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THE IMPORTANCE OF CALCAREOUS NANNOPLANKTON IN ESTABLISHING LITHOSTRATIGRAPHIC LANDMARKS IN THE EOCENE COLUMN OF TARCAU NAPPE IN THE SUCEAVA RIVER BASIN (OBCINA MARE)

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Abstract. The geologic research accomplished before 2007 in the Suceava river basin, as well as the cartographic revisions performed in 2007 by a research team including the following researchers: Grasu C.[4], Miclăuş Crina[5], Florea F. F., Juravle D.-T., Juravle Angelica[6] and Juravle V.[7], showed that in this region, over the area of the Eocene Tarcău Nappe, a particular facies can be found, characterized by the - sometimes total - substitution of the Straja, Sucevița and Tazlău flysch, with volumes of Kliwa-type rocks of Scorbura type. The advanced "lithostratigraphic alteration" of the classical formations created serious difficulties in the geologic mapping in the field, in carrying out the lithostratigraphic correlations with the southern zones in of the Moldova and Bistrița river basin and the realization of a tectonic model that is coherent with the whole structural image of the external flysch. Under such conditions, the establishing of the lithostratigraphic landmarks and their chronostratigraphic position was realized on the basis of the nannoplankton associations identified in the separated formations in the Suceava river basin.

Key words: Tarcău Nappe, Eocene deposits, lithostratigraphy, nannoplankton associations

INTRODUCTION

The development of Kliwa-type rock layers in the Eocene of the Paleogene flysch in the Suceava river basin, that complicates the lithostratigraphic horizons and the correlation of the lithostratigraphic formations with those in the Moldova river basin, was initially noticed by Joja in 1954. Then, referring to the internal facies in the area between the Suceava and Moldova rivers, other researchers noticed the more or less continuous development in the Sucevița Formations and in the equivalent ones, of several Kliwa-type rock layers, displayed in metrical bars (Băncilă, 1952, 1958; Turtureanu and Albu, 1957, Florea, 1999; Ionesi, 1967, 1971; Micu, 1981; Florea, 1999; Bogatu, 1999).

Juravle (2004, 2007) described the particular facies, predominantly arenitic, in which the deposits of the Eocene flysch in the Suceava basin are presented, and separated the heteropic facies and the lithostratigraphic formations characteristic to the area. In our area of interest, a massive contribution of arenitic material in the Eocene basin of the Tarcău is characteristic, with „lithostratographic alteration" of the classic formations, consisting of by the almost complete sustitution of the Straja, Sucevița and Tazlău flysch by the Kliwa-type massive sandstones of Scorbura type. The revisions in the field were carried out in the summer of 2007 by the authors, which pointed out that the invasion of Scorbura sandstone in the Eocene layer, is maintained towards south, at least to the Sucevița – Rusca – Hojdeni Alignment. Therefore, a regional development of the above mentioned lithostratigraphic reality did not occur only in the Suceava river basin.

Concerning this field reality, the maximum difficulty consisted in the establishing of certain lithostratigraphic landmarks, operational in the mapping of the formations. This problem has been solved by using the biostratigraphic data supplied by the calcareous nannoplankton analysis. In the present paper, our goal is to identify a series of lithostratigraphic landmarks for the Eocene, and to use them as „operational instruments" in geological field mapping. Their isochronism is also confirmed by the nannoplankton associations.

GENERAL GEOLOGICAL DATA

Eastern Carpathians cover an area of about 33500 km^2 (Pop, 2000) on the Romanian territory, between the northern country border and the Prahova Valley. They are characterized by a nappe thrusting structure that was formed during the Cretaceous tectogenesis (generating the Dacidic Nappes, *sensu* Dumitrescu et al., 1962) and Cenozoic tectogenesis (generating the Moldavic Nappes, *sensu* Săndulescu, 1975, 1980, 1984; Debelmas et al., 1980). Considering the criteria of the age of the major structogenetic moments, these subdivisions correspond geomorphologically to the sector of the internal Carpathians sector, made up of Dacidic units, and external Carpathians, made up of Moldavic units (Gigliuto et al., 2004) (fig. 1).

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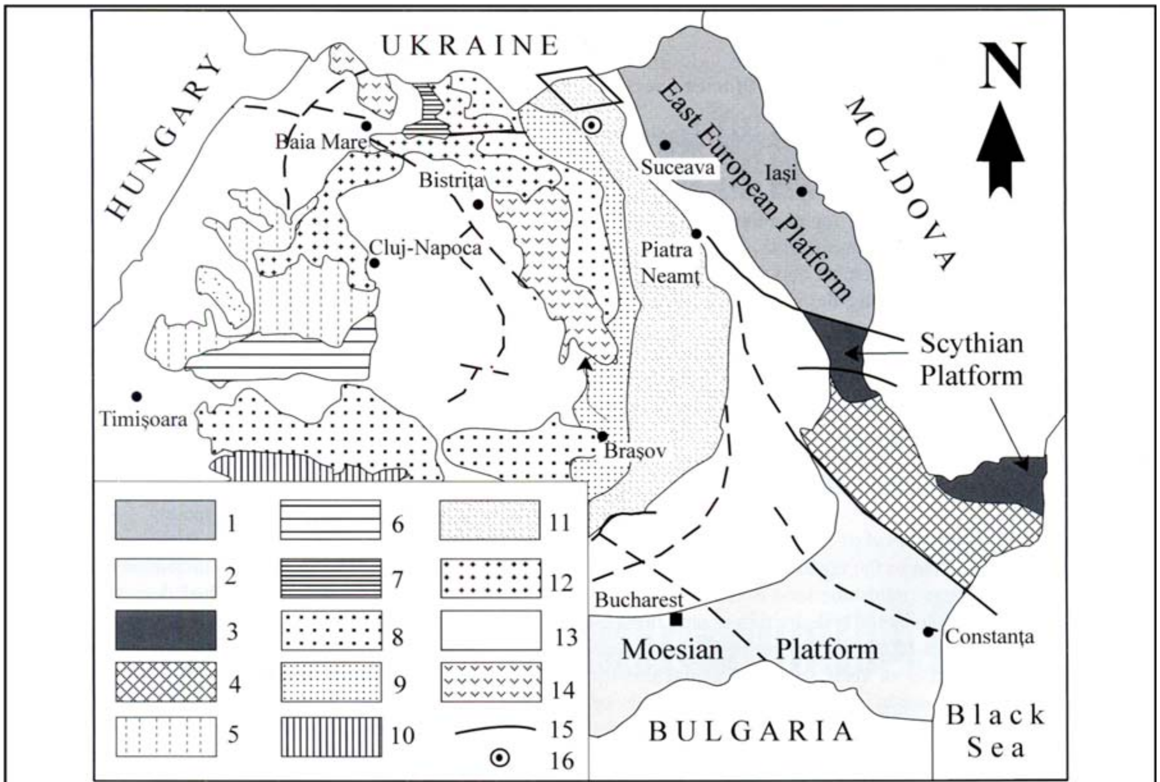

Geological sketch map of Romania (after Dumitrescu & Săndulescu 1968, simplified and modified). **1** — East European Platform; **2** — and **3** — Moesian and Scythian Platforms; **4** — North Dobrogea Orogen; **5** — Internal Dacides; **6** — Transylvanides; **7** — Pienide Units; **8** — Median Dacides; **9** — External Dacide Units; **10** — Marginal Dacides; **11** — Moldavide nappe complex; **12** — Post-orogenic covers; **13** — Neogene molasse depression and foredeep; **14** — Neogene magmatic arcs; **15** — faults, **16** — location of the study section.

Fig. 1 – The position of the Suceava – Suceviţa region on the Romanian territory (Gigliuto et al., 2004)

For the present paper, the Tarcău Nappe is representative. It belongs to the Moldavides and its structogenesis occurred during the Styrian tectogenesis (Miocene). From a lithostratigraphic point of view, the Tarcău Nappe is characterized by a column made up of Cretaceous, Paleogene and Miocene formations.

At the level of the Lower and Middle Cretaceous, the sedimentation conditions were uniform, in general, over the area of Tarcău Domain, giving birth to the deposits of Audia and Cîrnu-Şiclău formations. Starting with the Upper Cretaceous, the morphology of the sedimentation basin has changed generating conditions for the differentiation of the sedimentation and the accumulation of the heteropic facies (*sensu* Ionesi, 1971, Gigliuto et al., 2004). Under such conditions, in the proximal areas as related to the central-Carpathian source, deposits with a predominance of arenitic formations are accumulated, while in the distal areas, the characteristic feature is given by the close alternation of the arenitic and silto-lutitic deposits, with a strong calcareous character.

In the scientific literature, three heteropic facies have been described for the Eocene (Tarcău Lithofacies in the west, Doamna Lithofacies in the east, Tazlău Lithofacies in the middle). They are partially preserved in Oligocene-Lower Miocene level (Fusaru Lithofacies in the west, Kliwa-Petricica Lithofacies in the east, Moldoviţa Lithofacies in the middle) (Atanasiu, 1943; Ionesi, 1968; Mutihac and Ionesi, 1974; Gigliuto et al., 2004).

When examining the characteristic column for the three lithofacieses, lithostratigraphic variations from west to east can be noticed, as follows:

- in the ***Lower and Middle Eocene*** (Ypresian – Lutetian - Bartonian): *Tarcău Lithofacies* is characterized by the predominance of a sandy flysch, with a percentage of sandstones exceeding 80% in the lithologic column. These are arranged under the form of metric bars, 1-5 m thick (sometimes even over 10m thick), with intercalations of red and green clays in the middle part (Mutihac and Ionesi, 1974; Grasu et al., 1988); *Doamna Lithofacies*, characteristic for the eastern part of the Tarcău Unit, is made up of several lithologic units, with a remarkable longitudinal development between the Suceava valley and Slănicul de Buzău valley (Mutihac and Ionesi, 1974). The specificity is given by the presence of an arenito-calcareous-clay flysch in the lower part (Sucevița flysch, Joja, 1960), over which, the Doamna limestone Formation is found (*sensu* Athanasiu et al., 1927; Mutihac and Ionesi, 1974); *Tazlău Lithofacies* (initially described by Atanasiu, 1943, as Tazlău Nappe), marks the transition between the internal Tarcău facies and the external Doamna facies, made up of Tarcău-type flysch that alternates with Doamna-type flysch. In the same time, as a particular note, we can mention the fact that Doamna limestone Formation loses its identity as a distinct lithologic unit.

- in the ***Upper Eocene*** (Priabonian) the sedimentation is still differentiated, and as a result, the Podu Secu and Ardeluța formations are born in the area of *Tarcău Lithofacies*, the Bisericani Formation and Lucăceşti sandstone and marls with globigerinae in the area of *Doamna Lithofacies* and the Plopu and Lupoaia formations (*sensu* Ionesi, 1961, 1971) in the area of *Tazlău Lithofacies* were deposited.

THE GEOLOGY OF THE SUCEAVA RIVER BASIN

Geological research in the Suceava river basin has been done by Joja (1952, 1954, 1955, 1957), Joja et al. (1964, 1967, 1968, 1978), Micu (1981), Ionesi and Florea (1984, 1991), Ionesi and Grasu (1986), Ionesi et al. (1988, 1999), Florea (1990, 1999), Micu and Constantin (1993), Juravle (2002, 2003, 2004, 2005, 2006, 2007), Juravle and Androne (2005), as well as by the petrolist-geologists within the programmes for hydrocarbon accumulations identification.

As mentioned before, our research in this stage was focussed on the formations accumulated during the Eocene in the area of Tarcău Nappe, when, in the area of interest in the Suceava river basin, significant lithofacial differences have been recorded as compared to the southern area, with more similarities to the lithofacial context found between the Suceava Valley and Ceremuşului Valley.

As for the tectonic model of the Paleogene flysch in the Suceava river basin, this is still debated, at least two hypotheses being considered today:

- Joja (1954, 1955, 1957), Băncilă (1958), Băncilă and Hristescu (1963), Micu (1981), Săndulescu (1984) consider that the most external flysch structure in the Sucevița river basin belongs to an inferior unit, similar to that of Gura-Putnei semi-window, tectonically representing a rasp wedge of the upper unit, called „Voivodeasa rasp wedge";
- Ionesi and Florea (1984) and Ionesi and Grasu (1986) give a different interpretation to the structure of the external flysch in the Sucevița river basin, considering that the Vrancea Nappe appeared as a semi-window between Gura Putnei and Soloneț. In this unit, besides the „Voivodeasa rasp wedge", the authors also include the Dealu Rău-Cociniş and Sucevița faulted overturned fold. Under such circumstances, the forehead the Tarcău Nappe would correspond to the forehead of Treşoara-Maidan faulted overturned fold (Cernea, 1954; Polonic and Polonic, 1967) or Dragoşina faulted overturned fold (Micu, 1981). Dealul Rău – Cociniş faulted overturned fold is greatly overflowed over the Voivodeasa faulted overturned fold, completely covering it in the north (in the Voitinel river basin) and in the south (in the Haşca brook basin). In such a case, the Voivodeasa faulted overturned fold would represent a digitation of the lower unit. With the new structural image, the Vrancea Nappe appears between Tazlău and Suceava, as an almost continuous bar, with several reduced interruptions caused by the advancement of the Tarcău Nappe to the contact with the pericarpathic molasse. These advancements separate four semi-windows north to the Bistrița valley: Bistrița-Râşca, Humor, Sucevița-Putna and Gura Putnei.

