ACTA BIOL. SZEGED. 41, pp. 23-36 (1995/1996)

AGE AND PALAEOENVIRONMENT OF THE SPHERULITE-BEARING POLÁNY MARL FORMATION (UPPER CRETACEOUS, HUNGARY) ON BASIS OF PALYNOLOGICAL AND NANNOPLANKTON INVESTIGATION

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(Received: January 15, 1996)

Abstract

Spherulites and spherulite like forms microlapilli found in formations of different ages may be indicators of geological events in extraterrestrial space and faraway areas of the Earth. The age and conditions of embedding can be deciphered by investigating the enclosing rocks. Studying the Upper Cretaceous in this way may be of special importance in tracing the latest Cretaceous extinction as well.

The borehole Nagygörbö-1 can be considered as the "Spherulite-reference section" in the Upper Cretaceous Polány Marl Formation, because the spherulites described by VASKÓ-DÁVID (1994) occurred in these biostratigraphically well determined host sediments (SIEGL-FARKAS and WAGREICH, 1994).

Key words: Campanian, correlation, palynology, dinoflagellata, nannoplankton, palaeoenvironment.

Introduction

In Hungary, Upper Cretaceous deposits can be found in four facies realms. So far spherulites are known only from the Transdanubian Central Range area. There the

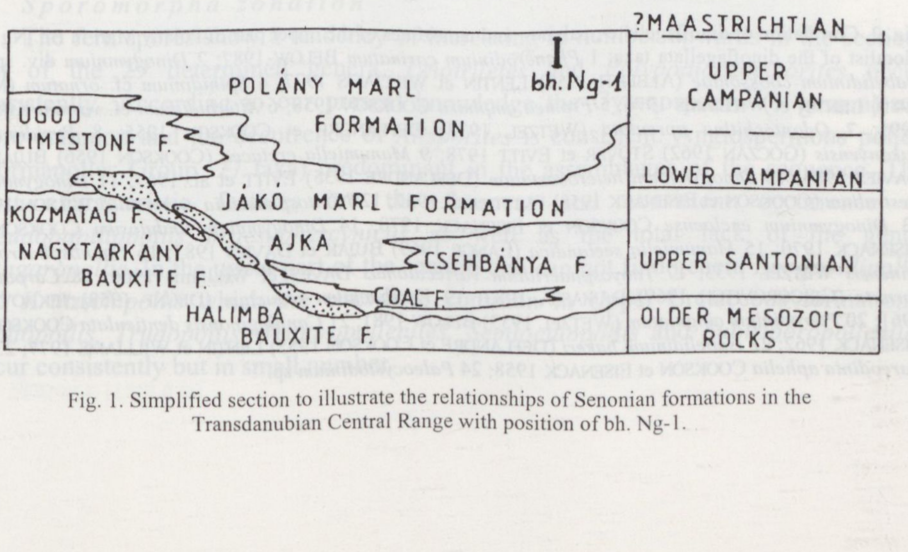

Fig. 1. Simplified section to illustrate the relationships of Senonian formations in the Transdanubian Central Range with position of bh. Ng-1.

whole Senonian sequence lies with the fluvial-lacustrine Csehbánya Formation or the palustrine Ajka Coal Formation over the older Mesozoic rocks. These are followed by different marine formations, the youngest of them being the Polány Marl Formation (Fig. 1).

Till now, spherulite occurrences have been established in the Csehbánya, Ajka Coal and Polány Marl Formations.

The borehole Nagygörbö-1 (Keszthely Mt.) penetrated the upper section of the Polány Marl between 1332.8-1515.0 m. The biostratigraphic study of the section and the correlation of the biozones allow a more accurate dating of the formation.

