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ON THE AGE OF THE SZOLNOK FLYSCH AND ITS POSSIBLE CORRELATION WITH THE CARPATHIAN FLYSCH UNITS

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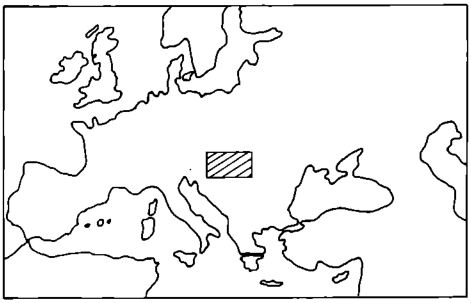
Key words: Nannoplankton, Late Cretaceous, Paleogene, Szolnok flysch, Carpathians, Hungary.



Abstract:

In the Szolnok flysch trough, beneath the Great Hungarian Plain, a more than 1000 meters thick clastic sedimentary series has been penetrated by drilling activity. This sequence is built up of rhythmic, turbidite--dominated sandstones and shales.

Earlier, the flysch was thought to be deposited during the Cretaceous and the Paleogene continuously. Detailed study of the available drilling cores proved that only a few Upper Cretaceous and Paleogene nannoplankton zones are present in the sequence and there is no proof of the others.

Evidence was found of the presence of Campanian - Lower Maastrichtian, Paleocene - Lower Eocene, Middle Eocene (Bartonian) and Lower Priabonian stages, as well as of most Oligocene nannoplankton zones.

This noncontinuous development of the Szolnok flysch sequence suggests, that it can be correlated with some of the Central ("Inner") Carpathian flysches and the correlation with the Outer Carpathian flysch units can be excluded.

Taking into consideration all the lithological and paleontological features of the Szolnok flysch, one can see a gradual change in its depositional conditions from deep-water pelagic, to a shallower, near-shore environment during the time of its formation.

1. Introduction

The Szolnok flysch has been studied earlier in detail by SZEPESHÁZY (1973). His monograph contains a number of biostratigraphical data as well. Further results of micropaleontological investigations can be found in MAJZON (1966) and SIDÓ

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(1969), but no plankton zonations were used at that time. The first nannoplankton data were published by BÁLDI-BEKE et al. (1981).

During this period of research two preliminary "postulates" developed by the end of the seventies:

1. The age of the Szolnok flysch ranges from the Early Cretaceous to the "Middle" (Late) Oligocene.

2. There was continuous sedimentation in the Szolnok flysch-belt from the Early Cretaceous until the Oligocene.

In the eighties, when there was a need to get further data on the age of the flysch sequence, one had to face the problem of the lack of samples. The core material of the previous boreholes had been handled badly, the bulk of it disappeared, or only a few cubic centimeters had been preserved in the files. The small amount of the remnant material permitted only nannoplankton investigations. More than 300 samples were available for the study presented here and about 100 of them contained calcareous nannofossils.

2. Distribution and lithostratigraphy

The Szolnok flysch trough extends beneath the Great Hungarian Plain along a SW-NE strike, from Szolnok through Debrecen up to Carei in Rumania (Figs. 1 and 2). The width of this belt rarely exceeds 30-40 kilometers.

