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Eocene microfossils from Podgrad

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From the flysch of Podgrad (Brkini, W Yugoslavia) 19 species and subspecies of nannoplankton, 10 of planktonic foraminifers and 9 of nummulitins were found. Among the new species and subspecies *Rhabdosphaera piriformis*, *Operculina marinelli similis*, *Nummulites brkiniensis* and *Nummulites postbearnensis* were determined. The fossiliferous strata belong to the Middle Cuisian and appear to be of the same stratigraphic level and fossil content as the Cuisian flysch of Ustje in Vipava valley.

Contents

1. Introduction

The flysch of south-western Slovenia is in some places rich with microfossils while in others it is poor. Some of the sections have been studied at Goriška Brda (Cimerman and others, 1974), Ustje in Vipava valley (De Zanche, Pavlovec and Proto Decima, 1967), and at Postojna (Gospodarič and others, 1967). As the flysch from different basins is not of the same age and of the same lithological development each new section is of interest. The Podgrad locality rich in nummulitins, planktonic foraminifers and nannoplankton resembles somewhat the fossil contents of Ustje section in Vipava valley. New species and subspecies have also been determined.

2. Locality

Figs. 1 and 2

Mujibur R. Khan

An outcrop of the flysch occurs approximately one kilometre to the NNE of Podgrad in south-western Slovenija (45° 31' 45"; 13° 09' 21"; fig. 1). The flysch forms gentle slopes or small hillocks in the topography and is often covered with vegetations. The flysch overlies the *Alveolina* and *Nummulites* bearing limestone of Early Paleogene (Paleocene-Lower Eocene) age. The contact between the limestone and flysch is covered and so is also the top of the flysch (fig. 2).

The flysch consists mostly of shale and claystone in alternation with sandstone and minor marl, conglomerate and breccia.

The shale is greenish gray to gray, soft, splintery or friable at places, bedding is thin to very thin. The claystone is also greenish gray to gray, nodular and soft. The sandstone is gray, greenish gray and brown in colour which weathers

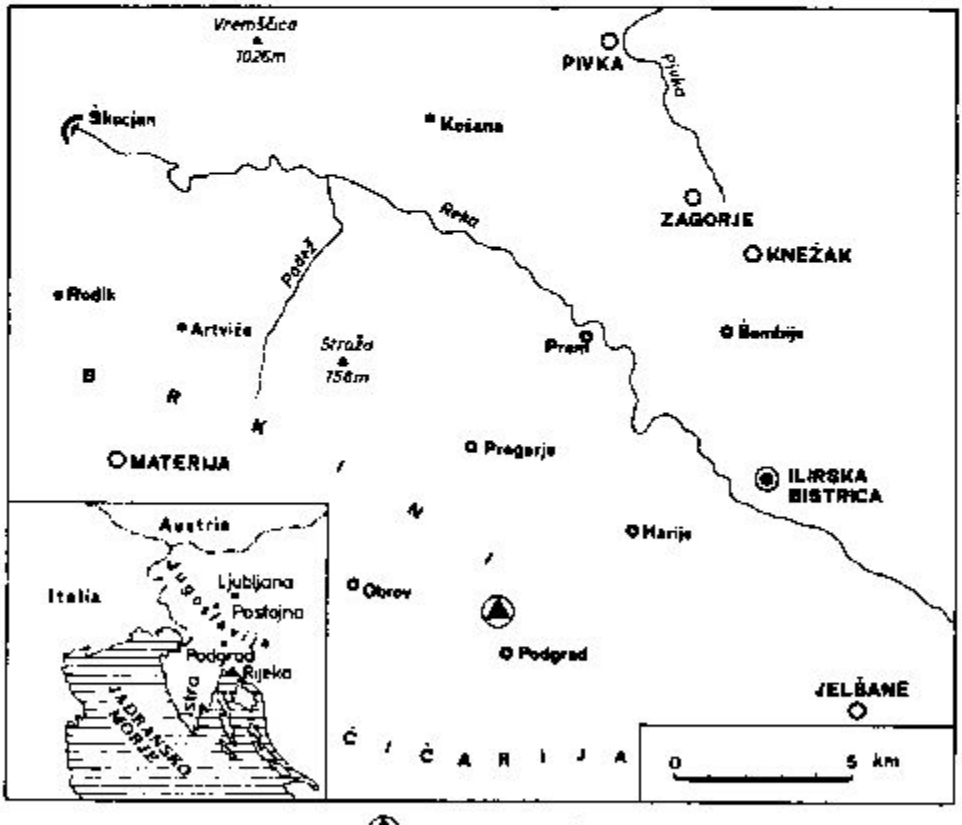


Fig. 1. Map representing the surroundings of Podgrad
Sl. 1. Zemljevid okolice Podgrada

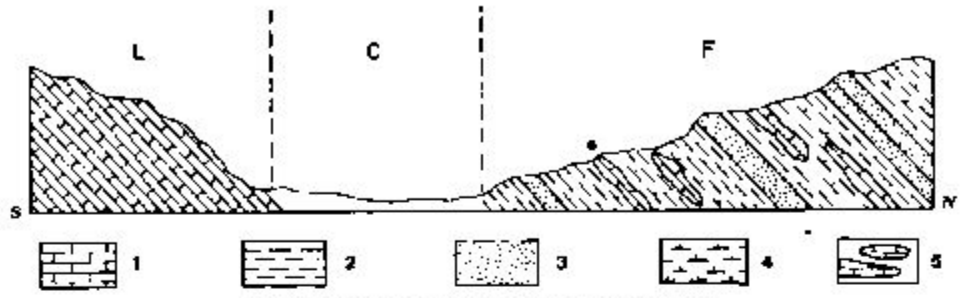


Fig. 2. Profile across the locality Podgrad

Sl. 2. Profil skozi nahajališče Podgrad

1 Limestone with nummulites and assilinas — Apnenec z numuliti in asilinami
2 Claystone — Glinovec
3 Sandstone — Peščenjak
4 Marl — Lapor
5 Conglomerate and breccia — Konglomerat in breča
F Flysch, Lower (?) and Middle Cuisian — Fliš, spodnji (?) in srednji cuisij
L Limestone, Lower Cuisian — Apnenec, spodnji cuisij
C Covered (Alluvium) — Prekrito s holocenskim nanosom
* Fossil locality — Nahajališče fosilov

to rusty brown. It is generally medium to thinly bedded, fine to medium grained and at places quite hard. The marl is a minor component having discontinuous thin beds. The conglomerate and breccia are of intraformational type having the form of lenses or boulders and being composed of argillaceous limestone. The formation, in general, is fossiliferous and particularly the marl, conglomerate and breccia are rich in *Nummulites*, *Operculina*, *Assilina*, *Alveolina*, bivalves, echinoderms, corals etc.