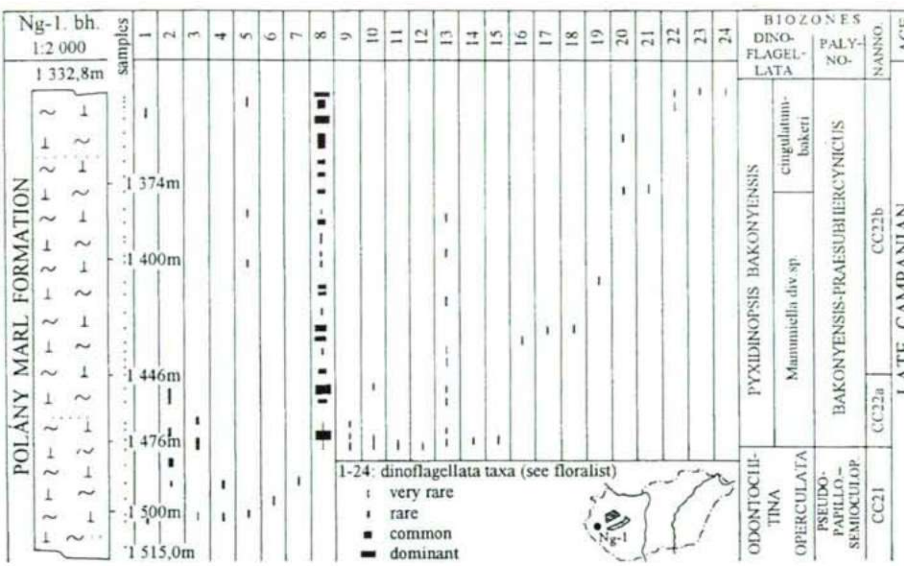

Fig. 2. Correlation of dinoflagellate-, palyno- and nanozones of the upper part of Polány Marl in Bh. Ng. 1. Floralist of the dinoflagellata taxa: 1 *Phanerodinium carinatum* BELOW 1987; 2 *Dinogymnium* div. sp.; 3 *Isabelidinium cooksoniae* (ALBERTI 1959) LENTIN et WILLIAMS 1977; 4 *Spinidinium* cf. *ornatum* (MAY 1980) LENTIN et WILLIAMS 1976; 5 *Fromea amphora* COOKSON 1958; 6 *Alterbidinium* cf. *varium* KIRSCH 1991; 7 *Odontochitina opreulata* (WETZEL 1933) DEFLANDRE et COOKSON 1955; 8 *Pyxidinopsis bakonyensis* (GÓCZÁN 1962) STOVER et EVITT 1978; 9 *Manumiella cretacea* (COOKSON 1956) BUJAK et DAVIES 1983; 10 *Dinogymnium heterocostatum* (DEFLANDRE 1935) EVITT et al. 1967; 11 *Dinogymnium westralium* (COOKSON et EISENACK 1958) EVITT et al. 1967; 12 "*Chitosphaeridia everricula*" WILSON 1974; 13 *Dinogymnium euclaense* COOKSON et EISENACK 1970; 14 *Dinogymnium undulosum* COOKSON et EISENACK 1970; 15 *Manumiella seelandica* (LANGE 1969) BUJÁK et DAVIES 1983; 16 *Cannosphaeropsis utinensis* WETZEL 1933; 17 *Tanyosphaeridium variecalamus* DAVEY et WiLliams 1966; 18 *Carpatella cornuta* (GRIGOROVITCH 1969) DAMASSA 1983; 19 *Veryhachium reductum* (DEUNF 1958) JEKHOVSKY 1961; 20 *Pterodinium cingulatum* (WETZEL 1933) BELOW 1981; 21 *Canninginopsis denticulata* COOKSON et EISENACK 1962; 22 *Isabelidinium bakeri* (DEFLANDRE et COOKSON 1955) LENTIN et WILLIAMS 1977; 23 cf. *Pareodinia aphelia* COOKSON et EISENACK 1958; 24 *Paleocystodinium* sp.

Palynological investigations

Both rich terrigenous spore-pollen and marine phytoplankton assemblages could be studied. The individual biozones and their correlation can be seen in Fig. 2, while the most significant palynomorphs in Plate I-III.

Dinoflagellata zonation

24 taxa could be determined. The dinoflagellates appear at 1503.0 m and from there downwards they occur consistently. Two assemblage zones and inside the youngest, two subzones could be designated. (SIEGL-FARKAS and WAGREICH, 1996; SIEGL-FARKAS 1996)

Odontochitina operculata Assemblage Zone (1467.0-1515.0 m)

The scattered occurrence of dinoflagellates is characteristic. The eponyms of the zone and the *Spinidinium ornatum* as well as the *Alterbidinium varium* occur only here, each being represented only by a single specimen. The *Dinogymnium* div. sp. occurs more frequently.

Pyxidinopsis bakonyensis Assemblage Zone (1332.8-1476.0 m)

The *Pyxidinopsis bakonyensis* occurs frequently and consistently. On the basis of the dinoflagellates appearing and disappearing beside it, the zone can be divided into two subzones.

Manumiella div. sp. Subzone (1380.0-1476.0 m): *Manumiella cretacea, Manumiella seelandica, Isabelidinium cooksoniae, Cannosphaeropsis utinensis, Dinogymnium* div. sp. are present only a few samples, beside the consistent occurrence of *Dinogymnium euclaense*. Apart from these, other determined species can be found only in a few samples and are represented by a few specimens only.

Pterodinium cingulatum-Isabelidinium bakeri Subzone (1332.8-1380.0 m): the assemblage dominated by *Pyxidinopsis bakonyensis* is completed by *Pterodinium cingulatum, Canninginopsis denticulata, Pareodinia aphelia* and *Isabelidinium bakeri*, which have been identified only here.

Sporomorpha zonation

The fern spores show a tendency of increasing in number upwards in the section. Out of the 29 determined genera, *Leiotriletes* and *Polypodiaceoisporites* occur consistently. According to our present knowledge the Gymnosperms (5 genera) are more common and the occurrence of *Alisporites* is consistent. Angiospermous pollen (Normapolles Group, 27 taxa) predominant in the assemblages of the sequence. The most characteristic features are the frequent and consistent occurrence of *Pseudopapillopollis praesubhercynicus* as well as the total lack of the genus *Hungaropollis*. In the upper part of the section one can not find genera *Longanulipollis* and *Krutzschipollis* which are elsewhere common in Upper Cretaceous formations. *Oculopollis, Trudopollis, Triporopollenites, Semioculopollis* and *Subtriporopollenites* occur consistently but in small number.