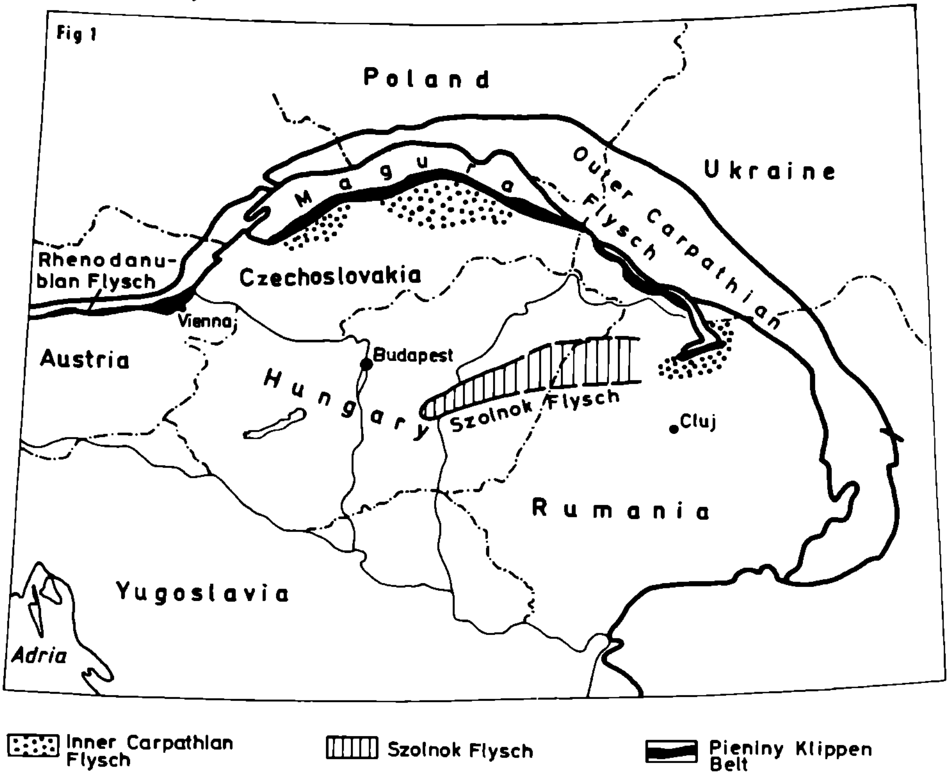

Fig. 1: Distribution of some flysch units in the Carpathian region.

th 2 to 3 kilometers of Miocene lacustrine and volcanic rocks more than of coarse and fine clastic deposits have been penetrated by drilling activity. r-15 Borehole stopped after having drilled 1,400 meters in this series. None of ; reached the basement beneath the flysch sequence, so it can be assumed ıess of the Szolnok flysch is considerably more than its upper, explored, part.

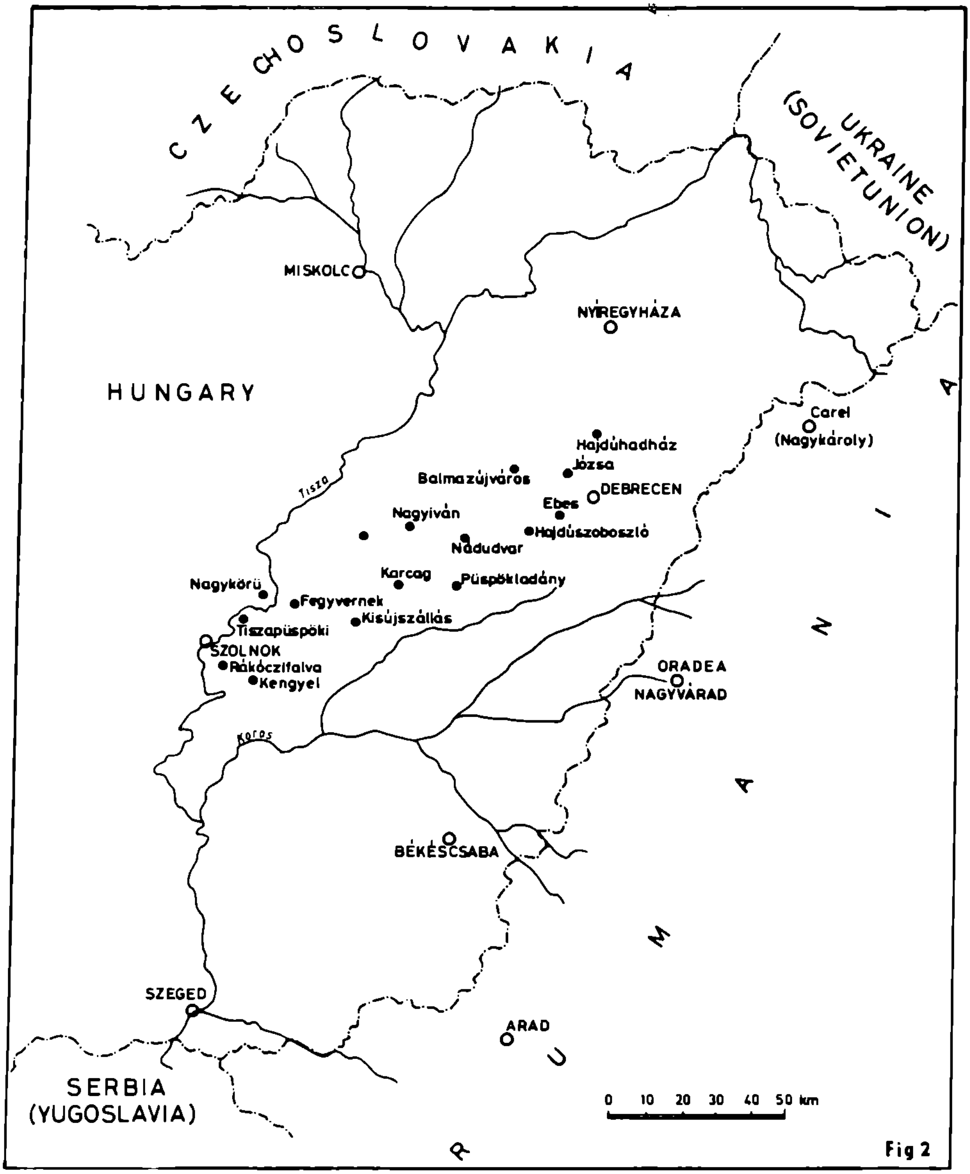

Fig. 2: Geographical position of drilling sites shown in Fig. 3.