Nummulites, *Operculina* and other fossils have been collected from the outcrop and the shale and marl samples were taken for the determination of the biozone of the flysch outcrop at Podgrad.

3. Nannoplankton

Jernej Pavšič

Introduction

The significant achievements in the studies of nannoplankton along with the other branches of the micropaleontology have been progressed parallely with the developments of the optical and electronic devices. At the present day this group of fossil plays an important role in the field of biostratigraphic studies of the younger Mesozoic and Tertiary beds; when beside the normal optical microscope electronic microscopes are available.

Owing to the shorter ranges of the different species the nannoplankton is useful for the classification of biozones. These biozones have effectively been used for the regional and interregional correlations due to the wide geographical distribution of the nannoplankton. Moreover, lately it has become very important in the interpretations of the paleogeography, because these tiny organisms are very susceptible to the changes of the environments.

Preparation of samples for observation

Standard method has been used for the preparation of the samples to be observed under the optical microscope. Particles dispersed in water were previously treated by the ultrasonic. The slides have been studied under the optical microscope Leitz-Ortholux.

Systematic part

Coccolithus pelagicus (Wallich)

Plate 1, fig. 8 a, b

1967 *Coccolithus pelagicus* (Wallich) — Bramlette and Wilcoxon, 102, pl. 3, figs. 13 to 15.
1971 *Coccolithus pelagicus* (Wallich) — Baldi-Beke, 26.
1974 *Coccolithus pelagicus* (Wallich) — Scherwood, 13, pl. 1, figs. 3, 4, pl. 2, fig. 2.

Elliptic placolith with the thin and elliptic central part. A very common form in the Tertiary beds without an exact stratigraphic importance.

Chiasmolithus grandis (Bramlette et Riedel)

Plate 1, fig. 9 a, b

1954 *Coccolithus grandis* Bramlette et Riedel — Bramlette and Riedel, 391, pl. 38, fig. 1.
1961 *Coccolithus grandis* Bramlette et Riedel — Bramlette and Sullivan, 140, pl. 2, figs. 1, 2 and 3.
1966 *Chiasmolithus grandis* (Bramlette et Riedel) — Hay and others, 388.
1971 *Chiasmolithus grandis* (Bramlette et Riedel) — Scherwood, 19, pl. 3, figs. 1, 2.

Quite common among our samples. Even under the optical microscope all characteristics of the coccolithus can be observed. Remarkable is a fine net in the central part and the segmentation of both cycles.

Cyclococcolithus neogammation Bramlette et Wilcoxon

Plate 1, fig. 4

1967 *Cyclococcolithus neogammation* Bramlette et Wilcoxon — Bramlette and Wilcoxon, 104, pl. 1, figs. 1 to 3, pl. 4, figs. 3 to 5.
1972 *Cyclococcolithus neogammation* Bramlette et Wilcoxon — Baldi-Beke, pl. 2, figs. 3, 4.

Very common species in all the samples.

Pontosphaera multipora (Kamptner)

Plate 1, fig. 5 a, b

1961 *Discolithus distinctus* Bramlette et Sullivan — Bramlette and Sullivan, 141, pl. 2, fig. 9.
1971 *Discolithina multipora* (Kamptner) — Baldi-Beke, 26.

1971 *Discolithina multipora* (Kamptner) — Perch-Nielsen, 34, pl. 26, figs. 15, 16, 19, 20, pl. 4, figs. 2 and 9.
1974 *Pontosphaera multipora* (Kamptner) — Scherwood, 30, pl. 3, figs. 15, 16, 19, 20.

Elliptical discolith with numerous perforations in the central part. The perforations are usually wider in the central part and more or less round.

Pontosphaera plana (Bramlette et Sullivan)

Plate 1, figs. 10 and 11

1961 *Discolithus planus* Bramlette et Sullivan — Bramlette and Sullivan, 143, pl. 3, fig. 7.
1971 *Discolithina plana* (Bramlette et Sullivan) — Perch-Nielsen, 35, pl. 29, fig. 4.
1974 *Pontosphaera plana* (Bramlette et Sullivan) — Scherwood, 31, pl. 3, fig. 24, pl. 5, figs. 3, 4.

Elliptical discolith with a uniform plate bearing two oblong perforations. Only some specimens appear in the pattern.

Blackites scabrosus (Deflandre)

Plate 1, figs. 6 and 7

1961 *Rhabdosphaera scabrosa* (Deflandre) — Bramlette and Sullivan, 147, pl. 5, fig. 11.
1974 *Blackites scabrosus* (Deflandre) — Scherwood, 41, pl. 5, fig. 23.

The rugose surface, characteristic for this species, can be very well observed. The species occurs rather frequently.

Rhabdosphaera piriformis n. sp.

Plate 1, figs. 1 to 3

Derivatio nominis: After the pear-shaped form of the rhabdolyte.
Locus typicus: Podgrad.
Stratum typicum: Lower part of the Middle Cuisian, lower part of the biozone *Discoaster sublodoensis*.
Holotypus: In the »Podgrad 6« (pl. 1, fig. 3), in the collection of the Institute of Geology and Paleontology, Ljubljana University.
Paratypi: In the »Podgrad 3 and 4« (pl. 1, figs. 1 and 2), in the same collection as holotypus.
Diagnosis: *Rhabdosphaera piriformis* is a cone-shaped rhabdolyte with considerably inflated process, which starts to get thicher just above the basal plate and soon acquires its largest diameter.
Description and comparison: The rhabdolyte has a small basal plate with central perforation. The process is spherically thickened just above the basal plate. In this it differs from the similar species *Rhabdosphaera inflata* which gets thick only at the end of a short or long neck. After the thickening, the process becomes more and more narrow and ends acutely pointed. In exterior the rugose surface is obvious.