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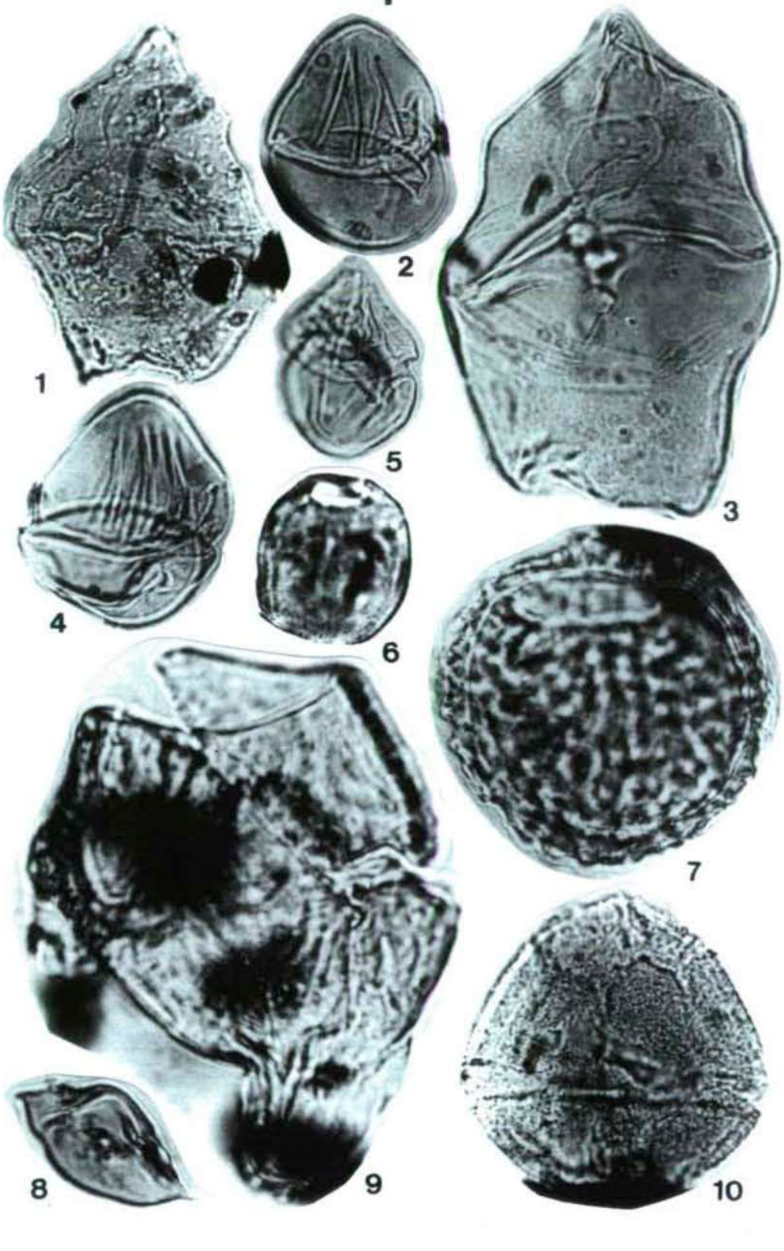


On the basis of the presence of the determined genera *Concavipollis, Interpollis, Labrapollis, Nudopollis* and *Plicapollis* a similarity can be noticed with the assemblages known in the southern part of the Great Hungarian Plain (SIEGL-FARKAS, 1986).

Taking into account the above listed facts, two zones can be designated: the *Pseudopapillopollis-Semioculopollis* Assemblage Zone (1476.0-1515.0 m), and above it the *Palaeostomocystis bakonyensis-Pseudopapillopollis praesubhercynicus* Assemblage Zone.

Redeposition

In the course of the investigations some Carboniferous (*Tripartites sp.*) and Upper Triassic (*Classopollis sp., Corollina sp.*) sporomorpha was determined.

Animal remnants

In the sequence, organic Foraminifer tests and *Scolecodonta* (Annelidae) remnants occur consistently.