Although more than 100 boreholes reached the Szolnok flysch, its lithological composition is poorly known because of insufficient coring. The most important rock-types are (after SZEPESHÁZY, 1973 and the original core descriptions):

1. Upper Cretaceous red and greenish-grey marls and calcareous marls, similar to those of the Púchov Marl in the West Carpathians; grey rhythmic sandstones and shales with graded conglomerates.

2. Paleocene and Lower Eocene red, green or greenish-grey, non-calcareous shales, rare marls and fine-rhythmic sandstones.

3. Middle and Upper Eocene grey and variegated shales with fine-rhythmic sandstones, badly sorted sandstones, conglomeratic sandstones, polymict conglomerates and breccias; rarely *Nummulites*- and *Lithothamnium*-bearing limestone and sandy marl (in the Hajduszoboszló-5 and-8 Boreholes).

4. Oligocene clayey marl with rare sandstone interbeds and *Lepidocyclina*-bearing conglomerate (in the Ebes-10 Borehole).

3. Nannoplankton investigations

Though only one third of the studied samples contained calcareous nannofossils, we suppose that the number of samples (more than 100) can be considered as representative from the point of view of stratigraphical evaluation (Fig. 3).

A. Late Cretaceous

Cores of four boreholes contained Upper Cretaceous nannofossils: Nádudvar-15 (1,912-1,924 m; 2,458-2,724 m), Debrecen-2 (1,519-1,532 m), Kunmadaras-3 (1,819--2,002 m) and Kunmadaras-8 (1,824-1,852 m).

The moderately poor Cretaceous nannoplankton assemblages do not enable us to fix their stratigraphical position exactly in the nannoplankton zonations. The occurrence of *Quadrum trifidum* and *Ceratholithoides aculeus* in the Debrecen-2 Borehole determines its age between the limits of the Late Campanian and Early Maastrichtian. The Cretaceous sections of the Nádudvar-15 Borehole can also be fixed in the Late Campanian , based on the occurrence of *Eiffellithus eximius* and *Arkhangelskiella specillata.* The Cretaceous cores of the Kunmadaras-3 and -8 Boreholes contain a few specimens of *Micula* sp., thus proving a Late Cretaceous age in a wide sense.

B. Late Paleocene-Early Eocene

The oldest Tertiary nannoplankton of this area has been found in the Alcsi-2 and Nádudvar-15 Boreholes.

Four cores of the Alcsi-2 (2,292-2,420 m) Borehole contained diagnostic Upper Paleocene forms such as *Sphenolithus anarrhopus* and *Cyclococcolithus robustus,* as well as *Coccolithus crassus* and *Sphenolithus radians* having their first occurrence at the Paleocene/Eocene boundary. The age of these assemblages is probably NP 10 but an age of NP 9 can not be excluded.

Nannoplankton assemblages of three cores from the Nádudvar-15 Borehole (1,981-2,079 m) contained *Toweius eminens*, *Coccolithus crassus*, *Chiasmolithus bidens* and *Ch. solitus*. These index forms together prove an Early Eocene (NP 10) age.

C. Middle-Late Eocene

The greatest part of the fossiliferous cores show an age of Middle or Late Eocene.

The presence of the older Middle Eocene (NP 14 and 15 nannoplankton Zones, Lutetian) cannot be proven in the Szolnok flysch.

The oldest zone of the Middle Eocene occurring in the flysch sequence is Zone NP 16. In the Nádudvar-3 (1,994.5-2,102.0 m) and Szandaszöllös-11 (2,114.5-2,162.5 m) Boreholes *Sphenolithus furcatholithoides* occurs together with the first specimens of *Reticulofenestra umbilicus* and *R. bisecta*, thus indicating NP 16 nannoplankton Zone (Bartonian).

In the case of a number of cores it was not possible to determine the exact nannoplankton zone. We fixed their ages between the wider limits of the NP 16-17 nannoplankton Zones (Bartonian) based on the co-occurrence of such species as *Reticulofenestra bisecta, R. umbilicus, Sphenolithus pseudoradians, Chiasmolithus grandis.* Cores in the Kisujszállás-4 (1,745-1,748 m), Rákóczifalva-1 (1,507.5-1,510.7 m; 1,820-1,916 m), Rákóczifalva-3 (1,800-1,837 m) Boreholes can be considered as Bartonian in this sense.