Distribution: The new species appears to be very abundant in the Cuisian flysch of Podgrad (biozones *Discoaster sublodoensis).*

Micrantholithus flos Deflandre
Plate 2, figs. 5, 8

1961 *Micrantholithus flos* Deflandre — Bramlette and Sullivan, 155, pl. 9, fig. 8.
1973 *Micrantholithus flos* Deflandre — Kapellos, 104, pl. 20, fig. 4.

Pentaloid with triangle segments which are slightly concave on the distal side. The species occurs frequently in the samples.

Sphenolithus radians Deflandre
Plate 2, fig. 11

1961 *Sphenolithus radians* Deflandre — Bramlette and Sullivan, 166, pl. 14, figs. 6, 7, 8.
1974 *Sphenolithus radians* Deflandre — Scherwood, 55, pl. 9, figs. 3, 4.

The species occurs frequently in the samples.

Discoaster barbadiensis Tan
Plate 2, figs. 3, 6, 9

1954 *Discoaster barbadiensis* Tan — Bramlette and Riedel, 398, pl. 32, fig. 5.
1961 *Discoaster barbadiensis* Tan Sin Hok — Bramlette and Sullivan, 158, pl. 11, fig. 2.
1973 *Discoaster barbadiensis* Tan Sin Hok — Kapellos and Schaub, pl. 4, figs. 2, 3.
1974 *Discoaster barbadiensis* Tan — Scherwood, 59, pl. 9, fig. 12, pl. 10, fig. 1.

The species has 12 to 14 rays which have blunt ends. The sutures between the rays are very distinct. On the surface tiny hollows are scattered and they can be noticed under phase contrast. In the centre there is a distinct central elevation — knob.

The species is abundant in Eocene beds. Often considerable variations of the species have been observed in our samples.

Discoaster distinctus Martini
Plate 2, figs. 1, 4, 7

1958 *Discoaster distinctus* Martini — Martini, 363, pl. 4, fig. 7.
1961 *Discoaster distinctus* Martini — Martini, 14, pl. 3, fig. 28.
1973 *Discoaster distinctus* Martini — Kapellos, 111, pl. 9, fig. 12, pl. 13, fig. 9, pl. 14, figs. 7 to 9, pl. 18, fig. 7.
1974 *Discoaster distinctus* Martini — Scherwood, 61, pl. 11, figs. 6—8.

Discoaster with 6 or 7 rays which elongate and bifurcate at the end. Each branch has a node on it. Characteristic is the central area made of the central knob and the rays reaching out to the legs. Authors state considerable variations for this species, especially in the aspect of the rays, Kapellos (1973, 111) for

instance records even 5 to 10 rays. Martini (1958, 363) on the other hand, reports in his original description the presence of 5 to 7 rays. Our specimens have 6 to 8 rays.

Discoaster lodoensis Bramlette et Riedel
Plate 2, figs. 10, 12, plate 3, fig. 9

1954 *Discoaster lodoensis* Bramlette et Riedel — Bramlette and Riedel, 398, pl. 39, fig. 3.
1958 *Discoaster lodoensis* Bramlette et Riedel — Martini, 366, pl. 6, fig. 28.
1961 *Discoaster lodoensis* Bramlette et Riedel — Bramlette and Sullivan, 161, pl. 12, figs. 4 and 5.
1973 *Discoaster lodoensis* Bramlette et Riedel — Scherwood, 64, pl. 9, fig. 10, pl. 12, figs. 1, 2.

The species is very common in flysch of Podgrad. It has 6 to 7 pointed rays which have on their distal sides distinct ridges running radially from the central knob. The rays are slightly twisted counter-clockwise.

Discoaster sublodoensis Bramlette et Sullivan
Plate 2, fig. 2, plate 3, figs. 4 and 7

1961 *Discoaster sublodoensis* Bramlette et Sullivan — Bramlette and Sullivan, 162, pl. 12, fig. 6.
1973 *Discoaster sublodoensis* Bramlette et Sullivan - Kapellos, 113, pl. 15, fig. 4, pl. 17, figs. 1 to 4 and 8.
1974 *Discoaster sublodoensis* Bramlette et Sullivan — Scherwood, 65, pl. 9, fig. 14.

The species has five or six sharply pointed rays. From a wide central area they quickly transform into points. In the middle of the central area there is a distinct knob.

Discoaster saipanensis Bramlette et Riedel
Plate 3, fig. 1

1954 *Discoaster saipanensis* Bramlette et Riedel — Bramlette and Riedel, 398, pl. 39, fig. 4.
1958 *Discoaster saipanensis* Bramlette et Riedel — Martini, 367, pl. 6, fig. 29.
1973 *Discoaster saipanensis* Bramlette et Riedel — Kapellos, 113, pl. 19, figs. 10, 11, pl. 20, figs. 2 to 3, pl. 21, figs. 4, 7, pl. 23, fig. 4.
1974 *Discoaster saipanensis* Bramlette et Riedel — Scherwood, 65, pl. 9, fig. 16, pl. 12, fig. 4.

The *Discoaster* has seven legs and a big central plate. Strong sutures between the legs can be observed running from the central knob.

Marthasterites tribrachiatus (Bramlette et Riedel)
Plate 3, fig. 8

1954 *Discoaster tribrachiatus* Bramlette et Riedel — Bramlette and Riedel, 396, pl. 38, fig. 11.

1961 *Discoaster tribrachiatus* Bramlette et Riedel — Bramlette and Sullivan, 162, pl. 13, figs. 6 to 13.