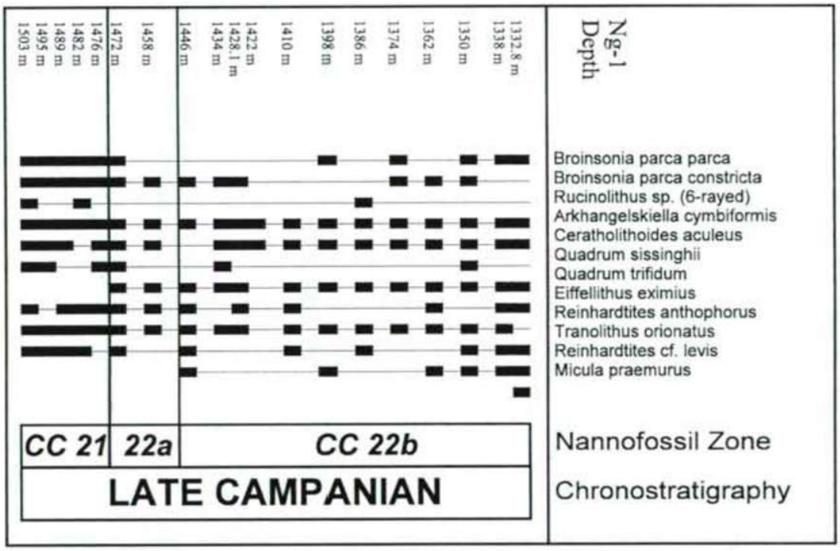
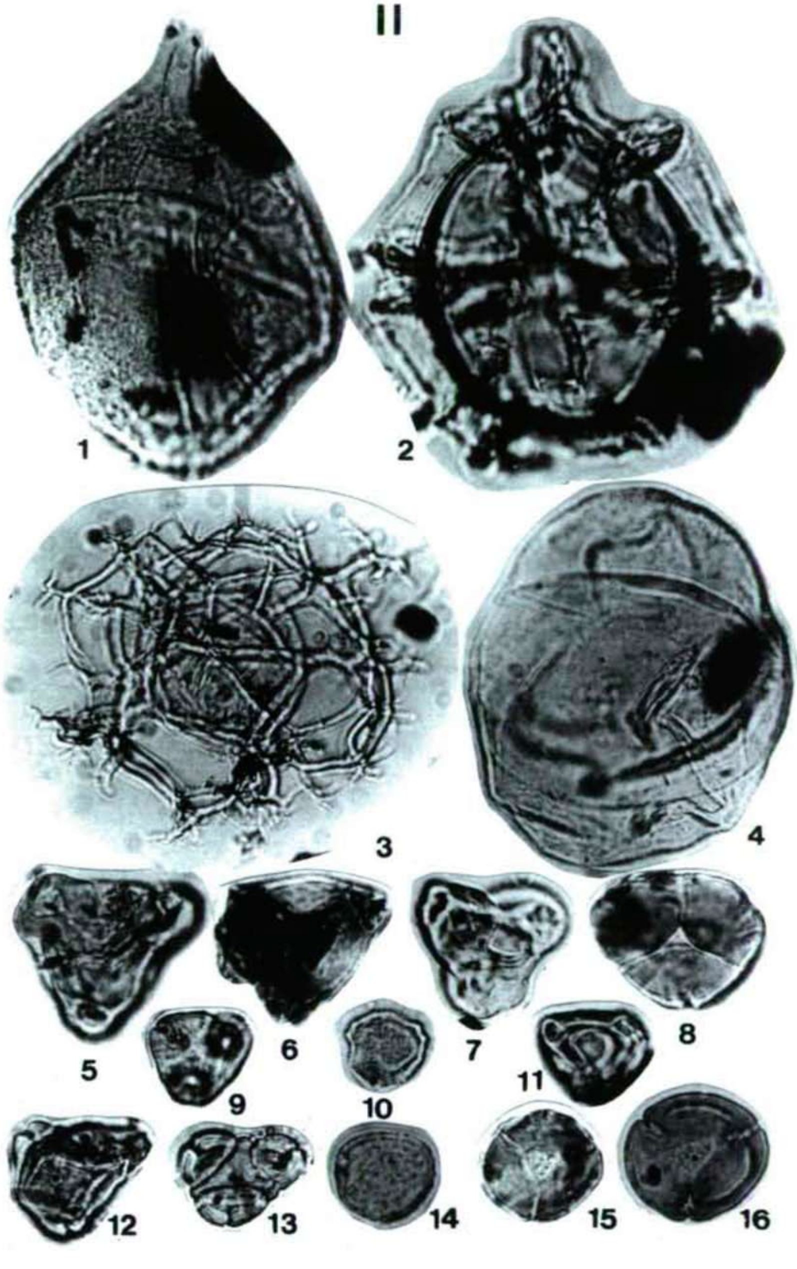


Fig. 3. Distribution of calcareous nannofossil marker species in the investigated Ng-1 section, 1332.8-1503.0 m.

Plate I. 1 *Spinidinium ornatum* (May) BUJAK et DAVIES (1489.0 m); 2 *Dinogymnium euclaense* COOKSON et EISENACK (1452.0 m); 3 *Isabelidinium cooksoniae* (ALBERTI) LENTIN et WILLIAMS (1503.0 m); 4 *Dinogymnium euclaense* COOKSON et EISENACK (1440.0 m); 5 *Dinogymnium euclaense* COOKSON et EISENACK (1458.0 m); 6 *Fromea amphora* COOKSON (1404.0 m); 7 *Pyxidinopsis bakonyensis* (GÓCZÁN) STOVER et EVitt (1472.0 m); 8 *Veryhachium irregulare* JEKHOVSKY (1410.0 m); 9 cf. *Odontochitina operculata* (WETZEL) DEFLANDRE et COOKSON (1489,0 m); 10 *Canninginopsis denticulata* COOKSON et EISENACK (1368.0 m).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Calcareous Nannofossils

19 samples of the Ng-1 core interval from 1332.8 m to 1503.0 m were investigated for their calcareous nannofossil content. Smear slides of the samples were analysed under the light microscope. The preservation and abundance of the nannofossils was generally moderate, although some samples contained well preserved nannofossils (Table 1).

Two nannofossil zones, one of them divided into 2 subzones according to the standard zonation of the Cretaceous of SISSINGH (1977) and PERCH-NIELSEN (1985) could be distinguished (Fig. 3, Plate IV).