An exact Late Eocene nannoplankton datum occurred in only a few cores. In the 1,840.0-1,859 m Core of the Nádudvar-3 Borehole *Chiasmolithus oamaruensis* and *Cribrocentrum reticulatum* occurred together indicating NP 18 nannoplankton Zone (Lower Priabonian). In the Szandaszöllös-11 Borehole (1,679-1,684 m) *Chiasmolithus oamaruensis* has also been found (BÁLDI-BEKE at al., 1981) together with other Upper Eocene nannofossils, but their autochthonous position is doubtful, since the lithostratigraphy of the beds indicated a Pannonian (Late Miocene) age for this core.

No diagnostic nannofossils of latest Eocene age (NP 19-20), such as *Isthmolithus recurvus* have been found in the Szolnok flysch.

In a number of wells the badly preserved nannoplankton assemblages did not allow us to determine their exact age. The greatest parts of the Debrecen-2, Kengyel-1, Kisujszállás-13, Tatárülés-2, Rákóczifalva-2, Hajduszoboszló-5, Nádudvar-6 drilling profiles are of Middle to Late Eocene age in a wide sense. Here the age determination was possible in terms of Bartonian, Priabonian or even earliest Oligocene only.

D. Oligocene

The Lower Oligocene nannoplankton zones occur only sporadically in the available core material. NP 21 nannoplankton Zone (and P 18 planktonic foraminifera Zone, BÁLDI-BEKE et al., 1981) has been proven from the Hajduszoboszló-17 Borehole (1,344-1,346 m) with abundant *Lanternithus minutus* and *Ericsonia subdisticha.*

Strict NP 22 has not been found so far. One sample from the Hajduszoboszló-9 Borehole (1,368-1,370 m) contained a monospecific *Reticulofenestra ornata* bloom, which is very typical of the NP 23 nannoplankton Zone in the Central Paratethys.