1973 *Marthasterites tribrachiatus* (Bramlette et Riedel) — Kapellos, 104, pl. 6, fig. 8, pl. 7, fig. 12, pl. 9, figs. 4 and 6, pl. 10, figs. 1 to 4, 6, pl. 11, fig. 10.

The species appears in the typical form and corresponds completely with the samples described in the literature.

Microrhabdulus decoratus Deflandre

Plate 3, figs. 10 and 11

1959 *Microrhabdulus decoratus* Deflandre — Deflandre, 140, pl. 4, figs. 1 to 5.

1964 *Microrhabdulus decoratus* Deflandre — Bramlette and Martini, 314, pl. 6, figs. 1 and 2.

1974 *Microrhabdulus decoratus* Deflandre — Cimerman and others, 27, pl. 3, fig. 8.

The rhabdulus appears in samples reworked from the Upper Cretaceous.

Neococcolithes dubius (Deflandre)

Plate 3, figs. 2 and 3

1961 *Zygolithus dubius* Deflandre — Bramlette and Sillivan, 150, pl. 6, figs. 12 to 13, 14.

1969 *Neococcolithes dubius* (Deflandre) — Stradner, 418, pl. 87, figs. 1 to 3.

1974 *Neococcolithes dubius* (Deflandre) — Scherwood, 70, pl. 11, fig. 20.

Characteristic elliptic coccolithes with the central part in the shape of the letter H.

Ellipsolithus distichus (Bramlette et Sullivan)

Plate 3, fig. 6

1961 *Coccolithes distichus* Bramlette et Sullivan — Bramlette and Sullivan 152, pl. 7, fig. 8.

1967 *Ellipsolithus distichus* (Bramlette et Sullivan) — Hay and Mohler 1530, pl. 201, figs. 1, 2, 3, 4, 5, pl. 202, figs. 6 to 8.

The species has an elliptical form showing perforations on both sides of the ridge running along the longer axis. The species is referred to the biozone *Discoaster multiradiatus* and *Marthasterites tribrachiatus*. It is assumed that the present species is reworked.

Clathrolithus cf. *ellipticus* Deflandre

Plate 3, fig. 5

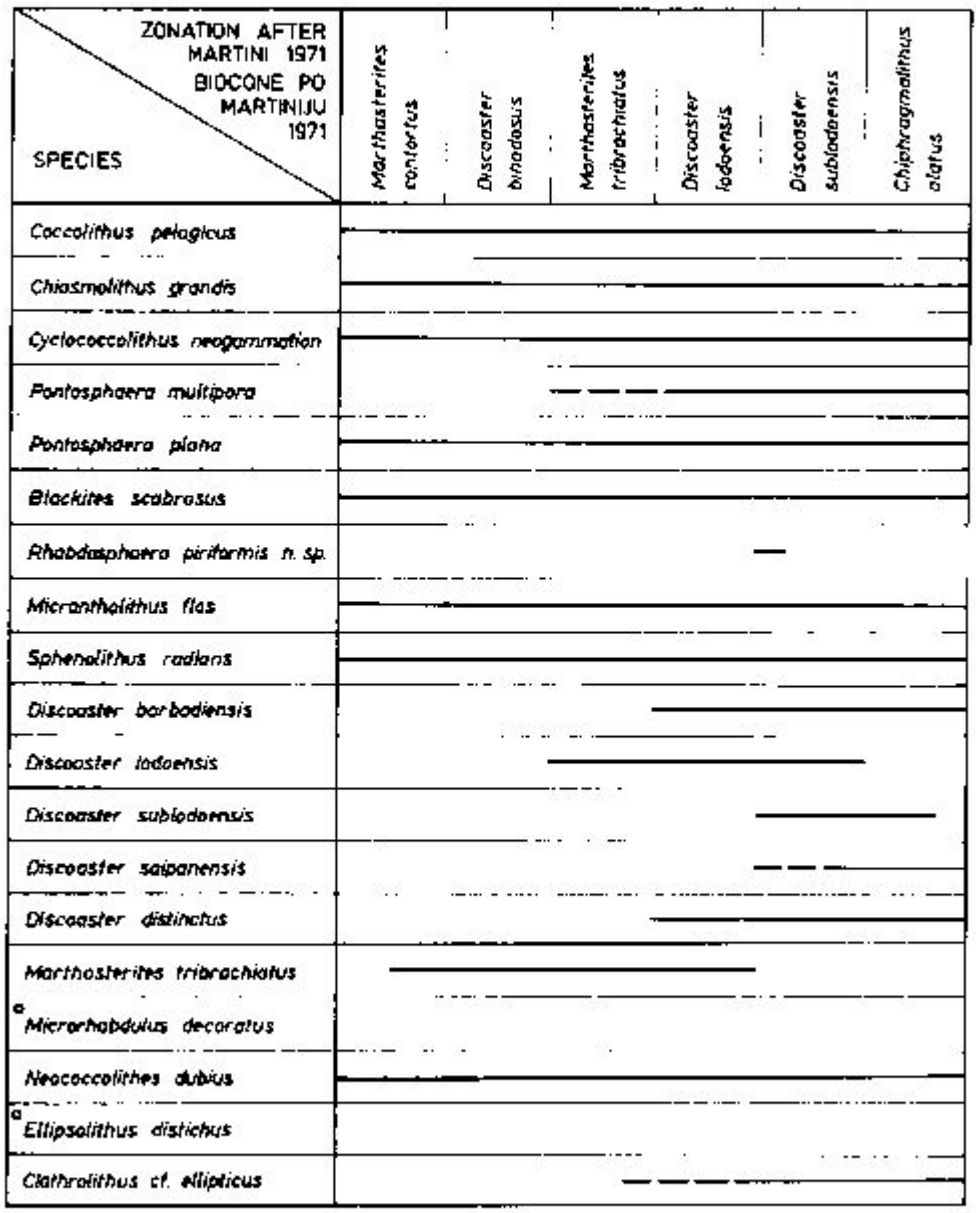
Very badly preserved samples have been determinated after Bramlette and Sullivan (1961, 157), and Stradner (1960, 421).