Quadrum sissinghii Zone (CC21) (Authors: SISSINGH, 1977; PERCH-NIELSEN, 1985), (1503.0-1472.0m)

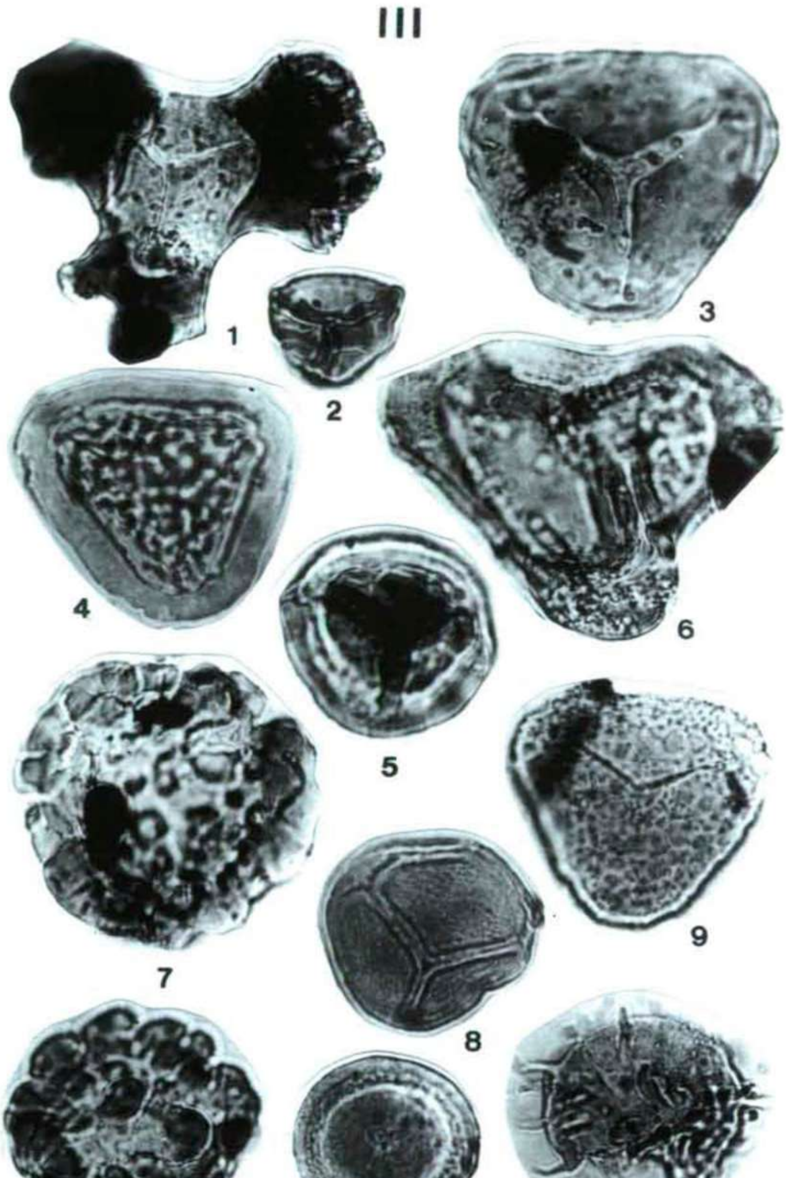
The marker species *Quadrum sissinghii* occurs together with other typical nannofossils of the Campanian, e. g. *Broinsonia (Aspidolithus) parca constricta, Broinsonia (Aspidolithus) parca parca, Ceratolithoides aculeus, Arkhangelskiella cymbifirmis and Reinhardtites anthophorus*. The nannofossil zone CC21 can be correlated with the middle part of the Late Campanian (PERCH-NIELSEN, 1985; SCHÖNFELD and BURNETT,1991).

Quadrum trifidum Zone (CC22) (Authors: SISSINGH, 1977; PERCH-NIELSEN, 1985), (1472.0-1332.8 m)

CC22a The lowermost subzone of the *Quadrum trifidum* Zone ranges from 1472 m to 1458.0 m. It is defined by presence of *Quadrum trifidum* without *Reinhardtites levis*, although transitional forms from *Reinhardtites anthophorus* to *R. levis* (SISSINGH, 1977) are already present. Subzone CC22b starts in 1446.0 m and goes up to 1332.8 m. A 1446.0 m large Reinhardtites with a completely closed central area occur for the first time. They are grouped into *R. cf. levis* (SISSINGH, 1977; WAGREICH and KRENMAYR, 1993).

According to the correlations of SCHÖNFELD and BURNETT (1991) and WAGREICH and KRENMAYR (1993), the upper boundary of the Campanian defined by the last occurrence of the planktonic Foraminifer *Globotruncanita calcarata* falls at the base or into the nannofossil zone CC22c. Therefore the investigated Ng-1 core section from 1503.0 m to 1332.8 m is of middle to late Late Campanian age in the sense of Tethyan zonations.

Plate II. 1 *Pareodinia aphelia* COOKSON et EISENACK (1386.0 m); 2 *Pterodinium cingulatum* (WETZEL) BELOW (1344.0 m); 3 *Cannosphaeropsis utinensis* WETZEL (1434.0 m); 4 *Manumiella cretacea* (Cookson) BUJAK et DAVIES (1476.0 m); 5 *Interporopollenites nennhausensis* KRUTZSCH (1332.8 m); 6 *Plicapollis pseudoexcelsus* GREIFELD (1468.0 m); 7 *Interporopollenites gracilis* GOCZÁN et SIEGL-FARKAS (1468.0 m); 8 *Oculopollis* sp. (1410.0 m); 9 *Semioculopollis minimus* GÓCZÁN (1344.0 m); 10 *Labrapollis labraferus* (POTONIE) KRUTZSCH (1452.0 m); 11 *Interpollis* cf. *microsupplingensis* KRUTZSCH (1392.0 m); 12 *Triatriopollenites lubomirovae* (GLADKOVA) KEDVES (1350.0 m); 13 *Suemegipollis germanicus* KRUTZSCH (1503.0 m); 14 *Pseudopapillopollis praesubhrcynicus* GÓCZÁN (minor typ) (1332.0 m); 15 *Psedopapillopollis praesubhercynicus* GÓCZÁN (1452.0 m).