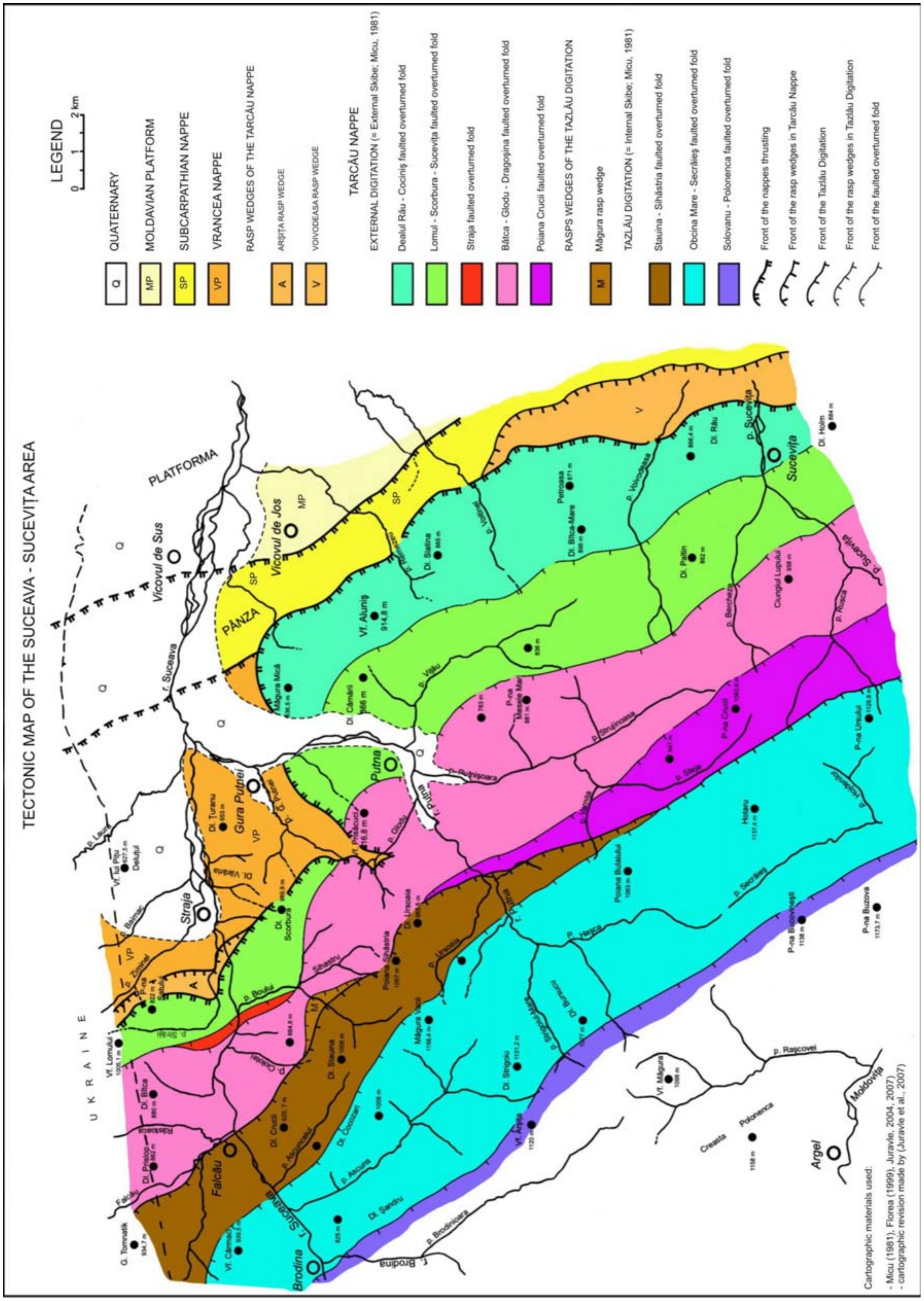

Fig. 2 – Tectonic model of Suceava – Sucevița region

Considering the fact that disapproving or approving one of the above mentioned hypothesis depends on a series of research with deep drilling works, in order to clarify the existence of the deposits in the Vrancea Domain to the west, under the Tarcău Nappe, we decided to correlate the units distinguished in the area of Suceava Valley – Putna Valley with those in the Sucevița river basin, based on the tectonic models proposed by Ionesi (1971), Micu (1981), Săndulescu (1984) and Juravle (2004, 2007). Therefore, the tectonic complex of the research area is made up of the Sub-Carpathian Nappe, in a lower position, the rasp wedge of the Tarcău Nappe (Arşița and Voivodeasa) and the Tarcău Nappe, in the upper position. The tectonic units are also complicated by digitations made up of faulted overturned fold.

In the Suceava river basin the Tarcău Nappe crops out west from the surface trace of the Tarcău thrusting plane, and it overlaps to the east either the Arşița and Voivodeasa rasp wedges, or the deposits of the Vrancea Nappe (Gura Putnei semi-window), or directly the Sub Carpathian Nappe (fig. 2). The eastern limit follows the localities Straja, Gura Putnei, Voitinel and Voivodeasa. To the west, our research extended up to a tectonic alignment marked by the lower course of Brodina brook (a Suceava river tributary), the main course of Brodinioara brook (tributary to Brodina river) and Secrăieş brook (tributary of Moldovița brook). This line has also a lithofacial connotation approximately superposing the limit between the Scorbura-Tazlău and the Tarcău lithofacieses. Tectonically, in the area, the external and the Tazlău digitations crop out (Săndulescu, 1984) (= external skibes and internal skibes; Micu, 1981).

Lithostratigraphically, in comparison with the accepted model for the external flysch Domain in the references (Dumitrescu, 1952, 1963; Dumitrescu and Săndulescu, 1968, 1969; Dumitrescu et al., 1962; Ionesi, 1971; Mutihac and Ionesi, 1974; Grasu et al., 1988; Gigliuto et al., 2004), in the Suceava river basin, significant differences were noticed by Joja (1952, 1953, 1954, 1955, 1957), Micu (1981) in the Sucevița river basin and Juravle (2004, 2007) in the area between the Suceava and Putna rivers (fig. 2). The particular evolution of the area was recorded during the Lower and Middle Eocene when a massive invasion of arenitic material occured, almost totally substituting the Ypresian - Bartonian flysch formations in the profile from the Suceava valley. The situation from the Suceava Valley was checked to the south up to the alignment marked by Sucevița brook – Rusca brook – Hojdenilor brook, and further research will be carried on up to the Moldova valley.

In the investigated area, the lithological formations that crop out from the column of Tarcău Nappe that crop out belong to the Senonian (Santonian – Campanian - Maastrichtian) – Lower Miocene (fig. 3).

The ***SENONIAN*** is represented by *Hangu Formation* (*sensu* Atanasiu, 1939; revised by Joja, 1952, 1955 and Ionesi, 1961,1967), made up, from a lithological point of view, of a rhythmic lutito-arenitic flysch, represented by an alternation of grey-blue marls, with traces of Chondrites, grey calcareous diaclased sandstones, micaceous sandstones with numerous carbonized fragments, yellow micritic limestones, micro-conglomerates and grey-green clay. In the epiclastic deposits the lutito-silitic material is predominant in comparison to the arenito-ruditic material. Usually, turbiditic sequences can be easily noticed, and besides those of arenite-sandy marls–marls, arenit-marls, arenite–lutite (clay and marls) type, sequences of micro-rudite (seldom rudite)–arenite–lutite (limestones, clay limestones, marls and clay) type were added (Ionesi and Florea, 1991; Florea, 1999; Juravle, 2004, 2007). The Senonian formation usually occurs on NW-SE alignments, in the forehead of the nappe, digitations and faulted overturned fold, marking the thrusting plane and the reverse faults that mark the forehead of the tectonic units.

The ***PALEOCENE*** follows with continuity in sedimentation on the top of the Senonian deposits on the whole surface of the research perimeter. The Palaeocene deposits make up the *Izvor Formation* (*sensu* Ionesi, 1961, 1967) (= Putna Formation, *sensu* Joja et al., 1968; Micu, 1981), characterized by turbiditic deposits, predominantly calcareous. These are made up of an alternation of detritic limestones, sandy limestones, Calcareous sandstones, sometimes micaceous, silicious sandstones, and subordinatedly, glauconitic sandstones, conglomerates and micro-conglomnerates with elements of green rocks, marls and clays. The rocks that give the characteristic feature to these formations are allodapic limestones (Ionesi, 1961, 1967, 1971; Grasu et al., 1988; Juravle, 2004, 2007).

The ***EOCENE*** is marked by the change of the morphology of the Tarcău Nappe sedimentation basin, which leads to important petro-facial and sedimentological variations

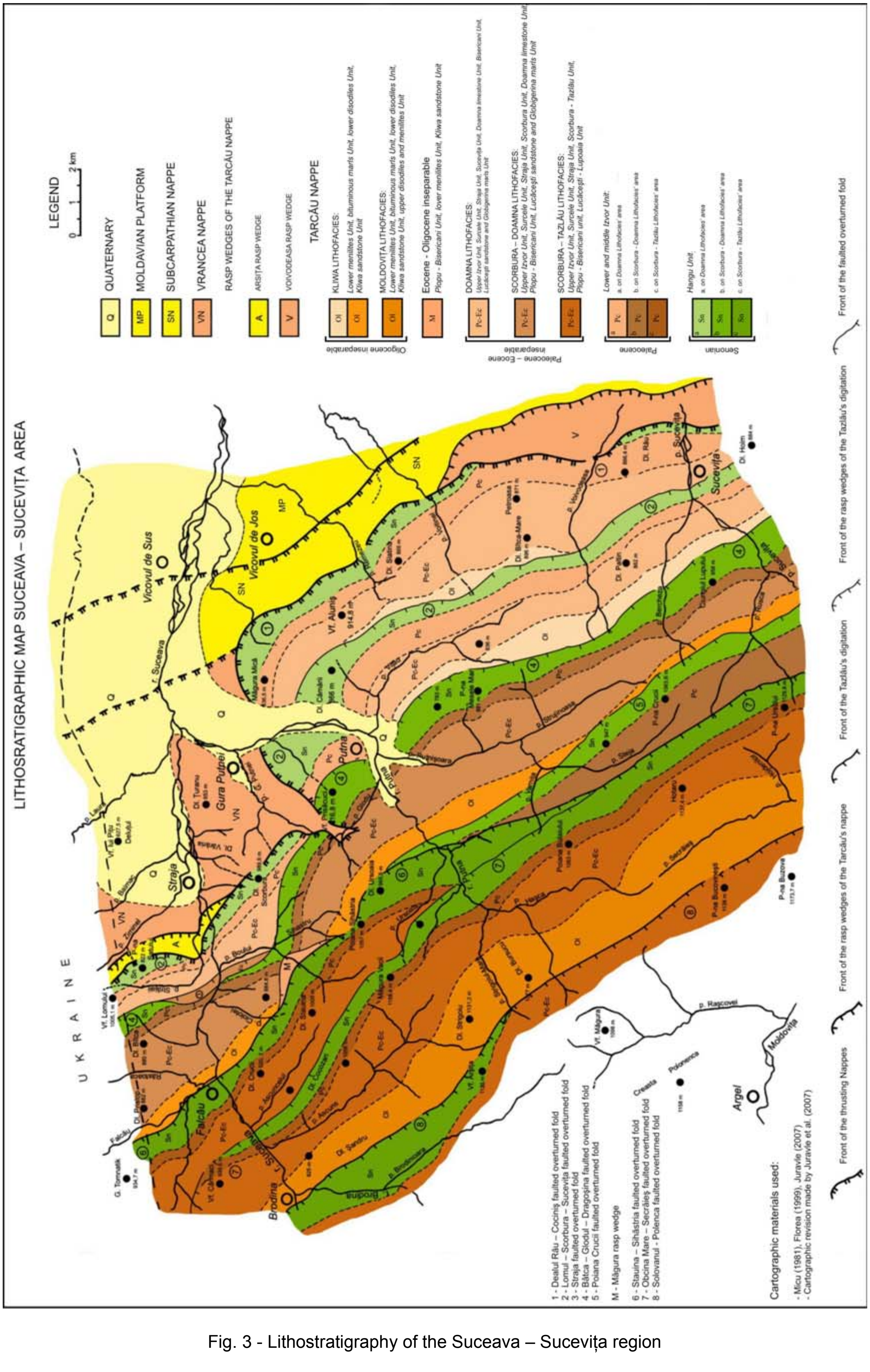

Fig. 3 - Lithostratigraphy of the Suceava – Sucevița region

along the proximal-distal direction, reported to the Central-Carpathian source-areas and the Cretaceous flysch. In such a context, at the level of the Eocene, in the external flysch basin, the Doamna, Tazlău and Tarcău heteropic lithofacieses (*sensu* Ionesi, 1971) developed.