Elliptic calcareous body with a network of pores similar to honeycombs. The hexagonal pores are rounded by a comparatively frail circumference and that is probably the reason for the bad preservation of the species.

The form appears from Paleocene to the Upper Eocene. The species has originally been described from the Lower Lutetian.

Table 1 — Tabela 1

Nannoplanktonic species from Podgrad with the corresponding biozones
Nannoplanktonske vrste iz Podgrada in ustrezne biocone



o *Reworked species - presedimentirane vrste*

Plate 1 — Tabla 1

1, 2, 3 *Rhabdosphaera piriformis* n. sp.
1, 2 between crossed nicols, 3 phase contrast
1, 2 pri navzkrižnih nikolih, 3 pri faznem kontrastu

4 *Cyclococcolithus neogammation* Bramlette et Wilcoxon
crossed nicols
pri navzkrižnih nikolih

5 a, b *Pontosphaera multipora* (Kamptner)
a crossed nicols, *b* phase contrast
a pri navzkrižnih nikolih, *b* pri faznem kontrastu

6, 7 *Blackites scabrosus* (Deflandre)
between crossed nicols
pri navzkrižnih nikolih

8 a, b *Coccolithus pelagicus* (Wallich)
a phase contrast, *b* crossed nicols
a pri faznem kontrastu, *b* pri navzkrižnih nikolih

9 a, b *Chiasmolithus grandis* (Bramlette et Riedel)
a crossed nicols, *b* phase contrast
a pri navzkrižnih nikolih, *b* pri faznem kontrastu

10, 11 *Pontosphaera plana* (Bramlette et Sullivan)
10 phase contrast, 11 crossed nicols
10 fazni kontrast, 11 pri navzkrižnih nikolih
1800 × enlarged — 1800 × povečano

The photographs of the nannoplankton made by J. Pavšič.
Nanoplankton je fotografiral J. Pavšič.

Plate 1 — Tabla 1


1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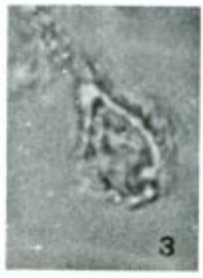
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5a


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8a


8b


5b


9a


10


11


9b

Plate 2 — Tabla 2

1, 4, 7 *Discoaster distinctus* Martini
phase contrast
pri faznem kontrastu

2 *Discoaster sublodoensis* Bramlette et Sullivan
phase contrast
pri faznem kontrastu

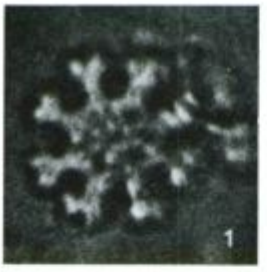
3, 6, 9 *Discoaster barbadiensis* Tan
phase contrast
pri faznem kontrastu

5, 8 *Micrantholithus flos* Deflandre
5 phase contrast, 8 crossed nicols
5 pri faznem kontrastu, 8 pri navzkrižnih nikolih

10, 12 *Discoaster lodoensis* Bramlette et Riedel
phase contrast
pri faznem kontrastu

11 *Sphenolithus radians* Deflandre
crossed nicols
pri navzkrižnih nikolih
1800 × enlarged — 1800 × povečano

Plate 2 — Tabla 2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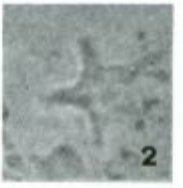
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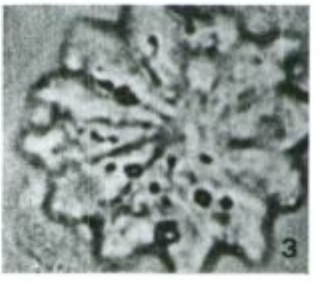
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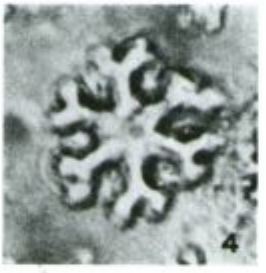
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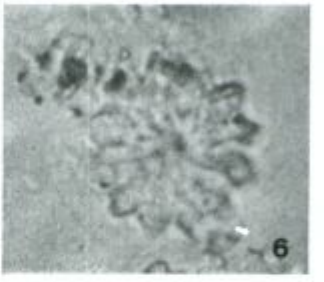
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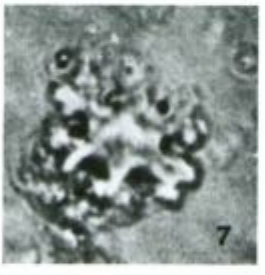
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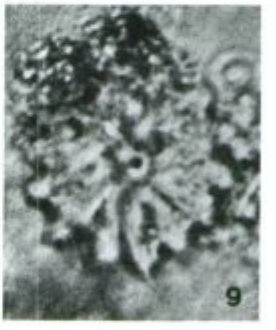
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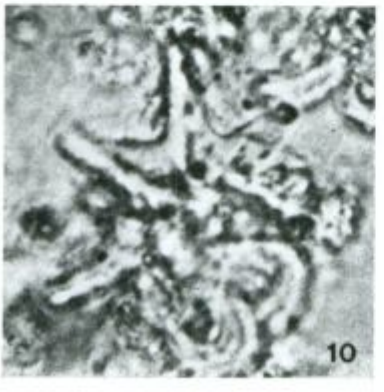
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Plate 3 — Tabla 3

1 *Discoaster saipanensis* Bramlette et Riedel
phase contrast
pri faznem kontrastu

2, 3 *Neococcolithes dubius* (Deflandre)
2 crossed nicols, 3 phase contrast
2 pri navzkrižnih nikolih, 3 pri faznem kontrastu

4, 7 *Discoaster sublodoensis* Bramlette et Sullivan
phase contrast
pri faznem kontrastu

