, from my view-point, the premises used on the Romanian territory remain still disputable.

(1) As far as some terms of the Palaeogene turbiditic sequence, their continuation to the west seems to be sure under the Baia Mare volcanics in some erosional windows with nummulitic rocks, and further in the basement of the Tisa fields (the Szolnok Depression on the Hungarian territory) below the Neogene cover.

(2) The marginal formational suite Prislop – Viseu-Vaser – Preluca Izei – Valea Carelor presents some suggestive facial relation with the Tatra Palaeogene, and farther even with the so-called "Nummulitique Alpin" (the Maritime Alps).

(3) Because of lack of some direct, detailed and comparative observations, I cannot put forward opinions concerning equivalences and correlations between the Palaeogene turbiditic formations from the Romanian and Ukrainian sectors of Maramures (in Săndulescu & Bădescu, 1994: Petrova Fm. syn. Sopur Fm.; Rozavlea Fm. syn. Metov Fm.; Strâmtura Fm. syn. Dragovo Fm.; Voroniciu Fm. syn. Watkowa Fm.).

In the last 50 years the geological study of Maramures has made real and valuable progress. However, for the moment all these are associated with some important controversies. The solutions remain a task for the coming generation.

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