As for the cause of sedimentation differentiation, all the references agree that this is due to the installation of a geotectonic regime with an accelerated dynamics as compared to the Upper Cretaceous. The mobility of the basin resulted in the formation of the cuvettes (internal basins), separated by Cordilleras and the multiplication of the source areas. The presence of the Cordilleras is unanimously accepted, and it is only their location that is debated as well as the tectogenetic moments responsible for their uplifting/re-activation.

As for the tectogenetic moments that lead to the formation of the Cordilleras, there are different opinions. Thus, Atanasiu (1952) considered that the deposition of the sediments in different lithofacieses in the area of the Tarcău Unit vas due to the instability of the sedimentation basin caused by the savic folding, and Filipescu (1955) considers that the Laramic paroxysm would have been responsible for the transformation of the sedimentation basin into smaller basins, with different depths, bordered by Cordilleras with diverse lithological constitution, which represented sources of detritic material with a great lithological variability.

Considering the paleogeographic and paleoenvironmental aspects of the flysch, as well as the source-areas for the basin, Săndulescu (1984), Săndulescu and Micu (1989), Grasu et al. (1988, 2002), admitted the existence of the Cordilleras with a complex sedimentologic and tectonic role. A system of Cordilleras is assumed, with west to east display, with a differentiated temporal „functioning", these authors have attempted to locate them in accordance with the knowledge of the moment.

The detailed field mapping realized in the Suceava valley and Putna valley, further continued southwards up to the Sucevița – Rusca – Hojdeni line, revealed a particular sedimentological evolution as compared to the similar southern areas (Moldova – Bistrița), materialized in the intensification of several arenitic episodes starting with the final Palaeocene and continued during the Eocene. Due to the massive arenitic contribution, the Eocene formations characteristic to the Doamna and Tazlău lithofacieses of Tarcău Nappe described in the scientific literature, are sometimes totally altered, confirming the separation of new heteropic lithofacieses. Nevertheless, this time, the lithofacieses are relevant not only for the installation of the transversally differentiated sedimentation conditions in the flysch basin, along east-west direction, as well as longitudinally, but also along the north-south direction. At the same time, in order to explain this field reality, it is necessary to involve new source areas, with another location but western, in order to support this lithofacial differentiation on north-south direction as well.

This lithofacial context characteristic to the Suceava river basin calls for a different paleogeographic reconstruction than that imagined for the central and southern areas of the external flysch basin, meant to solve the problem of the paleoenvironmental conditions compatible with a source area (or several source areas), source/sources capable of producing and supplying to the sedimentation basin of huge quantities of quartz sand to the sedimentation basin that make up the Scorbura type sandstones levels. Considering that the great sand „production" is an exclusive result of different paleoclimatic conditions in the southern and northern part of the Eastern Carpathians, is hazardous if we relate to the present geographical context of the external flysch, as the extent of this area over only 2^0 of latitude, cannot point to significant climatic differences in the extremities of the basin. Still, annual mean temperature differences of $2\text{-}3^0$, corroborated with the diurnal and annual amplitudes in certain climates, can probably have a decisive influence on the quantity of detritic material in a certain area, but only connected with a certain petrographic and mineralogical composition of the source areas. As for the intra-basin sources (the Cordilleras), their insular development in the flysch basin (Grasu et al., 1988) could partially solve the problem of the particular evolution of its northern part (Sucevița – Ceremuş area).

From a stratigraphic point of view, the „massive alteration" of the Eocene lithologic column created further difficulties for the chronostratigraphic correlation of the formations with those in the Moldova and Bistrița river basins and in establishing the lithostratigraphic landmarks that will be used as „operational instruments" in the field geologic mapping. For a satisfactory solving of such aspects, the separation of new lithologic formations has been done, and the study of the nannoplankton associations characteristic

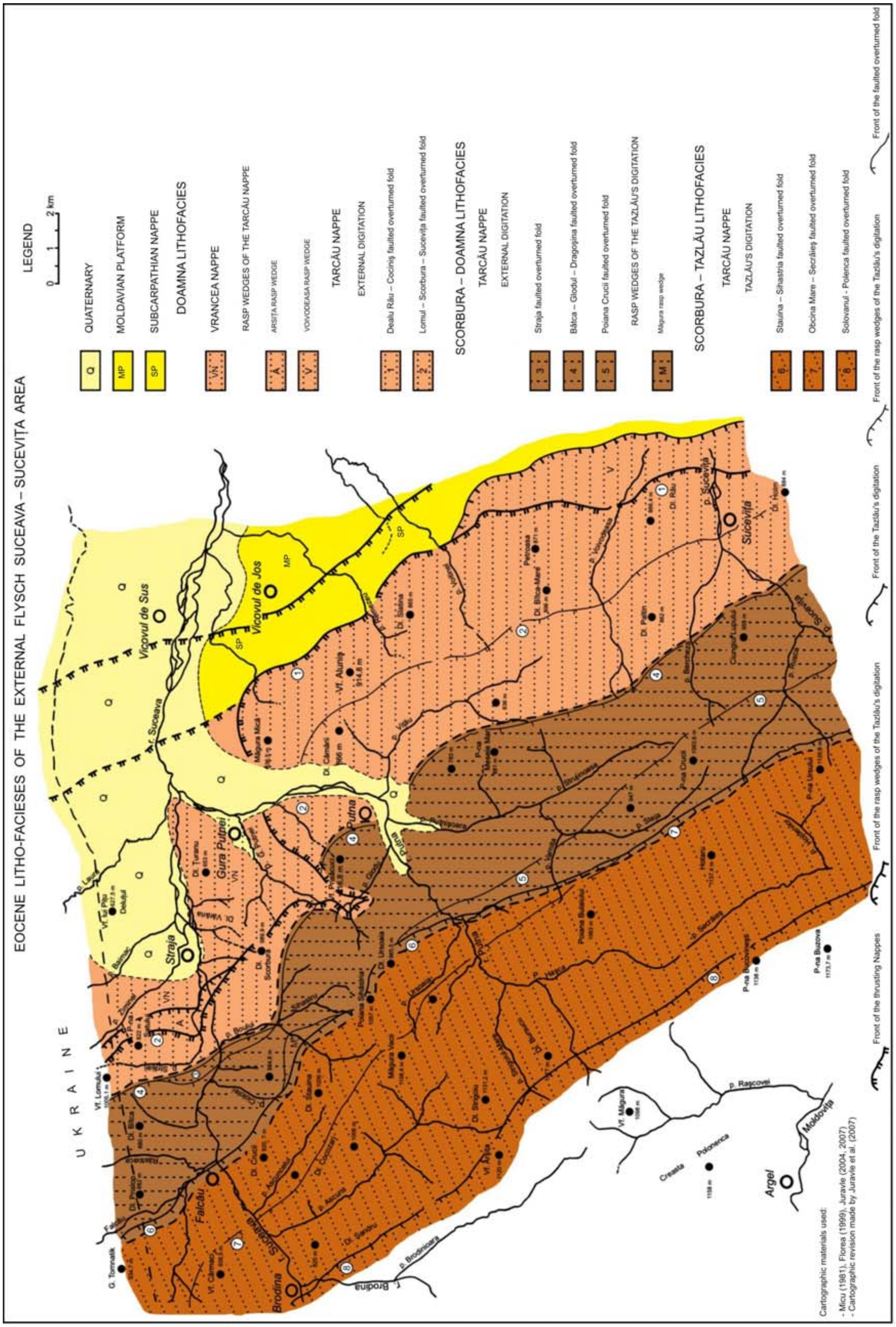

Fig. 4 – The distribution of the Eocene lithofacieses in the Suceava – Sucevița region

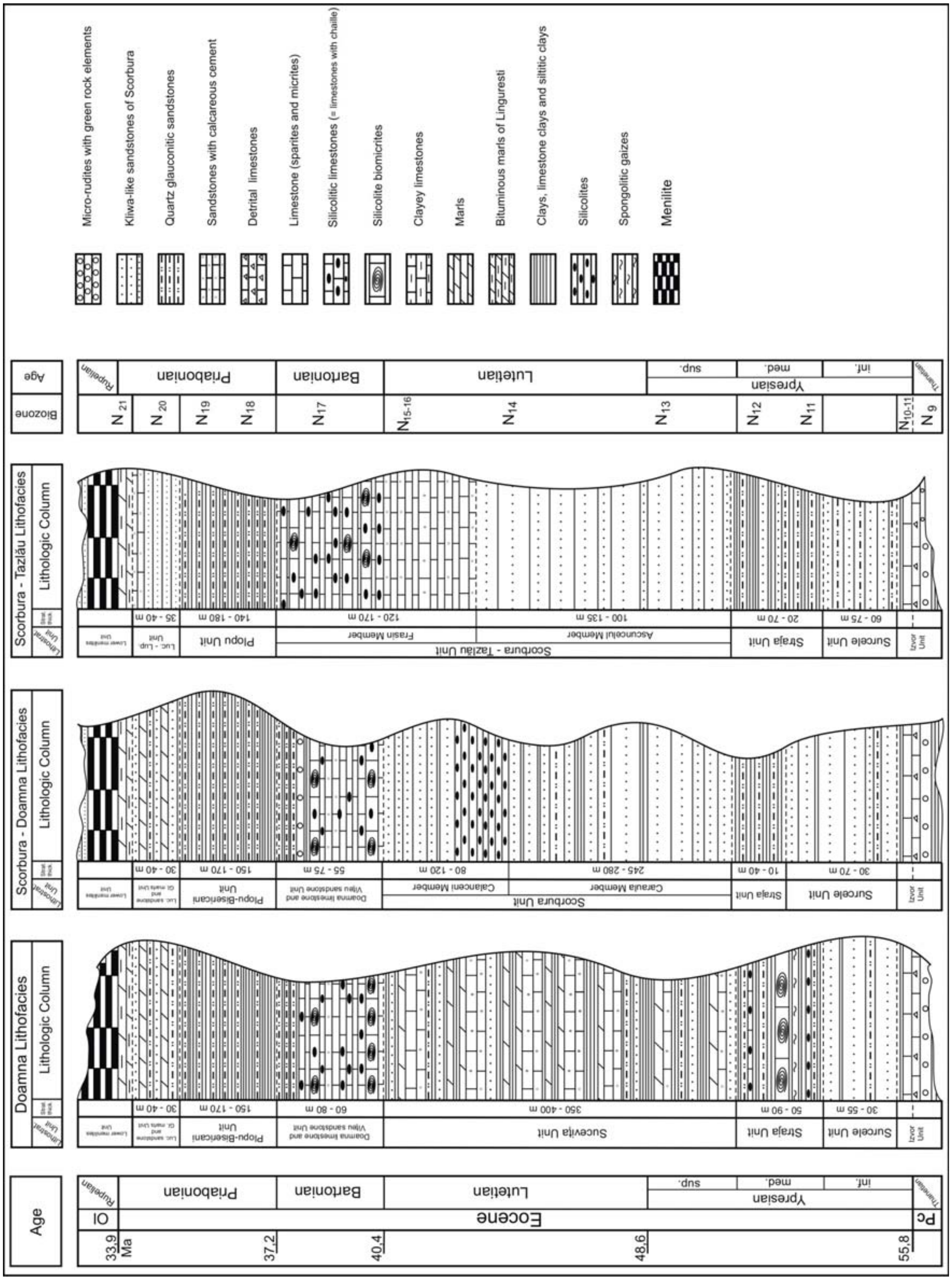

Fig. 5 – Lithostratigraphic columns of the Eocene lithofacieses in the Suceava – Sucevița region and the corresponding biozones

to the Eocene deposits in the Suceava river basin has been carried out (fig. 4).

The Doamna, Scorbura-Doamna and Scorbura-Tazlău heteropic lithofacieses characteristic to the Suceava river basin will constitute the subject of the next chapter.

The ***Oligocene–Lower Miocene*** interval is characterized by the maintaining of the differentiated sedimentation conditions in the Tarcăului Domain, generating, in our area of interest, the Kliwa and Moldovița heteropic lithofacieses (*sensu* Ionesi, 1971). The classic lithologic columns are developed, in the east, in the *Kliwa Lithofacies*, the inferior menilite, bituminous marls, inferior disodiles and Kliwa sandstone Formations (Ionesi, 1971; Micu 1981; Florea, 1999; Juravle, 2004, 2007), and in the west, in the *Moldovița Lithofacies*, the inferior menilite, bituminous marls, inferior disodiles, Kliwa sandstone Formations and superior disodiles and curbicortical sandstones (Ionesi, 1971; Micu, 1981).