5 *Clathrolithus* cf. *ellipticus* Deflandre
phase contrast
pri faznem kontrastu

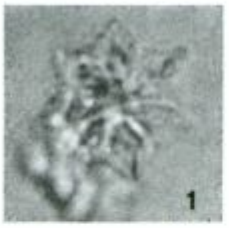
6 a, b *Ellipsolithus distichus* (Bramlette et Sullivan)
a crossed nicols, b phase contrast
a pri navzkrižnih nikolih, *b* pri faznem kontrastu

8 *Marthasterites tribrachiatus* (Bramlette et Riedel)
phase contrast
pri faznem kontrastu

9 *Discoaster lodoensis* Bramlette et Riedel
phase contrast
pri faznem kontrastu

10, 11 *Microrhabdulus decoratus* Deflandre
crossed nicols
pri navzkrižnih nikolih
1800 × enlarged — 1800 × povečano

Plate 3 — Tabla 3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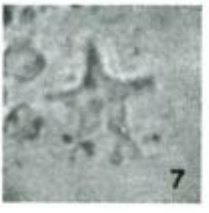
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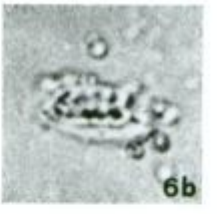
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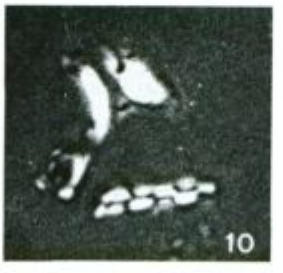
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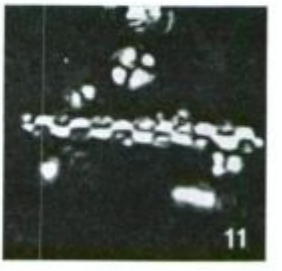
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4. Planktonic foraminifers

Mujibur R. Khan

Table 2

Globigerina linaperta Finlay

1975 a *Globigerina linaperta* Finlay - Bolli, 70, pl. 15, figs. 15 to 17.
1962 *Globigerina linaperta* Finlay — Hillebrandt, 128, pl. 11, figs. 2 and 3.
1965 *Globigerina linaperta* Finlay — Proto Decima and Zorzi, 14, pl. 1, fig. 3.

The species is common in the samples taken from the flysch. According to the various authors the species ranges from the Late Paleocene to the Early Eocene. It has also been recorded from the Cuisian flysch of Ustje (De Zanche, Pavlovec and Proto Decima, 1967, 8) and from the Eocene rocks exposed near Postojna (Gospodarič, Kolosváry, Pavlovec and Proto Decima, 1967, 12). After Pavšič (1973, 143) it occurs also in the Paleocene part of the Podsabotin strata in SW Slovenia.

Globigerina taroubaensis Bronnimann

1957 a *Globigerina taroubaensis* Bronnimann — Bolli, 72, pl. 15, figs. 1—2.
1965 *Globigerina taroubaensis* Bronnimann — Proto Decima and Zorzi, 17, pl. 1, fig. 11.

The species is fairly common and resembles the forms described by Bolli (1957 a, 72), Proto Decima and Zorzi (1965, 17) from the zone of *Globorotalia aragonensis* from Trinidad and northern Italy, respectively.

Globigerina triangularis White

1957 a *Globigerina triangularis* White — Bolli, 71, pl. 15, figs. 12 to 14.
1965 *Globigerina triangularis* White — Proto Decima and Zorzi, 17, pl. 1, fig. 4.

The species ranges from the Late Paleocene to Early Eocene. It has also been found in the Cuisian flysch of Ustje (De Zanche, Pavlovec and Proto Decima, 1967, 8) as well as at Postojna (Gospodarič, Kolosváry, Pavlovec and Proto Decima, 1967, 12).

Globigerina turgida Finlay

1957 a *Globigerina turgida* Finlay — Bolli, 73, pl. 15, figs. 19—23.
1965 *Globigerina turgida* Finlay — Proto Decima and Zorzi, 18, pl. 1, figs. 9—10.
1968 *Globigerina turgida* Finlay — Samuel and Salaj, 134, fig. 33.

The specimens from Podgrad resemble the forms of Bolli (1957 a, 73), Samuel and Salaj (1968, 34). The species is very similar in looks with the *Globigerina taroubaensis* but differs in being larger in size and somewhat more trochoid. Bolli (1957 a, 73), Proto Decima and Zorzi (1965, 18) described the species from the *Globorotalia aragonensis* zone of Trinidad and northern Italy. In the West Carpathians *Globigerina turgida* occurs in the *Globorotalia aragonensis crater* zone and in the basal part of *Turborotalia (Acari-*

nina) crassata densa zone of Samuel and Salaj (1968, 134). The species has also been reported from the flysch exposed at Postojna (Gospodarič; Kolosváry, Pavlovec and Proto Decima, 1967, 12).

Globorotalia aragonensis Nuttal

1957 a *Globorotalia aragonensis* Nuttal — Bolli, 75, pl. 18, figs. 7—9.
1957 b *Globorotalia aragonensis* Nuttal — Bolli, 167, pl. 38, figs. 1.
1965 *Globorotalia aragonensis* Nuttal — Proto Decima and Zorzi, 22, pl. 3, fig. 8, pl. 5, fig. 16.
1968 *Globorotalia aragonensis aragonensis* Nuttal — Samuel and Salaj, 148, pl. 11, fig. 5.
1971 *Globorotalia aragonensis* Nuttal — Subbotina, 274, pl. 16, fig. 6 and 7.

The species is well preserved but not common in the area. The vertical range of the species is generally mentioned in the literature as Early Eocene to Middle Eocene. After Bolli (1957 a, 75; 1957 b, 167) and Postuma (1971, 172) the species ranges from the *Globorotalia formosa aragonensis* zone to the *Globigerapsis kugleri* zone. In the West Carpathians the species has been reported (Samuel and Salaj, 1968, 149) from the Early and Middle Eocene, representing the *Globorotalia aragonensis* to *Turborotalia (Acarinina) crassata densa* zones. Proto Decima and Zorzi (1965, 23) described the species from the *Globorotalia formosa formosa* zone and *Globorotalia aragonensis* zone. In NW Caucasia the species occurs in the Early to Middle Eocene beds (Subbotina, 1971, 275). *Globorotalia aragonensis* has also been found in the Cuisian flysch of Ustje (De Zanche, and Proto Decima, 1967, 212) and at Postojna (Gospodarič, Kolosváry, Pavlovec and Proto Decima, 1967, 40).

