STUDIA UNIVERSITATIS BABEŞ-BOLYAI, GEOLOGIA, XLVI, 2, 2001, 109-114

THE SPATIAL EXTENSION AND THE AGE OF THE TOMNATEC FORMATION IN AUDIA NAPPE

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KEYWORDS: Thanetian – Priabonian, calcareous nannoplankton, Tomnatec Formation, Audia Nappe, East Carpathian Flysch

In the northern area of Audia Nappe, in between Sălătruc River (a right hand tributary of Moldova River) and the northern border of our country, the Tomnatec Formation crops out. It unconformably overlies the Variegated Formation (Vraconian - Maastrichtian) and is covered by Ionul Formation (Priabonian). We have to mention that the Tomnatec Formation is better developed in the eastern part of Audia Nappe whereas on the rest of it crops out only sporadically. On this basis Ionesi divided Audia Nappe (1965, p. 66-67) in two digitations: the lower one, Prisaca Digitation, in the eastern part and the upper one, Black Shales' Digitation, in the western part. The Black Shales' Digitation is overthrusting upon the Prisaca Digitation after the Feredeu Fault. The lower digitation is tectonically subsided which could explain the better preservation of it while the upper digitation is tectonically uplifted. The upper digitation position is supposed to be the explanation for the missing of Tomnatec Formation from it. The same interpretation was reconsidered and developed by Ionesi (1971, p 157-158).

The two digitation defined by Ionesi (1965) are represented also on Geological Map of Romania (Câmpulung Map, 1:50 000; Săndulescu et al., 1987) edited by Geological and Geophysical Institute of Romania. Săndulescu (1984, p. 264-265), in Geotectonica României (*Geotectonics of Romania*) paper, names the Black Shales' Digitation as Inner Digitation. He also considers it as being an equivalent of Cernahora Unit (s. s.) is extended to south along the Audia Nappe. This means that the sandstone which cover the Variegated Formation could be equivalent to Siriu Sandstone (Senonian - Paleocene) and not to Prisaca Sandstone (= Tomnatec Sandstone) of the same digitation.

This point of view is again defended by Săndulescu et al. (1990, 1993). In the latter paper the authors exclusively study the sandstone of the inner digitation, which is named Benia Digitation. This sandstone is given the same name as the digitation (Benia Sandstone). The authors think that this sandstone is Santonian - Lower Campanian (?) while the sandstone of Prisaca Digitation is considered to be Maastrichtian - Lutetian age.

We consider the above introduction as being useful in the development of our paper.

We propose the name Feredeu Digitation for former named Black Shales'

Digitation (Ionesi, 1965, 1971) or Inner Digitation (Săndulescu, 1984) or Benia Digitation (Săndulescu et al., 1990, 1993) having in view the name of the front fault, Feredeu Fault (Ionesi, 1965, 1971).

The sandstones which unconformably cover Variegated Formation were distinguished by Paul (1876) and incorporated in the "Middle Carpathian Sandstone" (Cretaceous age). Athanasiu (1913) names them Tomnatec Sandstone and places them in Cenomanian - Senonian span. Later on, Macovei (1927) matches them with Tarcău Sandstone (Eocene age). Băncilă (1955, 1958) concludes that these sandstones are older, Senonian - ?Eocene, and names them Prisaca Sandstone. On the basis of priority principle the name Tomnatec Sandstone (Athanasiu, 1913) has to prevail. The combined terms, Tomnatec - Prisaca or Prisaca - Tomnatec (used by us), are not admitted by Hedberg Code. Most part of petrographic and biostratigraphic data, except the ones provided by Săndulescu et al. (1993), are referred to as sandstones of Prisaca Digitation.

Petrographically, Tomnatec Formation is formed by quartzose - feldsparic, feldsparic, lithic and litho - feldsparic sandstones (Ionesi et al., 1998; Turturean 1999). All the sandstone varieties mentioned above also contain micas flakes, especially muscovite. The sandstones are interbedded with siltstones and greenish - grey, rarely red, claystones. On Gavriloi River, south of Moldova Valley, crops out a conglomeratic unit (<12 m) with clasts from Audia Formation (opalithe, quartzose sandstones) and of crystalline schists. The conglomeratic unit has lens shape so that it cannot be used as a marker level. On the basis of sandstone varieties, Turturean (1999) divides the Tomnatec Formation in 4 members:

1. the member of quartzose - feldsparic sandstones;
2. the member of lithic and litho - feldsparic sandstones;
3. the member of claystones and microconglomerates;
4. the member of feldsparic and lithic sandstones.

Despite their mineralogical composition the field appearance is uniform.

Ionesi (in Ionesi et al., 1998) signalled a unit of paraconglomerates, ruditic sandstones with clasts from Audia and Variegated formations (<30 m), rhythmic alternation of thin quartzose sandstones and green claystones (5 m) and a microconglomeratic bed (0,8 m) with feldsparic and quartzose clasts. The later one crops out on Demăcuşa River and can be followed up to Roşoşa River. To the southern area of Boului Valley it is hidden under Feredeu Fault plane, in front of Feredeu Digitation.