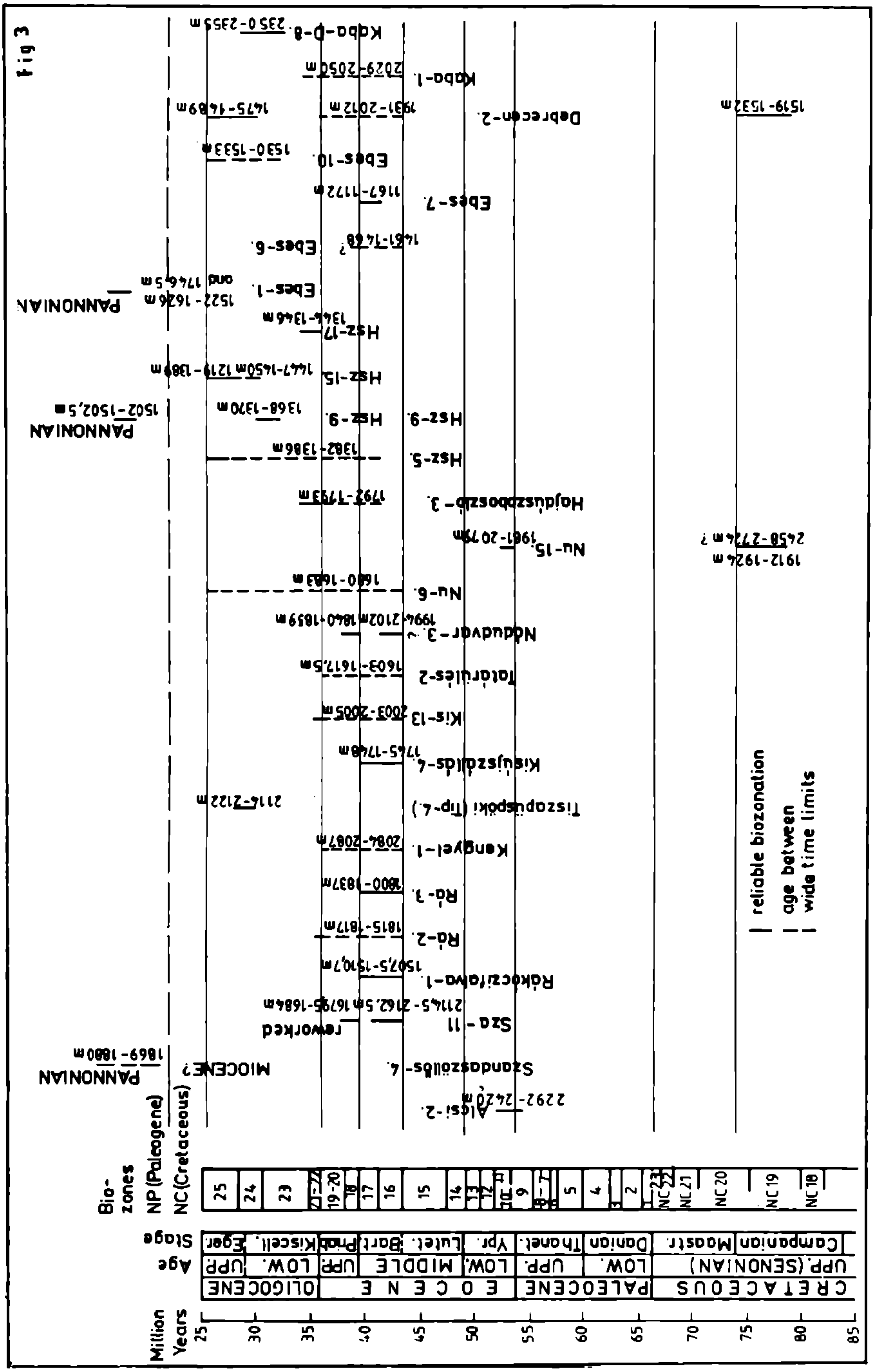

Fig. 3: Stratigraphical range of the studied drilling profiles.

Several cores display an age of NP 24 and 25 based on the occurrences of the species *Sphenolithus ciperoensis, S. distentus, S. predistentus* and *Reticulofenestra lockeri.* Late Oligocene ages were determined from the Hajduszoboszló-15 (1,447-1,450 m; 1,219-1,389 m), Tiszapüspöki-4 (2,119-2,122 m), Debrecen (Dá)-1 (1,645.2-1,651.8 m), Debrecen (D)-2 (1,475-1,489 m) and Ebes-10 (1,530-1,533 m) Boreholes.

4. The age of the Szolnok flysch

The nannoplankton data presented show (Figs. 3 and 4), that the deposition of the Szolnok flysch was not continuous, but happened in discrete time intervals.

The Upper Cretaceous sediments are limited to the Late Campanian and to the earliest Maastrichtian.

Earlier, MAJZON (1966) and SZEPESHÁZY (1973) described a *Trochamminoides*-dominated agglutinated foraminifera fauna, which was thought to be of Late Cretaceous to Paleocene age. Re-investigation of these samples proved that most of them contain Lower Eocene nannoplankton, some of them (Alcsi-2 Borehole) even an Ypresian foraminifera fauna (SIDÓ, 1969). Thus, in the recently explored part of the Szolnok flysch no uppermost Cretaceous and Paleocene deposit can be proven, the oldest Tertiary deposits belong to the Lower Eocene Zone NP 10 (perhaps also to NP 9). This statement is in good accordance with the opinion of JUHÁSZ (1966), who described an erosional unconformity at Rákóczifalva between the Cretaceous and Eocene.

There is no evidence of the presence of Zones NP 11 to 15 either, in the Szolnok flysch.

The most widespread nannoplankton zones in the studied area belong to the Bartonian stage (NP 16-17). The Lower Priabonian Zone NP 18 also occurs.

There is no proof of the presence of the Upper Priabonian in this area. The index species of Zone NP 19-20 are lacking. To highlight the paleogeographical separation of the flysch basin from the recent neighbouring Paleogene basins, it is necessary to mention that the NP 19 Zone indicator *Isthmolithus recurvus* is one of the most frequent forms in the Transdanubian Central Range and in north Hungary. On the other hand, it is possible that the Upper Priabonian is represented by those nannoplankton assemblages that consist of low-diversity Eocene nannofloras without index fossils.

In the Szolnok flysch almost all Oligocene nannoplankton zones are represented, though with the predominance of the NP 24 and 25 Zones. Since the Oligocene was followed by a long erosional period until the Middle Miocene, it is probable that the present day distribution of the Oligocene deposits is strongly controlled by Lower Miocene tectonics and denudation.

5. Paleoecology

The composition and preservation of the Cretaceous nannoplankton does not allow us to interpret their paleoecology in detail. Summarizing the general composition of the assemblages (lack of holococcoliths!), paleoecologic character of the foraminifera and the sedimentologic features, a deep-bathyal depositional environment can be supposed for the Cretaceous beds in the Szolnok flysch sequence.