Age and correlation possibilities

Antecedents

The palynostratigraphic standard zonation of GÓCZÁN (1964) divides the formations of the Bakony Mts. into eight (A-H) zones and gives the time of their deposition as Upper Santonian-Upper Maastrichtian. In this work of 1973 he assigned the whole of the Polány Marl Formation to the Maastrichtian and provided the zones with the names of the characteristic sporomorphs (GÓCZÁN, 1973). He assigned the Lower Maastrichtian formations to the *Pseudopapillopollis-Semioculopollis minimus* Assemblage Zone, while giving Dinoflagellata and Normapolles taxa names to the section representing the Upper Maastrichtian: *Palaeostomocystis bakonyensis-Pseudopapillopollis praesubhercynicus* Assemblage Zone.

SIEGL-FARKAS (1986) correlated the Senonian formations of borehole Bácsalmás-1 in the southern Great Hungarian Plain with the formations of the Bakony Mts. assigned to the Maastrichtian and distinguished two subzones in the Lower Maastrichtian: *devecserensis* and *sahi*.

The later correlation works (GÓCZÁN and SIEGL-FARKAS 1989, 1990; SIEGL-FARKAS 1993a) used the same stratigraphic subdivision.

The Foraminifera zonation of the formations of the Bakony Mts. designated the Campanian-Maastrichtian boundary in the lower third of the Polány Marl Formation (SIDÓ in GÓCZÁN 1973). The mollusc examinations gave a stratigraphic subdivision similar to the palynozones (CZABALAY in GÓCZÁN 1973).

Recent correlation results

For correlating the biostratigraphic standard zonation established in 1964 to the chronostratigraphic scale, we used the Dinoflagellata and Nannoplankton biostratigraphic data based on systematic investigations (Fig. 2).

On the basis of the so called global dinoflagellata zonation of WILLIAMS and BUJAK (1985), it would be reasonable to draw the Campanian-Maastrichtian boundary where *Odontochitina operculata* is replaced by *Dinogymnium euclaense* (1476.0 m). (This would be coincide with the Lower and Upper Maastrichtian respected of GÓCZÁN.) This is, however, hampered by the fact that the mentioned literature does not contain sufficient Tethyan data. Thus even the comparison of the dinoflagellata

Plate III. 1 *Tripartites* sp. (1422.0 m); 2 *Undulatisporites* sp. (1344.0 m); 3 *Bikolisporites* sp. (1374.0 m); 4 *Polypodiaceoisporites* cf. *granulatus* KEDVES (1458.0 m); 5 *Taurocusporites* sp. (1404.0 m); 6 *Matonisporites* cf. *weylandi* DÖRING (1422.0 m); 7 *Uvaesporites neerlandicus* HERNGREEN et al. (1434.0 m); 8 *Todisporites* sp. (1434.0 m); 9 *Vadaszisporites* cf. *urkuticus* DEÁK (1356.0 m); 10 *Uvaesporites neerlandicus* HERNGREEN et al. (1434.0 m); 11 *Corollina* sp. (1392.0 m); 12 *Echinatisporites* sp. (1476.0 m). Magnification is 1000 ×, except Pl. II. fig. 3: 500 ×.

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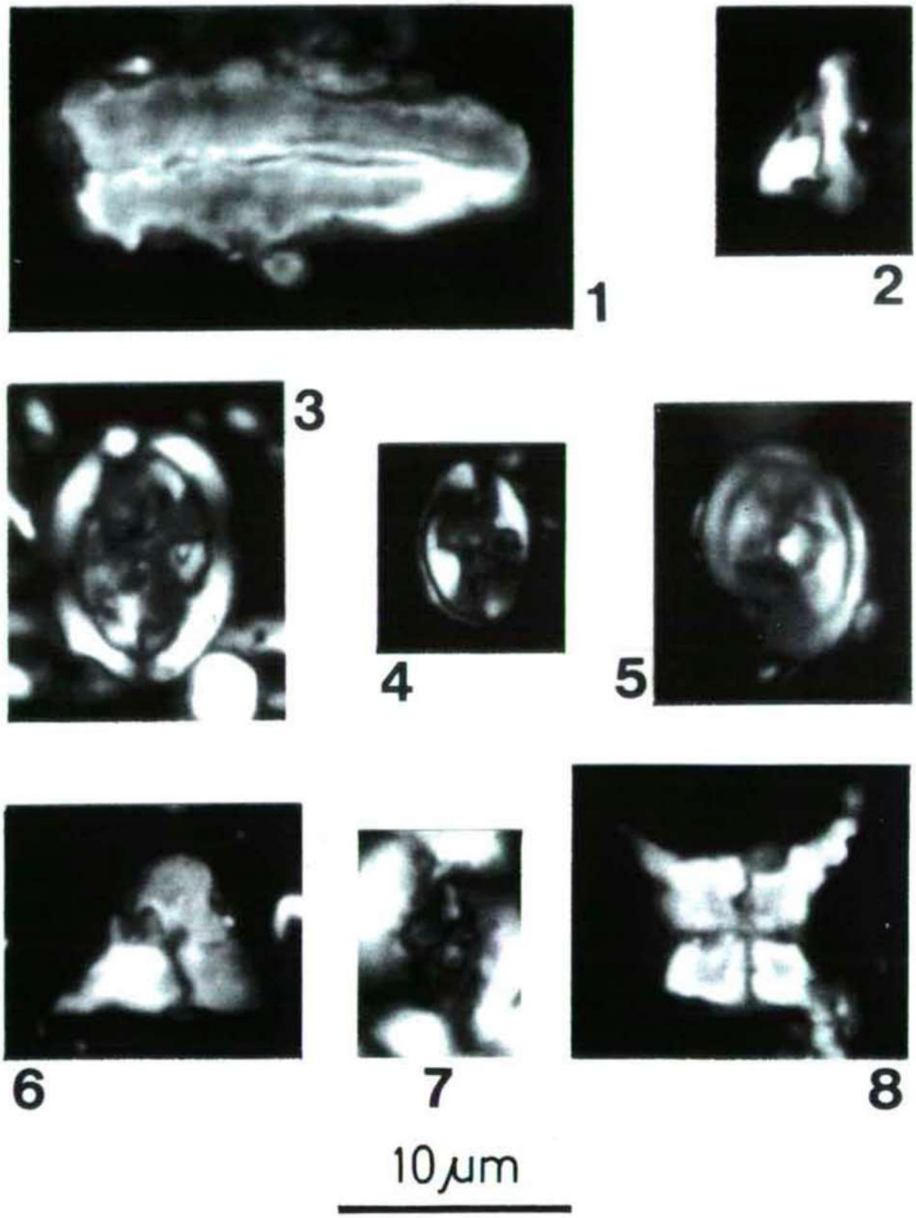