The age of Tomnatec Formation was and still is a controversial problem. At the beginning it was dated on geometrical position and lithological aspect. On this basis Paul (1860) and Athanasiu (1913) consider it as Cretaceous age because it reposed on the same age deposits while Macovei (1927) dates it as Eocene age because of its resemblance with Tarcau Sandstone. Even if after 1950s paleontological proves (from agglutinate microforaminifera, macroforaminifera, palinomorphes, calcareous nannoplankton) were provided the age of this formation is still a matter of controversy.

Consequently, the Tomnatec Formation was dated back in Upper Turonian - Eocene (Băncilă, Agheorghiesei, 1964; Agheorghiesei et al., 1965); the sandstones from Prisaca Digitation were dated as Maastrichtian - Lutetian (Săndulescu et al., 1990); the sandstones from Benia Digitation were considered Santonian - ?Lower

Campanian (Săndulescu et al., 1993). The entire formation was placed in Paleocene? - Eocene span (Ionesi, 1963, 1965, 1971, 1974; Ionesi et al., 1967), in Paleocene - Lutetian span (Ion, 1957) and Upper Thanetian? - Priabonian (Ionesi et al., 1998; Turturean, 1999).

Up to 1990 the massive sandstones in Audia Nappe were considered globally and of the same age, but afterwhile the matter became more complicated. On some agglutinante foraminifera (*Dendrophyra robusta*, *Dendrophyra excelsa*, *Carpatiella ovulum ovulum*, *Carpatiella ovulum giganthea* etc) and palinomorphes assemblages Săndulescu et al (1990, 1993) differently date the sandstones according to their positions in digitations: those from Prisaca in Maastrichtian - Lutetian span and those from Benia Digitation in Santonian -?Lower Campanian. The different ages attributed to the sandstones determined us to take also into consideration the calcareous nannoplankton content of which biostratigraphic value is well known.

Ionesi et al. (1998) and Turturean (2000) analysing the calcareous nannoplankton prove that the lowermost part of Tomnatec Formation, in Prisaca Digitation, belongs to NP_9 biozone (*Cruciplacolithus tenuis*, *Discoaster multiradiatus*, *Fasciculithus tympaniformis* etc), corresponding to Uppermost Thanetian or Lowermost Ypresian. The upper part of Tomnatec Formation belongs to NP_{20} (*Sphenolithus pseudoradians, Lanternitus minutus, Istmolithus recurvus*, *Discoaster barbadiensis* etc) which means Priabonian age. The Variegated Formation, covered by Tomnatec Sandstone, is attributed to Vraconian (CC_9) - Upper Maastrichtian (CC_{26}) on the basis of calcareous nannoplankton. This fact means that between the Variegated Formation and Tomnatec Formation there is a stratigraphic gap which corresponds to Paleocene.

In order to verify if the same situation exists in Feredeu Digitation too (equivalent with Benia Digitation named by Săndulescu et al., 1993) we analysed the calcareous nannoplankton contained in deposits beginning from the lowermost part up to Demăcuşa level of this formation.

As in the case of Prisaca Digitation the sandstones cover the Variegated Formation. We also recognise the Demăcuşa mark bed, which crops out on the right side of Benia River, near the confluence with Tomnatec River. This is formed by coarse sandstones, rich in micas flakes (mainly muscovite), with large lithoclasts from Audia Formation as well as claystone clasts (possibly from Variegated Formation) (8 - 10 m or more). They are covered by microconglomerate unit (0,8 m) with feldspar (including orthose), quartz, and some lithic fragment (from Audia Formation) grains. The rhythmic flysch doesn't appear. Sandstones with lithic clasts probably substitute it. The sandstone with lithic clasts and microconglomeratic units are placed at 300 m above the boundary with Variegated Formation. Between the Variegated Formation and the units mentioned above there are massive sandstones (300 m). The upper part of Demăcuşa mark bed does not crop out being in tectonic relationships with Audia Formation.

The sandstones with lithic clasts also crop out on Sulița River. The best exposure is on Feredeu River and on Benia River downstream of the confluence with Feredeu River.

The lowermost part of Tomnatec Formation and the boundary with Variegated Formation crop out on Feredeu River. There is an unexposed part (5 m) between

variegated claystones and Tomnatec Sandstone after which there crops out grey claystone (3m). In these claystones (the sample no 9418) there were determined taxa, as follows: *Fasciculithus tympanoformis* (which marks the bottom of NP_5 biozone and disappear in NP_9 biozone), *Fasciculithus lillianae* and *Fasciculithus aubertae* (common in NP_9 biozone), *Fasciculithus clinatus* (NP_7 - NP_9), *Braarudosphaera bigelowi* (mainly common in NP_2 - NP_{21}), *Chiasmolithus consuetus* (NP_5 - NP_9), *Heliolithus kneipellii* (NP_6 - NP_9), *Cruciplacolithus tenuis* (NP_2 - NP_9), *Ellipsolithus macellus* (NP_4 - NP_{12}) and *Marcalius inversus* (Cretaceous - NP_{23}). There are also some taxa reworked from Upper Cretaceous. The biostratigraphic value of these taxa (offered in the brackets after each bioform according to monography of Perch - Nielsen, 1965) proves that the deposits belong to NP_9 biozone (possibly its lower part) Uppermost Thanetian in age. The same situation was reported for Prisaca Digitation on Ionul River.