The EOCENE IN THE SUCEAVA RIVER BASIN

The existence of the Eocene lithofacieses in this region was recognized by Joja (1954), who points out, in the Suceava Valley *„three facies, that is: Scorbura facies, that does not find any correspondent in any of the facies of the Paleogene between the Suha and Bistrița, Putna facies, that corresponds to a large extent to the internal marginal facies – in the form it occurs between the Suha and Suha Mică, the thing that differentiates them is represented only by the presence of the chaille-s in the Pasieczna Limestone and Lucăceşti Sandstone at the upper part and Gura Putnei facies, similar, according to the observations so far, to the external marginal facies. The first two are characteristic to the Putna Nappe* (= Tarcău Nappe, n.n)*, and to the inferior unit* (= Vrancea Nappe, n.n)".

Juravle (2004, 2007) separates in the area between the Suceava valley and the Putna valley, from east to west, the *Doamna lithofacies* (= Putna facies; *sensu* Joja, 1954), *the Scorbura-Doamna Lithofacies*, and the *Scorbura-Tazlău Lithofacies*. The further mapping southwards confirmed the maintenance of the lithological context at least up to the Sucevița line (figs. 4, 5).

The separation of the lithofacieses was explained by the variation of the petro-facial characteristics of the mapped formations in the Suceava basin, either transversally, on east to west direction, or longitudinally, related to the southern areas.

The ***Doamna Lithofacies*** (figs. 4, 5) crop out in the eastern part of the area, from the forehead of the nappe to an alignment that superposes over the tectonic line that marks the forehead of Bâtca–Glodu–Dragoşina faulted overturned fold. It includes the lithological units that have the Izvor Formation in their base and the inferior menilite formation in their top. The lithologic column is made up, in chronostratigraphical order by the Surcele, Straja, Sucevița formation, Doamna limestone and Vițeu sandstone formation, Plopu-Bisericani formation, Lucăceşti sandstone and globigerinae marls formations.

The characteristic feature of this lithofacies is represented by the development, in the basis, over the Izvor Formation and under the Straja Formation, of a volume of Kliwa-type sandstones of Scorbura type, with a remarkable horizontal development, separated as the Surcele Formation (Juravle, 2004, 2007), the maintenance of the Sucevița flysch (*sensu* Joja et al., 1963) with reduced intercalations of sandstones of Scorbura type and Doamna limestone, as a distinct lithologic unit. At the upper part the Bisericani flysch undergoes petro-facial changes, that is an increase of the arenitic intercalations, gaining an aspect of transition formation between Bisericani and Plopu, separated by Micu (1981) as the Plopu-Bisericani Formation. The column is closed by the Lucăceşti sandstone Formation and by marls with globigerinae (*sensu* Joja, 1954; Joja et al. 1963; Ionesi, 1961).

Scorbura-Doamna Lithofacies (figs. 4, 5) crops out west from the tectonic line that marks the forehead of the Bâtca–Glodu–Dragoşina faulted overturned fold, up to the Falcău–Ştef–Merța–Bobeica line. Similar to the Doamna Lithofacies, the lithologic column has in its base the Izvor Formation, while the top is made up of the inferior menilite Formation. The column starts with the Surcele Formation, continues with the Straja and Scorbura formations (*sensu* Juravle, 2004, 2007), Doamna limestone and Vițeu and Plopu-Bisericani sandstone formations. At the upper part, the Lucăceşti sandstone and the marls with globigerinae formation can be found.

The specificity of this lithofacies consists in: the further development of the Surcele Formation, the reduction of the thickness of the Straja Formation as compared to the Surcele formation, the integral „alteration" of the Sucevița flysch, and its replacement by massive sandstones of Scorbura type, with reduced silicolitic intercalations (possibly recurrences of Straja type) and the maintenance, as a distinct unit, of the Doamna limestone and Vițeu sandstone Formation.

Scorbura-Tazlău Lithofacies (figs. 4, 5) is developed from the Falcău–Ştef–Merța–Bobeica line eastwards, up to the alignment marked by the lower Brodina course, continued, southwards, with Brodinioara. In the basis, the Surcele Formation is maintained, followed by the Straja and Scorbura-Tazlău Formations (*sensu* Juravle 2004, 2007), Plopu, Formation and in the upper part, the Lucăceşti-Lupoaia Formation (*sensu* Ionesi, 1971).

The arguments for the separation of this lithofacies consist in the advanced alteration of the Straja Formation deposits, by increasing the frequency and thickness of the Scorbura type sandstones, integral replacement of the Sucevița flysch (*sensu* Ionesi, 1971) with Kliwa-type sandstones of Scorbura type, the disappearance of Doamna limestone formation as a distinct unit, and the maintenance, between the Scorbura sandstones and Plopu Formation, of the Tazlău flysch (*sensu* Atanasiu, 1943; Agheorghiesei et al., 1967; Ionesi, 1971).

LITHOSTRATIGRAPHIC AND BIOSTRATIGRAPHIC DATA

Lower Ypresian–base of Middle Ypresian. ***Surcele Formation***. The field mapping revealed the constant development, over the Izvor Formation and under the Straja Formation, on the area of the three separated lithofacieses in the Suceava basin, of a predominantly arenitic lithostratigraphic unit, whose specificity is given by the massive development of Kliwa-type sandstones of Scorbura type (*sensu* Joja, 1954; = *Păltinoasa*; Băncilă, 1952, 1958). The cartographic revisions we have carried out in the southern areas confirmed the maintenance of this unit to the south, up to the Sucevița Valley. Nevertheless, in the literature, this volume of sandstones was described as showing variable thickness, even if it was not considered as a distinct unit in all the cases, in the areas of Putna - Sucevița (Joja, 1954; Micu, 1981; Florea, 1999), Râşca - Agapia (Joja, 1952 a), Voroneț - Suha Mică - Plotonița (Dicea, 1974), Moldova Valley (Ionesi, 1961, 1971), which indicates a regional development of this lithostratigraphic units, at least north of Moldova Valley.

Dicea (1974) referring to a perimeter situated south of Moldova Valley (Voroneț - Suha Mică – Plotonița) separated in the „Upper horizon of the Hangu strata Hangu" (*sensu* Joja, 1955; = *Izvor Formation*, *sensu* Ionesi 1967, 1971; = *Putna Formation*, Joja et al., 1968; Micu, 1981), under the Straja Formation, *„the level of the silicious glauconitic sandstones, of Scorbura type"*. At the same time, at the upper part of the Izvor Formation, a white-greenish or white-yellowish, glauconitic, brittle sandstone was distinguished, similar to the Kliwa sandstone in the Moldova river basin, by Ionesi (1961, 1971) and in the Putna – Sucevița area by Florea (1999). In the Sucevița basin, Micu (1981) identified, at the upper part of the Izvor Formation, yellowish or greenish Kliwa-type sandstone bars, with silicious or calcareous cement, and massive texture. The author makes an analogy between this level, in the southern part of the external flysch, and the Alunu sandstone from the Vrancea semi-window (*sensu* Dumitrescu, 1963), and in the Ukrainian Carpathians, with the upper part of the Strîi series, where glauconitic sandstones of Iamna type are massively developed. But these authors consider that this level has a lentiform development, specific only to the investigated perimeters.

Juravle (2004, 2007) notices the regional development of the level of rocks of Scorbura type to the north of the Moldova Valley, with a stratigraphic location between the Izvor Formation, in the base and the Straja Formation in the top, and separates this volume of rocks as Surcele Formation (fig. 5).

Stratonomically, the formation is present as massive sandstone bars 1-2 m, to 10-15 m thick, which grade into turbiditid binary rhythms: alternations of arenitic sequences with silto-lutitic sequences. These can be found in 40-80 cm thick sandstone strata and in silto-lutites strata, with thickness up to 20 cm. The silto-lutitic material has a reduced percentage in the column of the unit, with a variation between 0 and 10%.

In the eastern part, in the Doamna Lithofacies, the formation has a more massive aspect, with a predominance of the Scorbura type sandstones, in bars of 3–15 m, with only subordinated silto-lutitic intercalations. In the west, in the Scorbura–Doamna and Scorbura–Tazlău lithofacieses, the volume of rocks is similar to that described in the Doamna Lithofacies, with the only difference that here, it is more stratified, the sandstone bars never exceeding 5-6 m thickness. Lithologically, the formation is made up of the same monotonous alternation of coarse to fine granular, glauconitic, greenish or brownish quartz sandstones, with Kliwa-type yellowish-white sandstones of Scorbura type. These can be represented by the varieties with silicious cement to those with calcitic cement. The sandstone strata have thicknesses of 20-80 cm. In the thin strata, at the upper part, a concoidal structure can be noticed sometimes. In certain intervals, the gradual sorting is obvious, suggesting the turbiditic character of the deposits. The silto-lutitic intercalations are only subordinated, without exceeding 3-5% of the column, and with maximum thickness of 10 cm. Siltic, grey-greenish, grey or green clays and marls are distinguished.

In certain profiles (Putna river, Haşca brook, Bercheza brook), the massive sandstones of Scorbura type diminish their percentage in the favour of the glauconitic greenish hard sandstones, with a medium to coarse particle size, arranged in strata of 40-80 cm, occupying up to 40-50% of the lithological column of the formation. Under such circumstances, an increase of the silto-lutitic material can be noticed, up to 20% of the column. In none of the studied profiles, the Kliwa-type sandstones of Scorbura type decrease in relative amounts below 30-40%.

Petrographically, the characteristic feature of the formation is given by the Kliwa-type yellowish, white or yellowish-brown quartz sandstones of Scorbura type, sometimes grading into glauconitic sandstones. In their mass, one can notice, very seldom, fragments of green rocks and incarbonization traces. In some cases, the Scorbura type sandstones create effervescence with HCl due to the replacement of the silicious cement with calcitic cement.

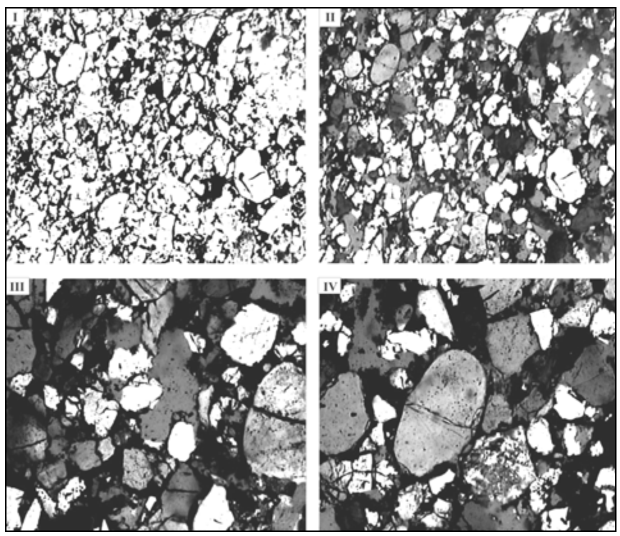

Fig. 6 - Microscope images of the quartz sandstones of Scorbura type (Surcele Formation) (*Fields: I, II – alogene rounded and sub-angular quartz grains , lithoclast of quartzite and feldspars, in silicious porous and pelicular cement; I – N-, x32; II – N+, x32; III, IV – details of fields I and II, N+, x200*)

Under the microscope, the following aspects were noticed: rounded and sub angular quartz extraclast, exceeding 90-95% of the rock mass, lithoclast (< 2%) of green rocks and quartzites and fragments of potasic feldspar (< 2%). Among the autigene components, glauconite was noticed (approx. 3 %) and pelicular or porous silicious, subordinately calcitic cement. These rocks are included in the category of the glauconitic quartz-arenites, with silicious cement.

The chronostratigraphic position of the formation was established considering the geometric relationships of continuity with the deposits of the Izvor Formation in the base, with those of the Straja Formation in the top, as well as the biostratigraphical significance offered by the nannoplankton associations identified in the clay levels situated immediately under or above the Surcele Formation, by Bogatu (1999), Florea (1999) and Juravle (2004, 2007), Juravle and Florea (2006 a).

An adequate profile for establishing the chronostratigraphic position of the Surcele formation is found in the confluence area of the Boului brook with the Surcele brook (in the Suceava Valley), where the contact with the formations in the base and top, Izvor and Straja respectively, are clear and the continuity relationships are clear.

In this point, in the upper part of the Izvor Formation, from the approx. 1 m of stratigraphic thickness, under the Scorbura sandstones, the following taxa were noticed: *Marthasterites tribrachiatus* (Bramlette et

Riedel); *Discoaster salisburgensis* Stradner; *Rhabdosphaera truncata* Bramlette, Sullivan; *Coccolithus pelagicus* (Walich), Schiller; *Ericsonia ovalis* Black; *Discoaster binodosus* Martini; *Discoaster falcatus* Bramlette et Sullivan; *Sphenolithus anarrhopus* Perch-Nielsen; *Neococcolithus protenus* Bramlette et Sullivan; *Toweius pertusus* Mohler.