Globorotalia convexa Subbotina

1957 *Globorotalia convexa* Subbotina — Loeblich and Tappan, 188, pl. 48, fig. 4, pl. 50, fig. 7, pl. 53, figs. 6—8, pl. 57, figs. 5—6, pl. 61, fig. 4, pl. 63, fig. 4.
1965 *Globorotalia convexa* Subbotina — Proto Decima and Zorzi, 24, pl. 1, fig. 13.
1968 *Turborotalia (Acarinina) convexa* (Subbotina) — Samuel and Salaj, 163, pl. 16, figs. 5 and 6.
1971 *Globorotalia convexa* Subbotina — Subbotina, 263, pl. 17, figs. 4 to 6.

The species resembles the forms determined by Subbotina (1971, 263) with variable dimensions of the tests. The number of chambers in the last whorl is generally five but there are also specimens with six chambers.

The type species has been described from the zone with the conical *Globorotalia* (Subbotina, 1971, 263). Loeblich and Tappan (1957, 188) mentioned the species from the formations representing the biozones from *Globorotalia velascoensis-acuta-spiralis* subzone to *Globorotalia rex* zone. In northern Italy (Proto Decima and Zorzi, 1965, 24) the species is present from the zone of *Globorotalia pseudomenardii* to the *Globorotalia aragonensis* zone. Samuel and Salaj (1968, 164) described the species from the Late Paleocene to Middle Eocene in West Carpathians and have placed the species in

their zone of *Globorotalia aequa* to the zone of *Turborotalia (Acarinina) crassata densa*. In western Yugoslavia the species appears in the Eocene flysch at Postojna (Gospodarič, Kolosváry, Pavlovec and Proto Decima, 1967, 44).

Globorotalia crassaformis (Galloway et Wissler)

1968 *Turborotalia (Acarinina) crassata densa* (Cushman, 1925) — Samuel and Salaj, 164, pl. 17, figs. 3 and 4.

1971 *Acarinina crassaformis* (Galloway and Wissler) — Subbotina, 290, pl. 21, figs. 1 to 7.

The species is common in the flysch at Podgrad. The dimensions of the test and the sizes of the chambers in different specimens are somewhat variable. These variations were also mentioned by Subbotina (1971, 291) while describing the *Acarinina crassaformis* from the Caucasia.

The range of the species may be disputed. It appears to be long for the planktonic species as has been mentioned by various authors from different areas.

The holotype has been described from the Late Cretaceous and Cushman (Subbotina 1971, 293) reported the species from the present sea as well. After Samuel and Salaj (1968, 165) it occurs in Early Eocene beds with the maximum development in the early part of the Middle Eocene layers; some have also been found in the lowermost part of the Late Eocene beds in the Carpathian region. According to them the species belongs to the biozones *Turborotalia (Acarinina) crassata densa* to *Truncorotalia rohri*.

In Caucasia (Subbotina, 1971, 292) the species occurs mainly in the zone with the conical *Globorotalia* and in the zone of *Acarinina* (Early Eocene to early part of the Late Eocene).

Globorotalia interposita (Subbotina)

1971 *Acarinina interposita* Subbotina — Subbotina, 303, pl. 23, figs. 6 to 7.

The species is common in the flysch. The *Globorotalia interposita* from Podgrad shows variability in the convexity on the spiral side. There are some specimens with almost flat spiral side whereas others are markedly convex. The ultimate chamber of some forms is smaller than the penultimate one and often contains a suplementary small vesicular chamber as has been pointed out by Subbotina (1971, 304).

The species has been mentioned from the Caucasia in the USSR and ranges from Paleocene to Middle Eocene representing the zone of compressed *Globorotalia* to the same of conical *Globorotalia* (Subbotina, 1971, 304).

Globorotalia pseudotopilensis (Subbotina)

1957 *Globorotalia pseudotopilensis* (Subbotina) — Loeblich and Tappan, 194, pl. 60, fig. 2.

1962 *Globorotalia (Acarinina) pseudotopilensis* (Subbotina) — Hillebrandt, 143, pl. 14, fig. 1.

1965 *Globorotalia pseudotopilensis* (Subbotina) — Proto Decima and Zorzi, 28, pl. 4, fig. 8.

1968 *Turborotalia (Acarinina) pseudotopilensis* (Subbotina) — Samuel and Salaj, 172, pl. 14, fig. 2.

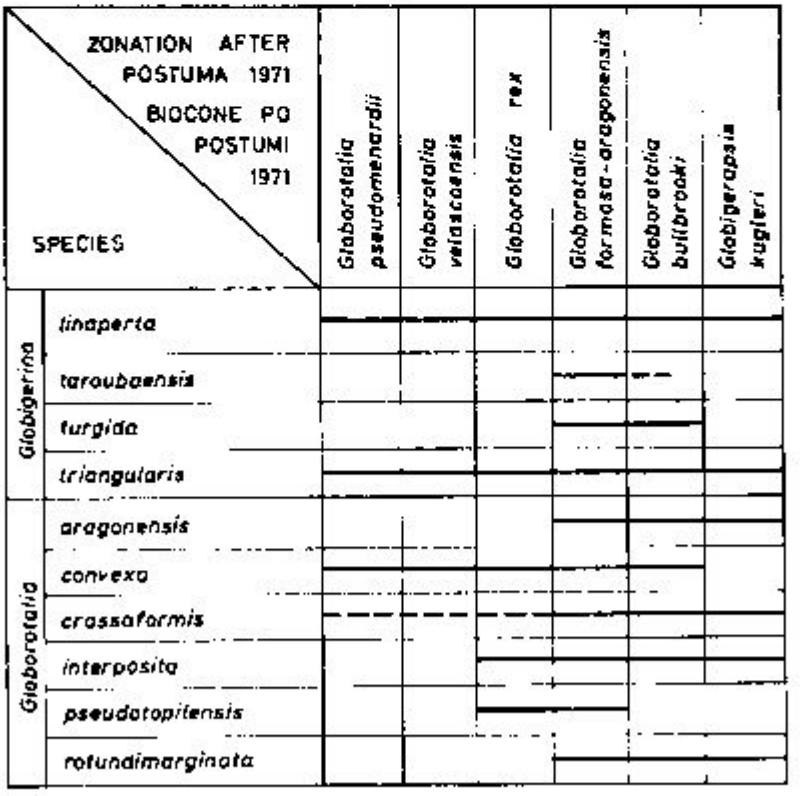
1971 *Acarinina pseudotopilensis* Subbotina — Subbotina, 294, pl. 21, figs. 8—9, pl. 22, figs. 1—3.