The two others analyzed samples (9412, 9414) were took from claystone interbeddings among sandstone beds at the 80 stratigraphic thickness above the already described sample. The taxa assemblage of the two samples is formed by *Discoaster deflandrey* (NP_{10} - NP_{25}), *Discoaster multiradiatus* (NP_9 - NP_{11}), *Discoaster mohleri* (upper part of NP_7 - NP_9 biozone), *Ellipsolithus macellus* (NP_4 - NP_{12}), *Braarudoshaera bigelowi* (NP_2 - NP_{21}), *Fasciculithus tympaniformis* (NP_5 - NP_9), *Rhabdosphaera pinguis*, *Rhabdosphaera scabrosa* and *Helicosphaera semilunum* (Lower and Middle Eocene). According to the evolution span of the determined taxa (the extinction of some of them in NP_9 and the apparition of *Discoaster multiradiatus* in NP_9) we think that the nannoplankton assemblage belongs to upper or even uppermost part of NP_9 biozone (Lower Ypresian). The NP_9 biozone has a large age span between Upper Thanetian and Lower Ypresian.

The next claystone unit (1 m), at 35 - 40 m stratigraphic thicknesses from the above ones, was also analyzed. The sample 9428 contains taxa as follows: *Discoaster martinii* (NP_{15} - NP_{16}), *Discoaster saipanensis* (NP_{15} - NP_{20}), *Rhabdosphaera inflata* (upper part of NP_{14} - lower part of NP_{15}), *Rhabdosphaera crebra* (NP_{15} - NP_{19}), *Rhabdosphaera pinguis* (Lower and Middle Eocene), *Lanternithus minutus* (NP_{15} - NP_{21}), *Nannotherina cristata* upper part of NP_{14} - NP_{15}), *Chiasmolithus solitus* (NP_{10} - NP_{16}). The presence of some taxa with apparition or with extinction in NP_{15} (Lutetian) makes us to place the assemblage in this biozone. In the same sample there were also identified some taxa of *Fasciculithus tympaniformis*, *Helicolithus kleinpelii*, *Cruciplacolithus tenuis* which we consider to be reworked because they evolved only up to NP_9 biozone.

After another 50 m stratigraphic thickness the 9432 sample was taken which contains *Reticulosphaera umbilica (*NP_{16} - NP_{22}), *Sphenolithus predistentus* (NP_{14} - NP_{25}), *Discoaster deflandrei* (NP_{10} - NP_{25}), *Zygrhablithus bijugatus* (NP_{11} - NN_1), *Braarudosphaera bigelowi* (Cenomanian - Lower Miocene), *Rhabdosphaera scabrosa* and *Rhabdosphaera crebra* (Lower and Middle Eocene), *Helicosphaera compacta* (NP_{17} - NP_{24}). The later taxon determines us to place the above listed assemblage in NP_{17} biozone (Bartonian).

The last one sample was taken at 25 m beneath the Demăcuşa mark bed. The taxa assemblage contains *Sphenolithus radians* (NP_{11} - NP_{19}), *Sphenolithus predistenus* (NP_{14} - NP_{25}), *Chiasmolithus consuetus* (NP_5 - NP_{19}), *Reticulofenestra umbilica* (NP_{16} - NP_{22}), *Zygrhablithus bijugatus* (NP_{11} - NN_1). We think that this assemblage belongs to the upper part of NP_{18} biozone, which is Priabonian age.

An argument for this interpretation would be the inferred age for the rhythmic flysch (5 m) of Demăcuşa mark bed which belongs to lower part of NP_{19} biozone (Ionesi et al., 1998; Turturean, 1999).

Conclusions

The massive sandstones of Feredeu Digitation (named by Săndulescu et al., 1993 as Benia Sandstone) are equivalent to those of Prisaca Sandstone, which means they had to be named in the same way, that means Tomnatec Sandstone (Athanasiu, 1913) or Tomnatec Formation, on the priority rule basis. We argue this with the following arguments:

1. In both of the digitations, the Tomnatec Formation covers the Variegated Formation. Although between the Tomnatec and Variegated formations there seems to be conformable relationships, on nannoplankton stratigraphic value basis we proved that there is a gap corresponding with NP_1 – NP_9 biozones (Paleocene but not Thanetian).
2. In both digitations we recognized the Demăcuşa mark bed in Tomnatec Formation.
3. Biostratigraphically, on nannoplankton data basis, the Tomnatec Formation belongs to NP_9 – NP_{20} biozones (Uppermost Thanetian or Lowermost Ypresian, Lutetian, Bartonian and Priabonian). The Bartonian deposits were dated also on large foraminifera basis (Senator mark unit).

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