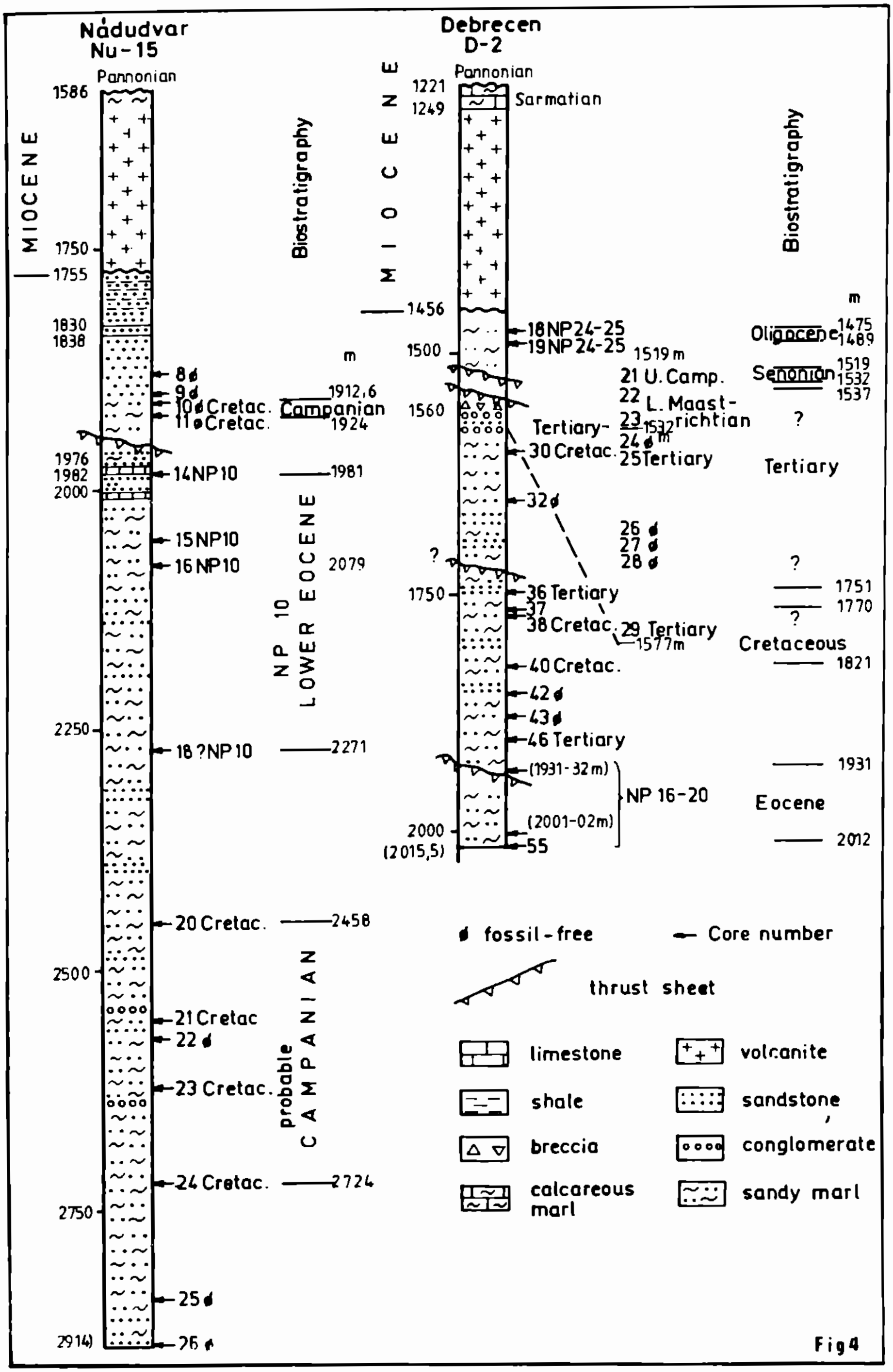

Fig. 4: Imbricated structures in the Nádudvar-15 and Debrecen-2 Boreholes.

Based on a number of paleoecologic observations, the Paleogene calcareous nannoplankton can be subdivided into diagnostic groups which indicate such environmental conditions as paleotemperature and distance from the shore. BÁLDI-BEKE (1984) established 7 groups of nannoplankton assemblages from the Transdanubian Paleogene based on their paleoecologic features. The 1st and 2nd group show pelagic character, the 3rd to 7th group indicate gradually predominating nearshore conditions.

In the Eocene assemblages of the Szolnok flysch sequence the 2nd group of BÁLDI-BEKE is the most abundant (i.e. the pelagic group of placoliths). The 1st group (discoasters+sphenoliths) is present, too. Forms of the 3rd group (*Helicosphaera, Zygrhablithus, Lanternithus*) occur only sporadically, while the nearshore forms of the groups 4-7 (other holococcoliths, pentaliths) are totally absent.

This composition of nannoplankton assemblages differs essentially from the coeval assemblages of the Transdanubian Paleogene Basin. In the latter the pelagic assemblages alternate frequently with nearshore assemblages. Based on the paleoecologic features of the nannoplankton, the paleobathymetry of the Szolnok flysch can be estimated as deep-bathyal (about 1000 meters), more than that of the Transdanubian Paleogene Basin.