Similar associations were noticed sothwards, in the Sucevița river basin by Florea (1999) and, in the Soloneț – Moldovița – Sucevița area, by Bogatu (1999)

As compared to the Cretaceous - Paleogene associations, the appearance of new taxa with biostratigraphical significance is noticed. They are:

- *Marthasterites tribrachiatus* which appears in the middle part of NP10 Biozone and has its extinction in a short time interval, in the final part of NP12 Biozone;
- *Discoaster binodosus* identified at its first appearance, which develops from NP9 Biozone up to NP15 Biozone, when the extinction takes place;
- *Discoaster deflandrei* which appears in NP11 Biozone and continues up to NP21 Biozone, sometimes up to NP25;
- *Discoaster falcatus* continues its evolution from NP8 and NP9 Biozones up to NP10 Biozone (Perch-Nielsen, 1983) or up to the half of NP12 Biozone (Bratu and Gheța, 1972);
- *Sphenolithus anarrhopus* appears for the first time in NP6 Biozone, the middle part and develops up to NP11 Biozone, the middle part (Perch-Nielsen, 1983). This taxon is cited by Ionesi and Mészáros (1995) in the final part of the Izvor Formation from the Bistrita Valley basin.

Under such conditions, the above mentioned nannoplankton species can be attributed to NP10 and NP11 Biozones, characteristic to the Lower Ypresian.

Immediately on the top of the Surcele Formation, from the lutites in the lower part of the Straja Formation, samples were collected. In the samples we identified a nannoplankton association with: *Discoaster binodosus* Martini; *Discoaster lodoensis* Bramlette, Riedel; *Chiasmolithus solitus* Bramlette, Riedel; *Discoaster distinctus* Martini; *Neococcolithus protenus* Bramlette et Sullivan; *Heliorthus junctus* Bramlette et Sullivan; *Marthasterithus tribrachiatus* (Bramlette et Sullivan) Deflandre; *Cyclococcolithus formosus* Kamptner; *Discoaster diastypus* Perch-Nielsen; *Coccolithus pelagicus* Perch-Nielsen; *Chiasmolithus grandis* Perch-Nielsen; *Toweius pertusus* Mohler.

As for the significance of the association, the appearance of the *Discoaster lodoensis* taxon is noticed, a taxon that marks the base of NP12 Biozone (it is a marker for the next Biozone, NP13). Other taxons also appear: *Chiasmolithus solitus* which develops from NP10 up to NP17, *Heliorthus junctus* with a development is the interval between NP10 and NP15 Biozones (Bratu and Gheța 1972) and *Cyclococcolithus formosus* which develops from NP12 Biozone up to NP20 Biozone. The extinction of *Neococcolithus protenus* taxon takes place in the middle part of NP12 Biozone and the extinction of *Marthasterithes tribrachiatusl* taxon occurs in the final part of it. The *Discoaster diastipus* Taxon appears at the base of NP10 Biozone, to which it is a marker and develops up to NP12 Biozone, with the last appearance in NP13 (Perch-Nielsen, 1983). Mészáros et al. (1991) cite the same taxon in the interval of NP9–NP13 Biozones. Sullivan (1961, fide Florea, 1999) considers that the taxon develops in the stratigraphic interval Paleocene–Lower Eocene inferior, and Hamilton et al. (1985, fide Florea 1999) mentions the presence of this taxon in the deposits belonging to NP12–NP19 Biozones on the territory of England. Under such conditions, the presented association belongs to NP12 Biozone, from the Middle Ypresian.

As one can conclude from the discussion on the age of the under and overjacent formations, the Surcele Formation belongs, logically, to the upper part of the Lower Ypresian and to the basis of the Middle Ypresian (it is inserted between NP10–NP11 Biozones, characteristic to Lower Ypresian and NP12 Biozone in the Middle Ypresian) (fig. 5 and Plate I).

Middle Ypresian

Straja Formation. Joja (1952 b) uses for the first time the name of „Straja strata" for the „Tisaroide strata" (*sensu* Dumitrescu, 1952) in the „external marginal and conglomeratic external facies". This name appears in the plate attached to the paper. Băncilă (1958) considers that the introduction of this name is appropriate as it solves the confusions created by the use of the name „Tisaru strata" (sens Athanasiu, 1913).

Lithostratigraphically, the deposits of this formation were studied by a series of authors among which we can mention Joja (1952 a, 1952 b, 1954, 1960), Băncilă and Papiu (1960), Ionesi (1971), Micu (1981), Grasu et al. (1988), Ionesi and Mészáros (1995).

According to Joja (1954, 1960), in the Putna - Suceava region, the thickness of the „*Straja Strata*” deposits varies from 80-90 m in the eastern part of the zone, in the forehead of the Tarcău Nappe, to 100-120 m in its western part, in the area of the Ascuns brook. The author states that *„the horizon of Straja Strata*” developed in the „*Putna facies*” is *„more obvious than in Voivodeasa – Sucevița region”.* Petrographically, the author describes stratified green and red marls (strata of 0.5-1 cm), displayed in 0.5-1 m thick piles, in which 10-15 cm thick strata of hard, variegated green-blue limestones, with hieroglyphs on the basal plane are intercalated. The silicolites form 5-20 cm thick intercalations; they are hard, brown-black in colour, and they were often transformed into gaizes with radiolars.

The stratonomic and petrographic characteristics of the formation vary in the Suceava river basin. The frequency and thickness of the intercalations of glauconitic quartz limestones and of Scobura type, increase westwards and this leads to the almost total loss of the lithostratigraphic identity (Micu, 1981; Florea, 1999; Juravle, 2004, 2007) (fig. 5).

The typical sequence of Straja Formation (*sensu* Atanasiu and Olteanu, 1952, fide Grasu et al. 1988; Joja, 1952, 1960; Băncilă and Papiu, 1960, Micu, 1981; Grasu et al., 1988; Florea, 1999; Juravle, 2004, 2007) characterized by a close stratification, in strata of 5-25 cm, rarely with bars of glauconitic sandstones up to 1,5–2 m, crops out in the eastern part, in the area of ***Doamna Lithofacies***. The thickness of the deposits can vary from 50-80 m in the Suceava Valley, up to 170 m in the Sucevița Valley. Lithologically, it is made up of an alternation of clays and silitites with glauconitic quartz sandstones, limestones, silicolitic and spongolitric gaize in thin strata, with a characteristic red-brown surface colour.

In the middle part, in ***Scorbura–Doamna Lithofacies***, the sedimentation conditions in the basin undergo a change, and, as a consequence, the lithologic column of the formation reduces to a 10-40 m thick rock pile, made up of an alternation of silto-lutite and arenite, arranged in strata of 5-15 cm.

The arenites are represented in a percentage of > 70% by green, glauconitic quartz sandstones, sometimes variegated due to the alternation of the greenish-white millimetric laminae, with the brown-blackish ones, with transition to more calcareous varieties. These are arranged in 5-15 cm thick strata, with hieroglyphs on the base, with macroscopic aspect that becomes identical with those in the eastern or western zones.

As for the silicious rocks levels, from the category of silicolite–spongolitic gaize, no clear levels are distinguished like in the Doamna Lithofacies, announcing the transition to a more arenitic facies, which becomes obvious in Scorbura–Tazlău Lithofacies. Despite the absence of red clays, the formations keep the characteristic red–brown colour at the surface.

In the west, in the area where ***Sorbura–Tazlău Lithofacies*** crops out, the stratonomic and petrographic context changes again. Lithologically, the formation is characterized by green, red and blackish silto-lutite in which strata and quartz glauconitic sandstones are inserted (Iamna sand stones, Ionesi, 1971; Micu, 1981) and Kliwa-type, yellowish-whitish quartz sandstones of Scorbura type. The sandstone strata show thicknesses of 30-80 cm, gradual sorting, hieroglyphs on the base and sometimes, convolute structure toward the top. At the surface, the thin sandstone strata have a red-brown colour, or darker colours caused by Mn oxides. As for some of the sandstone bars, the mapped profiles suggest a constant development, reaching 3 m thickness, while for others, they suggest a lenticular development. The green and red-brown silto-lutitic sequences are specific to Straja Formation. They occur as 0.60–3 m thick interalyers, which have, in their turn, centimetric intercalations of calcareous sandstones and glauconitic quartz sandstones. The rocks with silicolite aspect only occur as centimetric intercalations.

Considering the transversal lithofacial variation of the formation, the chronostratigraphic position was established by analysing the geometric realationships with the formations in the base and top and the determined nannoplankton associations.

Invariably, in the area of the three lithofacieses, Straja Formation follows, with sedimentation continuity, over the arenitic deposits, predominantly Kliwa-type, of the Surcele Formation, which was dated as being Lower Ypresian–basis of Middle Ypresian. But in the top, the Sucevița Formation follows in the area of Doamna Lithofacies, Scorbura Formation in Scorbura–Doamna Lithofacies and Scorbura-Tazlău Formation in the area of Scorbura–Tazlău Lithofacies. The age of the deposits on the basis of the formations is Upper Ypresian.

The nannoplankton determinations in the Suceava and Moldovița river basins (Bogatu, 1999; Florea, 1999 and Juravle, 2004, 2007) allowed the description of several associations located in the lower part and in the upper part of the formation, respectively.

From the lower part of the formation the following nannoplankton association was identified: *Discoaster binodosus* Martini; *Discoaster lodoensis* Bramlette, Riedel; *Chiasmolithus solitus* Bramlette, Riedel; *Discoaster distinctus* Martini; *Neococcolithus protenus* Bramlette et Sullivan; *Heliorthus junctus* Bramlette et Sullivan; *Marthasterithus tribrachiatus* (Bramlette et Sullivan) Deflandre; *Cyclococcolithus formosus* Kamptner; *Discoaster diastypus* Perch-Nielsen; *Coccolithus pelagicus* Perch-Nielsen; *Chiasmolithus grandis* Perch-Nielsen and *Toweius pertusus* Mohler.

Biostratigraphically, the appearance of *Discoaster lodoensis* taxon is significant, marking the basis of NP12 Biozone (with maximum development in NP13 Biozone), besides *Chiasmolithus solitus* which develops from NP10 up to NP17, *Heliorthus junctus* with a narrower distribution, in the interval between NP10 and NP15 Biozones (Bratu and Gheța, 1972) and *Cyclococcolithus formosus* which develops starting from NP12 Biozone up to NP20 Biozone. In the same time, the extinction of *Neococcolithus protenus* occurs in the middle interval of NP12 and that of *Marthasterithes tribrachiatus* in its final one. *Discoaster diastipus* appears in the basis of NP10 Biozone, being its marker, and develops up to NP12 Biozone, with its last appearances in NP13 Biozone (Perch-Nielsen, 1983). Mészáros et al. (1991) cite the same taxon in the interval of NP9-NP13 Biozones. Sullivan (1961) considers that the taxon develops in the stratigraphic interval Paleocene – Lower Eocene, and Hamilton et al. (1985, fide Florea, 1999) mentions the presence of this taxon in deposits belonging to NP12-NP19 Biozones, on from England. Under such conditions the presented association belongs to NP12 Biozone, (Middle Ypresian).

From the upper part of the lithological column the following taxa were determined: *Discoaster lodoensis* Bramlette et Riedel; *Discoaster gemmifer* Stradner; *Discoaster germanicus* Martini; *Coccolithus pelagicus* (Wallich) Schiller; *Schyphosphaera tubicena* Stradner; *Rhabdosphaera truncata* Bramlette et Sullivan; *Rhabdosphaera pinguis* Deflandre; *Helicopontosphaera seminulum lophota* Perch-Nielsen; *Heliorthus junctus* Bramlette et Sullivan; *Chiasmolithus grandis* (Bramlette et Riedel); *Chiasmolithus eograndis* Perch-Nielsen; *Reticulophenestra dictyoda* Perch-Nielsen and *Sphenolithus moriformis* Perch-Nielsen.

When analysing the association, one can notice the further presence of *Discoaster lodoensis*, which places the association in NP12 Biozone. *Rheticulophenestra dictyoda* appears at the basis of NP13 Biozone and evolves up to the final part of NP16 Biozone (Perch-Nielsen, 1983). *Chiasmolithus eograndis* appears in NP10 Biozone and has its extinction in the middle part of the NP13 Biozone (Perch-Nielsen, 1983). On the basis of the above mentioned nannoplankton, we consider that the age of Straja Formation is Middle Ypresian, corresponding to NP12 and NP13 Biozones (fig. 5 and Plate I).

Upper Ypresian–Lutetian-Bartonian

During this time interval, in the Suceava river basin, the differentiation of the sedimentation conditions was clearer, with significant petrofacial variations in the three lithofacieses.