associations of the Boreal and Mediterranean regions is still problematic. Since *Dinogymnium euclaense* occurs only in the middle section (1380.0-1476.0 m) of borehole Nagygörbö-1 it can be regarded only as of local value in the currently elaborated zonation.

According to the data of WILLIAMS and BUJAK (1985), the first occurrence of *Cannosphaeropsis utinensis* at 1434.0 m would suggest still Late Santonian age.

This dinoflagellata zonation covering the upper formations of the Transdanubian Central Range shows a lot of uncertainties due to the lack of literary data. A better chronostratigraphic framework is provided by Nannoplankton correlation. On the basis of the Nannofossils, the sections between 1472.0-1515.0 m could be assigned to the CC21, between 1458.0-1472.0 m to the CC22a and between 1332.8-1446.0 to the CC22b Nannofossil Zones.

The dinoflagellata zonation established on the basis of the investigation of the sequence correlates surprisingly well with the Nannofossil zonation elaborated for the Upper Cretaceous Gosau Group of the Northern Calcareous Alps (WAGREICH and KRENMAYR, 1983).

The *Odontochitina operculata* Assemblage Zone designated between 1476.0-1515.0 m correlates well to the CC21 Nannofossil Zone and the *Pyxidinopsis bakonyensis* Assemblage Zone between 1332.8-1476.0 m corresponds to the CC22ab Nannofossil Zones.

For the Tethyan realm the upper boundary of the Campanian is drawn at the extinction level of the planktonic foraminifera *Globotruncanita calcarata* (e. g. BIRKELUND et al., 1984; SCHÖNFELD and BURNETT 1991). Detailed investigations of the Campanian-Maastrichtian boundary by SCHÖNFELD and BURNETT (1991) and KENNEDY et al. (1992) showed a diachronism between the current Tethyan and Boreal definitions of this stage boundary by correlations of various fossil groups. The last occurrence of *G. calcarata* (upper boundary of the Campanian) in the Tethyan realm falls into the nannofossil zone CC22 (CC22c after SCHÖNFELD and BURNETT 1991, top of CC22ab after WAGREICH and KRENMAYR 1993) whereas according to the Boreal definition (base on *Belemnella lanceolata* Zone) the boudary is in the nannofossil zone CC23a (SCHÖNFELD and BURNETT, 1991). The last nannofossil event recognised in borehole Ng-1, the first occurrence of *Reinhardtites cf. levis*, defines a level well below both the Tethyan and the Boreal definition of the Maastrichtian. Therefore the deposition of the Polány Marl Formation in the studied borehole took place during the Late Campanian.

In Hungary, younger Upper Cretaceous formations can be expected to all probability in the vicinity of Ganna, in the northern part of the Bakony Mts.

Plate IV. 1 *Lucianorhabdus cayeuxii* DEFLANDRE (1374.0 m); 2 *Ceratolithoides aculeus* (STRADNER) PRINS et SISSINGH (1374.0 m); 3 *Arkhangelskiella cymbiformis* VEKSHINA (1428.1 m); 4 *Eiffelithus eximius* (STOVER) PERCH-NIELSEN (1374.0 m); 5 *Reinhardtites levis* PRINS et SISSINGH (1428.1 m); 6 *Quadrum trifidum* (STRADNER in STRADNER et PAPP) PRINS et PERCH-NIELSEN in MANIVIT et al. (1428.1 m); 7 *Broinsonia (Aspidolithus) parca parca* (STRADNER) BUKRY (1374.0 m); 8 *Quadrum sissinghii* PERCH-NIELSEN (1428.1 m). All figures with crossed nicols.