In the Cretaceous, Eocene and Oligocene cores agglutinated foraminifera faunas usually occur. Some of them, for example the so called *Trochamminoides*-fauna, were thought to indicate abyssal environment having lived at or below the CCD (MAJZON, 1966).

In the bulk of the samples these *Trochamminoides*-faunas occur together with calcareous tests of planktonic foraminifera (SIDÓ, 1969), thus, the depositional depth of these layers might not reach the CCD. It is worth noting that the red and variegated, non-calcareous and non-fossiliferous shales of the Paleocene/Eocene boundary indicate a depositional depth about at the CCD.

Another problem to be solved is the presence of larger foraminifera in the Paleogene parts of the sequence (Hajduszoboszló-5, -10, -17, Ebes-2, Debrecen-2, Nagykörü-1, Kengyel-1 Boreholes; SZEPESHÁZY, 1973; MAJZON, 1966). The biotope of the larger foraminifera might not be deeper than 80-100 meters. Our investigations confirm that these larger foraminifera occur together with rich pelagic nannoplankton (and planktonic foraminifera) assemblages, so they can be interpreted as allochthonous debris transported by gravitational submarine transport from the shelf-areas.

The Oligocene nannoplankton assemblages of the Szolnok flysch show less pelagic features than the Eocene ones. The higher abundance of holococcoliths together with rich placolith and *Sphenolithus* communities make these assemblages similar to those of the Tard and Kiscell Formations in the North Hungarian Paleogene Basin. The probable depositional depth of the Oligocene series might be shallow-bathyal.

6. Tectonics

KÖRÖSSY (1959, 1977), as well as SZEPESHÁZY (1973) several times emphasized the heavily tectonized shape of the Szolnok flysch sequence. Dips between 70 and 90 degrees were frequently reported in the field descriptions, as well as sheared and compressed sections in the drilling profiles. However, paleontological evidence of the tectonic dislocations was previously missing.

Our nannoplankton investigations proved in two cases (Debrecen-2 and Nádudvar-15 Boreholes), that older deposits have been thrusted over younger ones (Fig. 4).

In the Debrecen-2 profile, Tertiary nannoplankton occurred beneath Senonian rocks (1,519-1,532 m). In the Nádudvar-15 Borehole the Senonian (1,912.6-1,924.0 m) is tectonically overlying the Lower Eocene. A further imbricated structure has been reported by PAP (1990) in the Bucsa-Ny-1 Borehole.

The significant differences in thicknesses of the deposits should also be interpreted as a tectonic effect. For example, the thickness of Senonian beds is 13 meters in the Debrecen-2 Borehole, while the same Senonian beds are 11.4 and 266 meters thick in two sections of the Nádudvar-15 Borehole.

7. Correlation

The Szolnok flysch at the present day has an exotic position inside the Carpathian arc, showing no direct connection to any of the Carpathian flysch units. However, the stratigraphical sequence of the Szolnok flysch can give an indication to its correlation with the other flysch units.

Theoretically, there is a possibility to correlate the Szolnok flysch either with the Outer Carpathian nappes, including the Pieniny Klippen Belt, or with the Central ("Inner") Carpathian flysches. As Fig. 1 shows, the NE termination of the Szolnok flysch points toward the Maramures area, where the Magura Unit, the Pieniny Klippen Belt (in the Botiza klippe, see SANDULESCU, 1980) and the "Inner" Transcarpathian Flysch Belt are ending. The Szolnok flysch could be the subsurface prolongation of any of these three units.

We plotted on Fig. 5 the stratigraphical ranges of all Carpathian flysch units concerned here. It can be seen clearly, that no correlation exists between the continuous, long-range sedimentation of the Magura Unit and the repeatedly interrupted sedimentation of the Szolnok flysch. Formally, the greatest similarity exists in its lower part with the stratigraphical pattern of the Pieniny Klippen Belt (Polish sector, see BIRKENMAJER and OSZCZYPKO, 1989) and in its upper part with the Transcarpathian flysch in Maramures (DICEA et al., 1980). These similarities do not prove a direct stratigraphical connection, but indicate the marginal paleogeographical position of the Szolnok flysch during the time of its deposition.

In accordance with the nannoplankton record, MAJZON compared the Senonian foraminifera faunas of the Szolnok flysch to those of the Central Carpathian flysch of Soviet Transcarpathia, already in 1966 (p. 607). According to MAJZON (op. cit., p. 608) the Lower Eocene *Trochamminoides*-fauna also shows the most affinity to the Transcarpathian flysch faunas.

8. Conclusions

1. The Szolnok flysch is characterized by a discontinuous biostratigraphical record. The number of samples investigated allows interpretation of this fact as a consequence of interrupted sedimentation. However, the causes of the hiatus are unknown. No data indicate the sub-aerial erosion.