In the eastern and middle part, in the area of Doamna and Scorbura–Doamna Lithofacieses, during the Upper Ypresian–Lutetian interval the differentiated sedimentation is maintained, giving birth to Sucevița and Scorbura formation respectively, while in the Bartonian the sedimentological conditions become uniform, with an accumulation, over the whole area, of calcareous deposits of Doamna limestone Formation and Vițeu sandstone Formation. In the west, in the Scorbura–Tazlău Lithofacies, in the first part of the discussed stratigraphic interval, similar deposits as those of Scorbura Formation deposited, and in the upper part, a calcareous flysch that reminds of Tazlău Formation is formed. These deposits have been separated as the Scorbura-Tazlău Formation (Juravle, 2004, 2007) (fig. 5).

Sucevița Formation. Joja (1954) separates in Putna – Putnişoara area, between „*Straja Strata Hrison*" and „*Pasieczna Limestone Horizon*", the „*Inferior calcareous-sandy horizon"* of about 400 m thickness, and in 1963, Joja describes the stratotype of Sucevița Formation on a profile on the Sucevița brook. This profile includes the flysch deposits which follow, in continuity of sedimentation on the top of the Straja Formation and are overlaid by the Doamna Limestone.

In the Suceava river basin, the formation starts usually with Scorbura sandstone (with a grey-greenish or greenish colour), over which there is an alternation of quartz sandstones,

sandstones with calcareous cement with hieroglyphs in the basal plane, sandy limestone, bioclastic limestone, clay and grey or greenish marls. The formation reaches a thickness up to 500 m in the Sucevița valley.

Scorbura Formation. The first information on the development in the Suceava valley of the deposits over the Straja Formation, in a particular arenitic facies, comes from Joja (1954). What Joja dit not notice correctly is the fact that the maximum development of this levels of rocks, defined by him as the Scorbura sandstones, is not characteristic for Scorbura Hill, but for the western alignment Bâtca Hill - La Strungi – Glodu Hill and Culmea Cârmaci – Stauina Hill area.

The profile that permitted the separation and description of Scorbura Formation can be found in the Suceava Valley, in Caraula sector, where it is integrally cropping out and the contacts between Straja Formation in the base and Doamna limestone and Vițeu sandstone Formation in the top are visible.

In Caraula sector, over Straja Formation, on as stratigraphic thickness of about 370 m, a sequence made up of quartz sandstones (over 90%) follows. They are arranged in strata of 40-80 cm and metric bars, in which the silto-lutitic intercalations are reduced, representing < 10% of the lithological column. The monotony is interrupted only in the upper part by an intercalation of about 25 m thickness, by greenish fine-particle sized and silicolite sandstones. On their top, the same type of sandstones follow, reaching the limit with the Doamna limestone. The lithological situations mapped in Caraula sector in the Suceava Valley and in the south, in the Putna Valley and Glodu brook, justified the separation of two members: *Caraula Member* and *Calanceni Member*.

Doamna limestone and Vițeu sandstone Formation. They present sedimentation continuity on the top of the Sucevița and Scorbura Formations in Doamna and Scorbura–Doamna Lithofacieses; they are overlaid by the Plopu–Bisericani Formation.

Lithologically, in the lower half, is the deposits are made up, in a ratio of > 90 %, of silicolitic biomicrites (with silex nodules), spongolitic biomicrites and miocritic limestones, with white-yellow, chocolate, greenish and grey colour. In most of the cases, the silex nodules have menilitic aspect and a brown-black colour. In this limestone pile, in the lower part, two silto-lutitic sequences, of grey-greenish colour, with a thickness of 10-25 cm are inserted; in their middle part, a level of white rocks, with sandstone aspect, in layers of 15-25 cm, and a stratigraphic thickness of 1 m is found.

On the top of this level of rocks, a layer of 2 m of grey-greenish, greenish marls and clays follows, with gradual sorting, and hieroglyphs in the base, over which layers of micro-conglomerates with green rocks, 1 m thick, are present; in the upper part they grade into coarse sandstones, separated by green clays and marls. The sequence ends with a monotonous alternation of glauconitic calcareous greenish sandstones, in layers of 10-30 cm, with green or grey-greenish clays and marls, 3-25 cm thick.

Scorbura–Tazlău Formation. In the Suceava river basin, the formation shows continuous sedimentation on the top of the Straja deposits and it is overlaid by the Plopu Formation. Similarly to the Moldova river basin, in the Suceava Valley this formation keeps, in its lower part, the lithofacial characteristics from the middle part (Scorbura–Doamna Lithofacies), while in the upper part the deposits develop in a sandy-calcareous facies, close to that belonging to the Tazlău Formation. We must emphasize that the Doamna limestone Formation looses its individuality in the base of the deposits of the Plopu Formation. In this area, at the level of Bartonian, the deposition process has turbidic rhythms, with sequences of sandy sparite, silicolitic and silto-lutite limestones.

In the Suceava Valley, in Frasin sector the formation crops out with its whole stratigraphic thickness between Straja Formation and Plopu Formation. The contacts between the deposits in the base and the top are very sharp, and so is the limit between the two members. There is a continuity in sedimentation with the formations in the base and the top.

In the lower part, over a thickness of 100-135 m, the formation is made up of bars of quartz sandstones of Scorbura type and greenish glauconitic quartz sandstones (> 90 % of the rock), displayed in layers and bars with a thickness that varies from 2-3 m to 5-18 m. The sandstone bars are separated by Kliwa-type quartz or yellowish-whitish, brown, greenish weakly bound calcareous sandstones with hieroglyphs in the base and convolute structures at the upper part of the sandstones layers, with thickness up to 80 cm.

At the upper part, a monotonous alternation of calcareous sandstones and sandy limestone and limestones with hard silex nodules, with gradual sorting, with mica on the detachment surface, and grey-purple, sometimes blackish occurs. The layers, 20-40 cm thick, have hieroglyphs on the foot and, in the case of those layers with reduced thickness, they have convolute or concoidal structure at the upper part. The intercalations of silto-lutitic material are rare and with reduced thickness (3-10 cm). The deposits represent turbidites with binary sequences, being made up of arenites in the base and silto-lutite at the top or, subordinately, with ternary sequences of microrudit–arenite–siltolutite type.

The sections in the Suceava Valley (Frasin sector) and along the Ascuncelul and Ascuns brooks allowed the horizontalization of Scorbura–Tazlău Formation into two members: *Ascuncelul Inferior Member* and *Frasin Superior Member*.

The isochronism of the Sucevița, Scorbura and partially the Scorbura-Tazlău formations was demonstrated by the geometric continuity relationships between the base and the top, and the biostratigraphic information supplied by the identified nannoplankton associations.

As for the Scorbura-Tazlău Formation, our data show that only the lower and middle third is isochrone with the Sucevița and Scorbura Formations, the deposits in the upper third, overlaid by the Plopu Formation, being chronostratigraphically equivalent to the deposits of the Doamna limestone and Vițeu sandstone Formation.

In order to correlate chronostratigraphically the formations, we have used the data obtained in the Suceava Valley, Sucevița Valley and Soloneț – Moldovița area. The biostratigraphical analysis of the sections from the Suceava Valley, where the analysed samples are distributed from the base to the top of the deposits, allowed us to make a correct chronostratigraphical location of Scorbura Formation and its correlation with the isochrone formations Sucevița and partially Scorbura–Tazlău Formations (fig. 5 and II).

The nannoplankton identefied in the samples from the silto-pelitic intercalations of Scorbura Formation, allowed the description of two nannoplankton associations: *Association 1* (located in the lower part of the formation) with: *Discoaster lodoensis* Bramlette et Riedel; *Rhabdosphaera truncata* Bramlette et Sullivan; *Rhabdosphaera tenuis* Deflandre; *Discoaster germanicus* Martini; *Reticulophenestra dyctioda* Stradner; *Sphenolithes radians* Deflandre; *Micrantholithus flos* Deflandre; *Chiasmolithus solitus* Bramlette et Sullivan; *Discoaster barbadiensis* Tan Sin Hok and *Association 2* (located in the upper part of the formation), with: *Discoaster lodoensis* Bramlette et Riedel; *Rhabdosphaera truncata* Bramlette et Sullivan; *Rhabdosphaera tenuis* Deflandre; *Rhabdosphaera inflata* Bramlette et Sullivan; *Chiasmolithus gigas* Bramlette et Sullivan; *Coccolithus pelagicus* (Wallich) Schiller; *Coccolithus gamation* Bramlette et Sullivan; *Reticulophenestra placomorfa* (Kamptner) Stradner; *Chipragmalithus critatus* (Martini); *Reticulofenestra umbilica* Levin; *Chiasmolitus solitus* Bramlette et Sullivan and *Sphenolithus moriformis* Deflandre.

Wen analysing association 1, one can notice that new taxa appear besides those described within the associations in the Straja Formation, such as: *Rhabdosphaera truncata* with an evolution in a time interval between NP12 and NP14 Biozones; *Rhabdosphaera tenuis* that starts its evolution in NP12 Biozone and, together with *Rhabdosphaera truncata* constitutes the taxa that are common to the fauna in NP13 zone (Bratu and Gheța, 1972). In the same time, in the NP12 Biozone, the *Reticulophenestra dyctioda* starts to occur while its extinction takes place in the NP16 Biozone. *Chiasmolithus solitus* taxon evolves in NP10 Biozone, in the middle part, up to NP15 Biozone, final part (Perch-Nielsen, 1983). The same taxon is mentioned by Gheța (1972), in the same stratigraphic interval, from flysch deposits in the Şotrile facies in the Eastern Carpathians. Gartner (1968) states that the taxon was found in the NP12 and NP13 Biozones, in deposits from Florida, USA. Mészáros et al. (1991) cites this taxon as a common one in NP9–NP13 Biozones. Using these arguments, this association was attributed to the NP13 Biozone, of Upper Ypresian age.

Concerning association 2, one can notice that at the upper part of the stratigraphic interval, the following taxa disappear: *Discoaster lodoensis* and *Discoaster binodosus*. This takes place in NP14, and NP15 Biozones respectively. Rhabdospherides are maintained, with the species *Rhabdosphaera truncata* and *Rh. Tenuis*, and besides them, *Rhabdosphaera inflata* appears. This taxon is frequently used in defining NP14 Biozone, when the marker is missing. *Reticulofenestra umbilica* taxon appears in NP15 Biozone, final part, and the extinction occurs in NP22 Biozone (Perch-Nielsen, 1983). Gartner (1968) cites this taxon in the sedimentary deposits in Florida (USA), in NP11–NP17 Biozones. Mészáros et al. (1991) cites it as being common in NP16 Biozone. It is remarkable the presence of *Chiasmolithus gigas*, which is used for the subdivision of NP15 Biozone, representing a secondary marker of the mentioned biozone. The identified association covers the interval corresponding to NP14 and NP15 Biozones, and thus the corresponding sedimentary deposits can be attributed the Middle Eocene (Lutetian). These data are similar to those presented for the Sucevița Formation by Florea (1999), from Putna - Sucevița area and by Bogatu (1999), in Soloneț – Sucevița – Moldovița area.

In conclusion, by analysing associations 1 and 2, as well as those from the base and the top, the Scorbura Formation is attributed to the interval Upper Ypresian–Lutetian interval. In the same time, we have to mention that the Scorbura sandstones from the upper part, above the silicolitic level, which are in direct contact with the Doamna limestones, could represent the equivalent of the sandstones with asterocycline separated south from Putna river, in the Moldoviței river basin by Ionesi (1961, 1971) and Sucevița river basin by Florea (1999) (fig. 5 and Plate II).

The nannoplankton associations identified in the Doamna limestone and Vițeu sandstone Formation and in the calcareous-sandy flysch at the upper part of Scorbura-Tazlău Formations, plead for their isochronism.

In the deposits of Doamna limestone and Vițeu sandstone Formation an association was identified, including: *Micrantolithus vesper* Deflandre; *Rhabdosphaera tenuis* Deflandre; *Discoaster sp.*; *Zigrablithus bijugatus* Deflandre; *Coccolithus pelagicus* (Wallich) Schiller; *Laternithus minutus* Stradner; *Rhabdosphaera inflata* Bramlette et Sullivan; *Discoaster saipanensis* Bramlette et Riedel; *Sphenolithus predistentus* Bramlette and Wilcoxon; *Sphenolithus moriformis* Deflandre; *Sphenolithus radians* Deflandre; *Isthmolithus sp.*; *Braarudosphaera bigelowi* Bramlette et Braar.; *Discoaster martini* Stradner; *Scyphosphaera terescenis*; *Chiasmolithus oamaruensis* (Deflandre) Hay et Mohler; *Chiasmolithus solitus* Bramlette et Sullivan and *Chipragmalithus cristatus* (Martini).

Analysing the identified association, a series of taxa with biostratigraphic importance for the upper part of the Middle Eocene (Bartonian) can be noticed. Therefore, *Chiasmolithus oamaruensis* has its first appearance next to *Sphenolithus predistentus* which starts in NP17 Biozone, *Chiasmolithus solitus* being extinct. The presence of these taxa defines NP17 Biozone with *Discoaster saipanensis* according to Perch-Nielsen biozonation (1985). Besides the mentioned taxa, *Rhabdosphaera tenuis*, *Discoaster saipanensis, Laternithus minutus*, *Chiasmolithus solitus* appear, which are common for NP17 Biozone. The stratigraphic interpretation of the calcareous nannoplankton association allows us to assign the Doamna limestone and Vițeu sandstone Formation to the Bartonian.