On the basis of the recent investigations the deposition of the Transdanubian Upper Cretaceous marine formation (Jákó Marl) started in the late stage of the Late Santonian (SIEGL-FARKAS, 1993b; LANTOS et al., 1996; SIEGL-FARKAS and WAGREICH, 1996) and the youngest marine formation (Polány Marl) was deposited at the end of the Late Campanian.

Table 1. Alphabetic list of Calcareous nannofossil species

Ahmuellerella octoradiata (GORKA 1957) REINHARDT 1964
Arkhangelskiella cymbiformis VEKHSINA 1959
Biscutum constans (GORKA 1957) BLACK 1959
Biscutum sp.
Braarudosphaera bigelowi (GRAN et BRAARUD 1935) DEFLANDRE 1959
Broinsonia (Aspidolithus) parca constricta HATTNER, WIND et WISE 1980
Broinsonia (Aspidolithus) parca parca (STradner 1963) BUKRY 1969
Calculites obscurus (DEFLANDRE 1959) PRINS et SISSINGH 1977
Calculites ovalis (STRADNER 1963) PRINS et SISSINGH 1977
Ceratolithoides aculeus (STRADNER 1961) PRINS et SISSINGH in SISSINGH 1977
Chiastozygus litterarius (GORKA 1957) MANIVIT 1971
Cretarhabdus crenulatus BRAMLETTE et MARTINI 1964
Cretarhabdus conicus BRAMLETTE et MARTINI 1964
Cribrocorona gallica (STRADNER 1963) PERCH-NIELSEN 1973
Cribrosphaerella ehrenbergii (ARKHANGELSKY 1912) DEFLANDRE 1952
Cylindralithus serratus BRAMLETTE et MARTINI 1964
Eiffelithus eximius (STOVER 1966) PERCH-NIELSEN 1968
Eiffelithus turriseiffelii (DEFLANDRE et FERT 1954) REINHARDT 1965
Eiffelithus cf. *gorkae* REINHARDT 1965
Gartnerago obliquum (STRADNER 1963) NOEL 1970
Glaukolithus diplogrammus (DEFLANDRE 1954) REINHARDT 1964
Heteromarginatus sp.
Lithraphidites carniolensis DEFLANDRE 1963
Lucianorhabdus cayeuxii DEFLANDRE 1959
Lucianorhabdus cayeuxii DEFLANDRE 1959 ssp. B, WAGREICH 1988
Manivitella pemmatoidea (DEFLANDRE in MANIVIT 1965) THIERSTEIN 1971
Microrhabdulus decoratus DEFLANDRE 1959
Micula decussata VEKSHINA 1959
Micula praemurus (BUKRY 1973) STRADNER et STEINMETZ 1984
Ottavianus giannus RISATTI 1973
Placozygus fibuliformis (REINHARDT 1964) HOFFMANN 1970
Prediscosphaera cretacea (ARKHANGELSKY 1912) GARTNER 1968
Prediscosphaera spinosa (BRAMLETTE et MARTINI 1964) GARTNER 1968
Quadrum gartneri PRINS et PERCH-NIELSEN in MANIVIT et al. 1977.
Quadrum gothicum (DEFLANDRE 1959) PRINS et PEARCH-NIELSEN in MANIVIT et al. 1977
Quadrum sissinghii PEARCH-NIELSEN 1986
Quadrum trifidum (STRADNER in STRADNER et PAPP 1961) PRINS et PEARCH-NIELSEN in MANIVIT et al. 1977
Reinhardtites anthophorus (DEFLANDRE 1959) PERCH-NIELSEN 1968
Reinhardtites levis PRINS et SISSINGH in SISSINGH 1977
Rhagodiscus angustus (STRADNER 1963) REINHARDT 1971
Rhagodiscus splendens (DEFLANDRE 1953) VERBEEK 1977
Russellia multiplus (PERCH-NIELSEN 1973) WIND et WISE 1977
Rucinolithus sp. (6-rajed)
Scampanella cornuta FORCHHEIMER et STRADNER 1973
Tranolihus orionatus (REINHARDT 1966) PERCH-NIELSEN 1968
Vekshinella stradneri ROOD et al. 1971
Watznaueria barnesae (BLACK 1959) PERCH-NIELSEN 1968
Zeugrhabdotus embergeri (NOEL 1959) PERCH-NIELSEN 1984

Palaeoenvironmental conclusions

According to the latest palaeogeographic maps, the boundary of the the mediterranean and the boreal region of the Tethys developed at the border of the subtropical and polar oceanic fronts during the Late Cretaceous (HAY et al., 1994). This boundary was situated in the territory of present-day Central Europe. The extension of the Tethys was about three times greater than that of the present Mediterranean Sea. It was warm and shallow (HAY, 1994). On its territory rich in archipelagoes developed corresponding to the changes of the sealevel. The Hungarian Senonian formations were deposited in the northern archipelagic area of the Tethys. The dry lands had abundant fern, pine and diversified, predominantly angiospermous (Normapolles) vegetation. On the surrounding elevated relief, the erosion of Carboniferous and Upper Triassic formations took place. In the sea lived abundant phytoplankton assemblages (dinoflagellates, nannoplankton).

On the basis of the massive occurrence of the rich sporomorpha remnants, the sedimentation took place in the shallow marine and neritic nearshore region.

This is also proved by the consistent occurrence of *Scolecodonta* (Annelidae), remnants of bottom dweller worms.

Besides the abundant vegetation, the tropical-subtropical climate is also indicating by the common occurrence of thermophilic *Belemnites*.

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