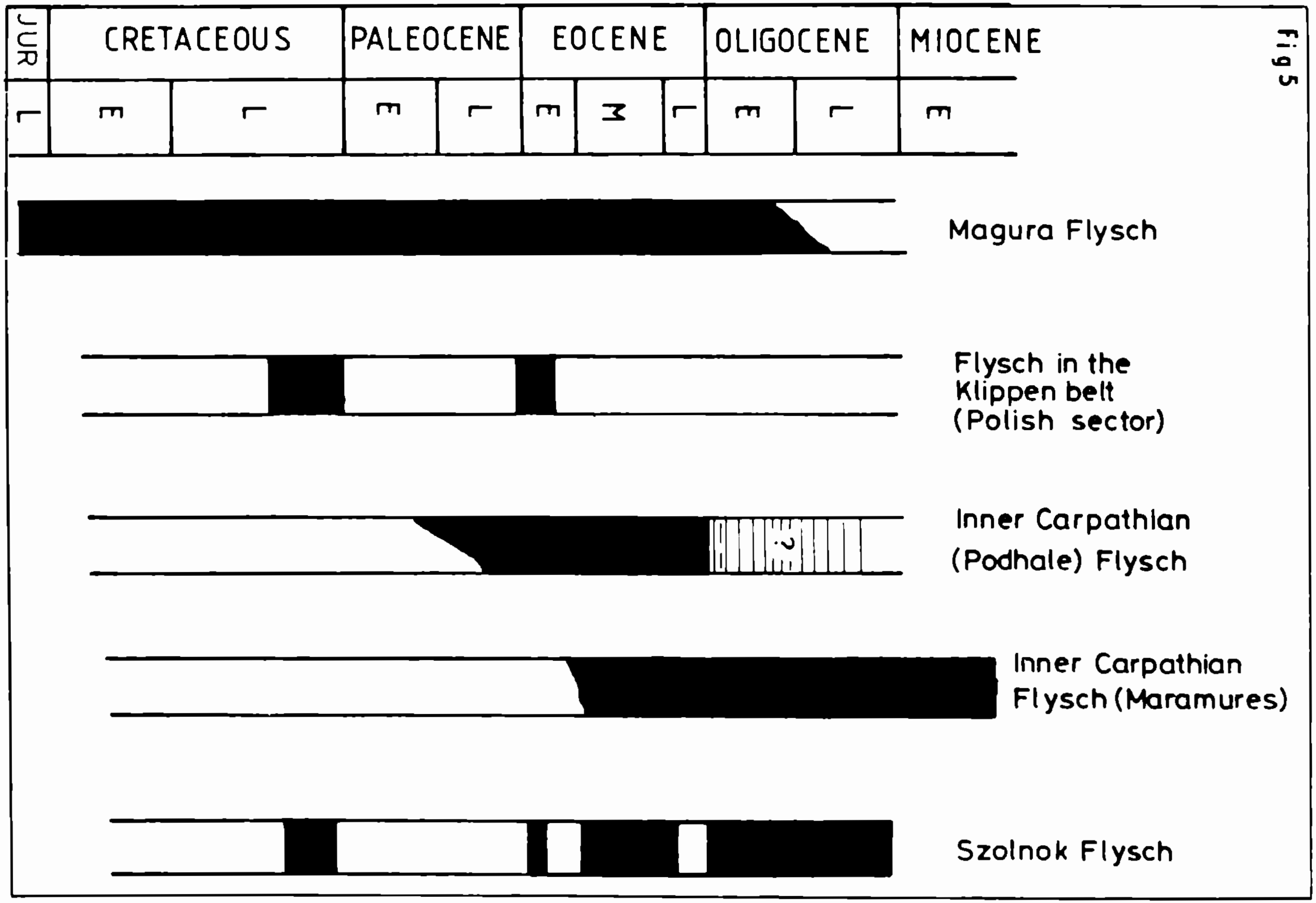

Fig. 5: Duration of sedimentation in some Carpathian flysch units.

2. Only Upper Campanian-Lower Maastrichtian nannoplankton zones and the NP10, 16 to 18, 21 to 25 Zones were recorded in the Szolnok flysch. No older Cretaceous or Paleocene nannoplankton zones were found.

3. The paleoecology of the fossil nannofloras indicate offshore, deep-water basin, differing essentially from the neighbouring Hungarian Paleogene shelf-basins. At the same time, a gradual change from the deep-water, pelagic to shallower, near-shore environment proceeded until the end of the Oligocene.

4. Imbricated sequences (proven by biostratigraphical methods) prove the compressed structure of the Szolnok flysch.

5. The time of deposition of the Szolnok flysch can be best correlated with other marginal flysch developments: its lower section with the Polish part of the Pieniny Klippen Belt, its upper section with the Transcarpathian flysch.

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