The association determined in the upper part of Scorbura-Tazlău Formation is made up of: *Coccolithus eopelagicus* Bramlette et Sullivan; *Coccolithus crassus* Bramlette and Sullivan; *Zigrablithus bijugatus* Deflandre; *Rhabdosphaera sp. af. Inflata* Bramlette et Sullivan; *Discoaster saipanensis* Bramlette et Riedel; *Discoaster barbadiensis* Tan Sin Hok; *Sphenolithus predistentus* Bramlette and Wilcoxon; *Rhabdosphaera tenuis* Deflandre; *Reticulophenestra umbilica* Levin (Martini and Ritzkowski); *Chiasmolithus oamaruensis* (Deflandre) Hay et Mohler; *Chiasmolithus consuetus* Bramlette and Sullivan; *Chiasmolithus solitus* Bramlette et Sullivan; *Coronocyclis nitescens* (Kamptner) Bramlette and Wilcoxon; *Laternithus minutus* Stradner; *Braarudosphaera bigelowi* Bramlette et Braar.; *Scyphosphaera sp. cf expansa* Stradner; *Rhabdolithus sp.* and *Reticulophenestra sp.*

The biostratigraphic significance of this association is similar to the one described in the Doamna limestone Formation in Scorbura–Doamna Lithofacies (characterizing NP17 Biozone). This feature does not justify the assignment of the turbiditic level in the upper part of Scorbura–Tazlău Formation to the Bartonian and, at the same time, its correlation with Doamna limestone Formation in the eastern lithofacieses. This interpretation is emphasized by the fact that, geometrically, the turbiditic level can be found immediately under the silto-pelites of Plopu Formation, a lithostratigraphic context similar to that of Doamna limestone and Vițeu sandstone Formation under the Plopu–Bisericani Formation. The above mentioned aspects are confirming the position expressed by Ionesi (1999) who attributed, on the basis of the Nummulites fauna, an Upper Ypresian–Bartonian age to the Tazlău Formation.

If we conclude on the chronostratigraphic significance, we can state that the Sucevița and Scorbura Formations belong to the Upper Ypresian–Lutetian interval, the Doamna limestone and Vițeu sandstone Formation belongs to the Bartonian while the Scorbura–Tazlău Formation extends in the Upper Ypresian–Bartonian interval.

Priabonian

At the level the Priabonian the sedimentation conditions become relatively uniform in the studied perimeter from the Suceava river basin. In the eastern part, in the areas of Doamna and Scorbura-Doamna Lithofacieses, deposits in Plopu–Bisericani facies (*sensu* Micu, 1981; Juravle, 2007) were described, and in the western part, in the Scorbura–Tazlău Lithofacies, deposits in Plopu facies (*sensu* Atanasiu, 1943; Ionesi, 1971) were identified. The Priabonian column ends in the outcrop area of the Plopu-Bisericani facies with deposits belonging to the Lucăceşti sandstone and the marls with globigerinae Formation, while in the area of Plopu facies with the deposits of the Lucăceşti-Lupoaia Formation (*sensu* Ionesi, 1971; Juravle, 2004, 2007) (fig. 5).

Plopu-Bisericani Formation (*sensu* Micu, 1981; Juravle, 2007). This formation included deposits that are predominantly silto-lutitic which have Doamna limestone and Viţeu sandstone Formation in the base, and they have the Lucăceşti sandstone and the marls with globigerinae Formation in their top.

The formation starts the *Strujinoasa red clays Member* (*sensu* Joja, 1957), made up of a variegated alternation of red-brown, green clays, grey clays subordinately, with small sized hieroglyphs on the base. The thickness of this member is appreciated to be 10-30 m.

At the upper part, the *green and grey clays Member* follows (*sensu* Ionesi, 1971), with a stratigraphic thickness of 120-150 m. Lithologically, it is made up of a monotonous alternation of rhythmic sequences of green and grey clays and siltites, with grey (sometimes green) glauconitic quartz sandstones and litic sandstones, grey or blackish, with hieroglyphs on the base and with a convolute structures at the top.

As compared to the lithological column of the stratotype described on the Bisericani brook (left tributary of the Bistriţa) by Athanasiu in 1921, re-analysed by Grasu et al. (1988), corroborated with the data presented by Ionesi (1971) in the Moldova river basin, Florea (1999) in the Suceviţa river basin and Bogatu (1999) in Soloneţ – Suceviţa – Moldoviţa sector, we could noticed that in the Suceava river basin the intercalations of arenitic material become more important quantitatively, representing up to 40-50% of the column. In this context, the described lithostratigraphic succession closer to that of Micu (1981), can by separated in the external skibes of the right Suceviţei basin as a transition facies, defined as the „Plopu–Bisericani layers".

Plopu Formation (*sensu* Atanasiu, 1943). This lithostratigraphic unit follows next on the top of the deposits of the Scorbura-Tazlău Formation, and has in its top the Lucăceşti–Lupoaia Formation.

Over the calcareous-sandy flysch of Scorbura-Tazlău *the red and green clays Member* follows, 10-25 m thick, made up of an alternation of red and green clays, with intercalations of greenish quartz sandstones, calcareous sandstones, weakly micaceous sandstones, with gradual sorting, displayed in 10-20 cm layers, with hieroglyphs on the base.

The sequence ends with *the green and grey clays Member,* 150–200 m thick, made up of silto-lutitic sequences of clays and green, grey-greenish and grey calcareous clays. These alternate with the arenitic sequences represented by greenish quartz sandstones and grey calcareous sandstones, displayed in 10-30 cm thick layers, with hieroglyphs in the base, and sometimes with concoidal or convolute structure at the upper part.

Lucăceşti sandstone and marls with globigerinae Formation. This lithostratigraphic unit ends the Eocene lithologic column, including in its top, the brown Lingureşti marls of the inferior menilite Formation.

Lithologically, they are made up of silto-lutitic sequences represented by grey, greenish, whitish, brown and rubanated marls and yellowish or grey pelitomorph limestones, in which grey-olive calcareous coarse sandstones with elements of green rocks, whitish Lucăceşti Kliwa-type quartz sandstones, and grey-whitish, weakly calcareous sandstones are intercalated. At the upper part, the sandstones are coarse, with micro-ruditic aspect, sometimes with lentiform development, with variable thickness from 10 cm to 50-60 cm. In the lower part, 30-60 cm thick quartz Kliwa-type sandstones and calcareous sandstones are identified. In the present case, the Lucăceşti sandstone does not occur as a distinct layer at the upper part of the marls with globigerinae, but it crops out as interlayers at different levels.

Lucăceşti–Lupoaia Formation. On the top of the Plopu Formation, quartz sandstones with Kliwa-type aspect, whitish or yellowish, brownish in certain sequences, transforming into weakly calcareous varieties, are displayed. They are massive, forming 1-2 m or 40-80 cm thick layers. The silto-lutitic intercalations are quantitatively subordinately.

Grasu et al. (1988) studies, in the stratotype area, from a chemical and mineralogical point of view, the deposits of Lupoaia Formation, over a thickness of 38 m, pointing out, despite the apparent lithological monotony in the field, a great petrographic variety: glauconitic quartz-arenites, subfeldspar arenites, graywache convolute, calcareous sandstones, sandy biosparites with transition to quartzilitic biosparites and clays. The rocks corresponding to the Lucăceşti sandstones are included in the category of glauconitic quartz-arenites and calcareous sandstones.

The chronostratigraphic dating of the formations has been done, as in the case of the lithostratigraphic units previously presented, on the basis of the superposition geometric relationship and of the identified nannoplankton associations.

The biostratigraphical analysis of the identified associations shows the fact that the Plopu-Bisericani and Plopu Formations, on one side, and Lucăceşti sandstone and marls with Globigerinae and Lucăceşti–Lupoaia marls on the other side, are isochrone.

The analysed samples from *Plopu–Biserican Formation*, collected from the two members, revealed two associations that contain the following taxa: Association 1 with: *Discoaster barbadiensis* (Tan Sin Hak); *Discoaster deflandres* Bramlette et Riedel; *Cycloccolithus formosus* (Black, Hay et al.); *Neococolithes (Zygolithus) dubius* (Deflandre); *Rhabdosphaera. tenuis* Deflandre; *Coccolithus pelagicus* (Walich, Schiller); *Chiasmolithus consuetus* Bramlette and Sullivan; *Reticulophenestra minuta* Müler; *Discoaster tani* Prins; and Association 2 with: *Discoaster saipanensis* Bramlette et Riedel; *Discoaster barbadiensis* Tan Sin Hok; *Discoaster tani* Prins; *Isthmolithus recurvus* Deflandre; *Rhabdosphaera tenuis* Deflandre; *Cyclicargolithus floridanus* Martini; *Reticulofenestra umbilica* (Levi) Martini et Ritzkovschi; *Zygrablithus bijugatus* Deflandre; *Sphenolithus moriformis* Deflandre; *Laternitus minutus* (Stradner); *Coccolithus pelagicus* Bramlette and Sullivan; *Sphenolithus predistentus* Bramlette and Wilcoxon; *Braarudosphaera bigelowii* (Gran et Braarud) Deflandre (fig. 5 and Plate III).

Association 3 was identified in the deposits of the Plopu Formation, being made up of the following taxa: *Discoaster saipanensis* Bramlette et Riedel; *Discoaster barbadiensis* Tan Sin Hok; *Isthmolithus recurvus* Deflandre; *Rhabdosphaera tenuis* Deflandre; *Cyclicargolithus floridanus* Martini; *Reticulofenestra umbilica* (Levi) Martini et Ritzkovschi; *Zygrablithus bijugatus* Deflandre; *Sphenolithus moriformis* Deflandre; *Discolitina plana* (Levin); *Helicosphaera seminulum lophota* Bramlette et Sullivan; *Coccolithus crassus* Bramlette et Sullivan (fig. 5 and Plate III).

In this respect, one can notice that in *association 1* biozone index taxa do not appear, the determinant species evolving in a wider stratigraphic spectre. Therefore, *Discoaster barbadiensis* is being extinct, this taking place in NP20 Biozone, same way as *Neococcolithus dubius* taxon (Bratu et Gheța 1972). *Reticulophenestra minuta* appears in NP18 Biozone, the middle part, and its extinction occurs in NP23 Biozone, the upper part, *Discoaster tani* appears in NP17 Biozone, the middle part, and evolves up to NP23 Biozone, the middle part (Perch-Nielsen, 1983). Gartner (1968) cites the same taxon in the NP10-NP17 Biozones (Middle Eocene – Upper Eocene), Hamilton et al. (1985, fide Florea, 1999) in the NP12-NP15 Biozones in England, and Lebenson (1972 a) in the NP_{19}-NP21 Biozones. On the basis of the presence of *Reticulophenestra minuta*, it is considered that the deposits of the green and red clays Member is included in the NP18 Biozone, especially because it is locadet below the deposits of the grey and green clays Member belonging to the NP19 Biozone. In this case, the age of the Member of the green and red clays, is Lower Priabonian, in agreement with the other biostratigraphic information available at present.

In *association 2* the presence of *Isthmolithus recurvus* is noticed, whose first occurrence marks the basis of NP19 Biozone, bearing its name. Besides this, other taxa also appear: *Cyclicarglolithus floridanus, Zygrablithus bijugatus, Reticulofenestra umbilica, Rhabdosphaera tenuis, Lanternithus minutus* and *Sphenolithus predistentus* which are common species for the calcareous nannoplankton association in NP19 Biozone.

In association 3, *Isthmolithus recurvus* also appears, whose first occurrence marks the base of NP19 Biozone, besides *Cyclicarglolithus floridanus, Zygrablithus bijugatus, Reticulofenestra umbilica, Rhabdosphaera tenuis, Lanternithus minutus* and *Sphenolithus predistentus*, frequent species in the association characteristic to NP19 Biozone.

According to the presented biostratigraphical data, the determined associations in the deposits of Plopu-Bisericani and Plopu formations are included in NP19 Biozone, which pleads for the

Priabonian age, and at the same time for their isochronism.

As for the stratigraphic position of the Lucăceşti sandstone Formation and of the marls with globigerinae and the Lucăceşti-Lupoaia marls, we relied on the information supplied by Bogatu (1999) and Florea (1982, 1999) in the Moldoviţa and Suceviţa river basins and by Juravle (2004, 2007) in the Suceava valley.

The associations of calcareous nannoplankton in the Moldoviţa river basin are made up of taxa like *Isthmolithus recurvus* Deflandre, *Cyclococcolithus formosus* Kamptner, *Coccolithus crassus* Bramlette et Sullivan, *Scyphosphaera tubicena* Stradner, *Rhabdolithus creber* Deflandre, *Coccolithus eopelagicus* Bramlette et Riedel, *Zygrablithus bijugatus* Deflandre, *Micrantolithus inaequalis* Martini, *Micrantolithus vesper* Deflandre, *Chiasmolithus oamaruensis* Deflandre and *Chiasmolithus solithus* Bramlette et Sullivan, being similar to those in the Putna - Suceviţa area (with *Isthmolithus recurvus* Deflandre, *Cyclococcolithus formosus* Kamptner, *Lanternithus minutus* Stradner*, Zygrablithus bijugatus* Deflandre, *Dictyococcites dictyodus* (Deflandre et Fert), *Micrantolithus vesper* Deflandre, *Cyclocargolithus floridanus* (Roth et Hay, Bukry).

In the Suceava Valley the following taxa were identified: *Isthmolithus recurvus* Deflandre; *Cyclococcolithus formosus* Kamptner; *Lanternithus minutus Stradner*, *Zygrablithus bijugatus* Deflandre; *Dictyococcites dictyodus* (Deflandre et Fert); *Micrantolithus vesper* Deflandre; *Cyclocargolithus floridanus* (Roth et Hay) Bukry; *Discoaster saipanensis* Bramlette et Riedel; *Sphenolithus moriformis* Deflandre; *Coccolithus eopelagicus* Bramlette et Riedel; *Corranulus germanicus* Stradner; *Sphenolithus predistentus* Bramlette and Wilcoxon

The associations are common to NP20-NP21 Biozones, fact that is demonstrated by the presence of the following taxa *Isthmolithus recurvus* Deflandre, *Cyclococcolithus formosus* Kamptner, *Coccolithus eopelagicus* Bramlette et Riedel, *Zygrablithus bijugatus* Deflandre, *Micrantolithus vesper* Deflandre, *Lanternithus minutus* Stradner*, Dictyococcites dictyodus* (Deflandre et Fert), *Cyclocargolithus floridanus* (Roth et Hay) Bukry. As for the *Corranulus germanicus* taxon, authors like Martini et al. (1986), Mészáros et al. (1991) and Gheţa (1972) agree that this evolves in NP19 and NP20 Biozones. Lebenson (1972 a) considered that this taxon appears in a level inferior to NP18 Biozone and develops up to NP21 Biozone.

Considering the above mentioned data, the Priabonian age is attributed to the deposits of the Lucăceşti sandstone formations and to the marls with globigerinae and Lucăceşti–Lupoaia marls, on the basis of the identification of the NP20-NP21 Biozones (fig. 5 and Plate III).

CONCLUSIONS

As a conclusion, the data presented in this paper analyse a series of lithostratigraphic landmarks in the eastern part of the external flysch (Tarcău Nappe) in the Suceava river basin. This approach was necessary due to the particular lithostratigraphic context in which the Eocene deposits of the Tarcău Nappe develop, identified as transition area between the facieses situated north of the Suceava Valley (Suceava – Ceremuş) and those in the southern areas, in the Bistriţa and Putna Vrânceana river basins.

In this paper, we have demostrated the continuity towards south, from the Suceava Valley at least up to the Suceviţa – Rusca – Hojdeni alignment, of the lithostructural context described by Juravle (2004, 2007) and a chronostratigraphic dating of the lithostratigraphic mapped units has been realized, on the basis of the nannoplankton associations identified by Bogatu (1999), Florea (1990, 1999), Juravle (2004, 2007) and the data available in the references.

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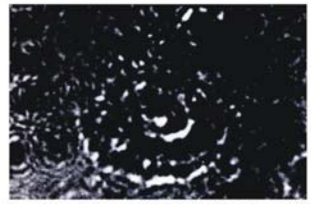
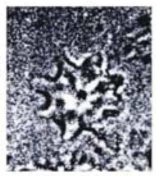
Calcareous nannoplankton associations - Izvor Unit


Chiasmolithus danicus, (Brotzen); n.x., x2300


Chiasmolithus danicus, (Brotzen); l.n., x2800


Coccolithus pelagicus, (Walick, Schiller); l.n., x2800


Discoaster salisburgensis, Stradner; l.n., x25 00


Discoaster falcatus, Bramlette and Sulivan; l.n., x25 00

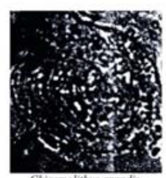

Discoaster multiradiatus, Bramlette and Riedel; l.n., x25 00


Micrantolithus pinguis, Bramlette and Sullivan; l.n., 3000

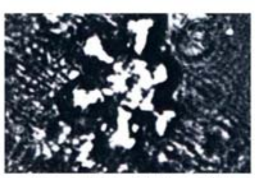
Calcareous nannoplankton associations - Straja Unit


Chiasmolithus eograndis, Bramlette and Riedel; l.n., x2800

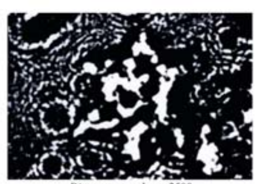

Chiasmolithus solithus, Bramlette and Sullivan; l.n., x2300

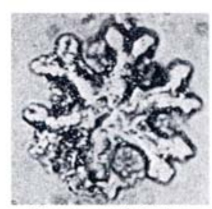

Chiasmolithus grandis, (Bramlette and Riedel); l.n., x2800

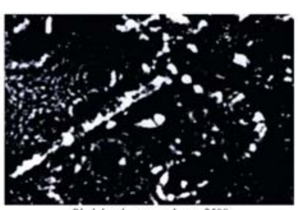

Discoaster lodoensis, Bramlette and Riedel; l.n., x3000


Discoaster distinctus, Martini; l.n., x2800


Discoaster germanicus, Martini; n.x., x2000

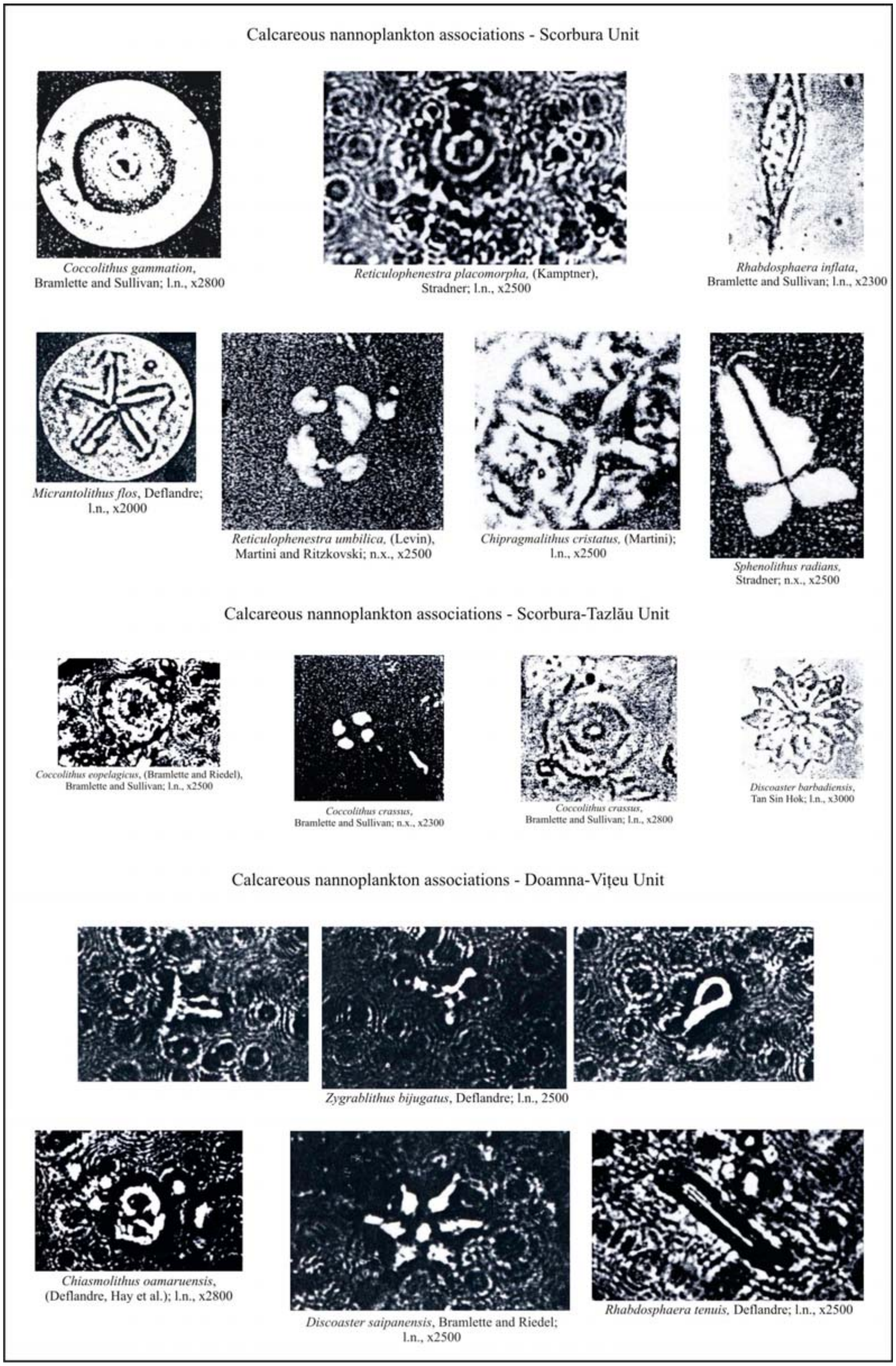

Discoaster sp.; l.n., x2500


Discoaster gemmifer, Stradner; l.n., x3000


Rhabdosphaera sp.; l.n.., x2500


Rhabdosphaera truncata, Bramlette and Sullivan; n.x., x2300


Rhabdosphaera truncata, Bramlette and Sullivan; l.n., x2300



Calcareous nannoplankton associations - Scorbura Unit

Coccolithus gammation, Bramlette and Sullivan; l.n., x2800

Reticulophenestra placomorpha, (Kamptner), Stradner; l.n., x2500

Rhabdosphaera inflata, Bramlette and Sullivan; l.n., x2300

Micrantolithus flos, Deflandre; l.n., x2000

Reticulophenestra umbilica, (Levin), Martini and Ritzkovski; n.x., x2500

Chipragmalithus cristatus, (Martini); l.n., x2500

Sphenolithus radians, Stradner; n.x., x2500

Calcareous nannoplankton associations - Scorbura-Tazlău Unit

Coccolithus eopelagicus, (Bramlette and Riedel), Bramlette and Sullivan; l.n., x2500

Coccolithus crassus, Bramlette and Sullivan; n.x., x2300

Coccolithus crassus, Bramlette and Sullivan; l.n., x2800

Discoaster barbadiensis, Tan Sin Hok; l.n., x3000

Calcareous nannoplankton associations - Doamna-Vițeu Unit

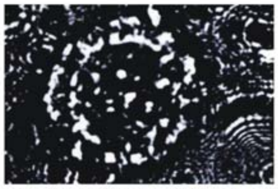
Zygrablithus bijugatus, Deflandre; l.n., 2500

Chiasmolithus oamaruensis, (Deflandre, Hay et al.); l.n., x2800

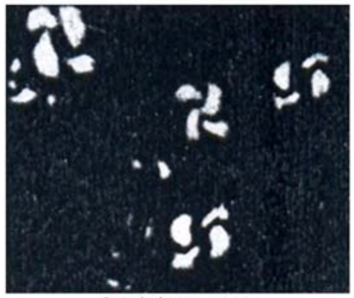
Discoaster saipanensis, Bramlette and Riedel; l.n., x2500

Rhabdosphaera tenuis, Deflandre; l.n., x2500

Calcareous nannoplankton associations - Plopu-Bisericani Unit



Cyclococcolithus formosus, (Black), Hay et al.; n.x., x3000



Reticulophenestra minuta, Müller; l.n., x2500

Cyclococcolithus floridanus, (Roth et Hay), Mohler; n.x., x2000

Reticulophenestra umbilica, (Levin), Martini and Ritzkovski; n.x., x2500

Cyclococcolithus formosus, (Black), Hay et al.; l.n., x2500

Calcareous nannoplankton associations - Plopu Unit

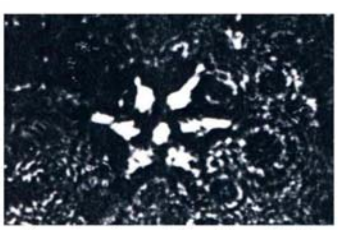
Isthmolithus recurvus, Deflandre; n.x., x2300

Discolithina plana, Levin; l.n., x2500

Isthmolithus recurvus, Deflandre; l.nx., x2800

Helicosphaera seminulum lophota, Bramlette and Sulivan; l.n., x2500

Calcareous nannoplankton associationsand - Lucăceşti-Lupoaia Unit



Discoaster saipanensis, Bramlette and Riedel; l.n., x2500

Dictyococites dyctiodus, (Deflandre and Fert); l.n., x2300