The species is rare in the flysch of Podgrad but resembles the type species from the Caucasia of the USSR (Subbotina, 1971, 294).

According to Subbotina (1971, 295) the species occurs in the Caucasia from the compressed *Globorotalia* to conical *Globorotalia* zone of Paleocene to Middle Eocene. In the Central Carpathians it occurs in the same age from the *Globorotalia aequa* to *Globorotalia aragonensis crater* zones (Samuel and Salaj, 1968, 172). According to Proto Decima and Zorzi (1965, 28) the species ranges in northern Italy from the *Globorotalia rex* zone to the *G. aragonensis* zone. This species has also been reported from the Nanafalia formation (Early Eocene) of Alabama, U.S.A. (Loeblich and Tap-

Table 2 — Tabela 2

Planktonic species from Podgrad and the corresponding biozones
Planktonske vrste iz Podgrada in ustrezne biocone



pan, 1957, 194). In western Yugoslavia, at Postojna, it has been found in the Eocene flysch (Gospodarič, Kolosváry, Pavlovec and Proto Decima, 1967, 12).

Globorotalia rotundimarginata (Subbotina)

1965 *Globorotalia rotundimarginata* (Subbotina) — Proto Decima and Zorzi, 30, pl. 2, fig. 7.

1968 *Turborotalia (Acarinina) rotundimarginata* (Subbotina) — Samuel and Salaj, 172, pl. 19, figs. 1 and 2.

1971 *Acarinina rotundimarginata* Subbotina — Subbotina 308, pl. 25. figs. 1—3.

The species is common and closely similar to the forms of Subbotina (1971, 308) and others.

According to Subbotina (1971, 309) the species occurs in the Early. Middle and Late Eocene. It is most abundant in the early part of the Late Eocene.

In the Carpathians the species occurs in the early part of the Late Eocene (Samuel and Salaj, 1968, 172). Proto Decima and Zorzi (1965, 30) described this species from the zone of *Globorotalia aragonensis* in northern Italy. It has also been reported from the Eocene flysch of Postojna (Gospodarič, Kolosváry, Pavlovec and Proto Decima, 1967, 13).

5. Nummulitinae

Mujibur R. Khan and *Rajko Pavlovec*

Operculina marinellii similis n. ssp.

Plate 4, figs. 1 to 8, plate 5, fig. 1

1967 *Operculina* cf. *marinellii* — De Zanche, Pavlovec and Proto Decima, 40.

Derivatio nominis: The new subspecies resembles the *Operculina marinellii marinellii*.

Holotypus: B form in the collection of the Institute of Geology and Paleontology, Ljubljana University, inv. no. 3838.

Paratypi: B forms in the same collection as the holotypus.

Locus typicus: 1 km north northwest of Podgrad, SW Slovenia, western Yugoslavia.

Stratum typicum: Lower part of the Middle Cuisian.

Diagnosis: *Operculina* with the larger test and somewhat slower increasing of the whorls as *Operculina marinellii marinellii*.

B form. The test is about 1 mm thick with a maximum diameter of 13 mm, often with slightly elevated area at the centre which is covered by slightly projecting bosses, almost circular in outline with somewhat undulated outer margin.

The septa and the marginal cord are remarkable and occasionally the marginal cord forms a distinct relief from the test surface. The number of the whorls

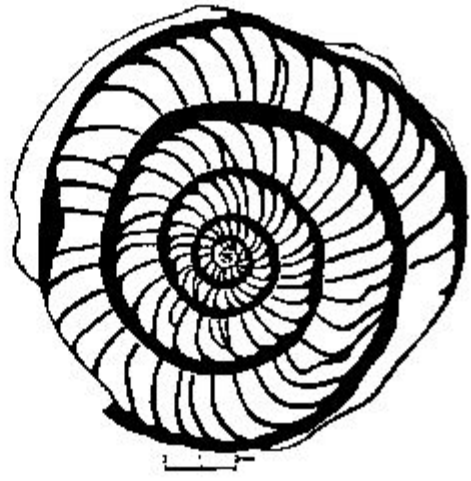


Fig. 3. *Operculina marinellii similis* n. ssp., B form. Podgrad No. 3839
Sl. 3. *Operculina marinellii similis* n. ssp., oblika B. Podgrad, inv. št. 3839

in usually 6 to 6 ¼ and they increase rapidly; the septa are numerous, in the final whorl 33 to 35 and are usually perpendicular to the marginal cord and nearly straight. The septa are thin and thickened in their upper parts (fig. 3). Well preserved tests show granulation between the septa.

Table 3 — Tabela 3

Numerical data for the subspecies *Operculina marinellii similis*, B form
Številčni podatki za podvrsto *Operculina marinellii similis*, oblika B

Sample Primerek	S_3	S_4	S_5	S_6	L_2	L_3	L_4	L_5	L_6
1	17	23	27	33	0,3—L_4	0,3	0,6	0,6	0,4
2	17	22	28	34	0,3—L_5	0,1	0,4	0,7	0,8
3	16	23	29	34	0,3—L_5	0,2	0,7	0,6	0,6
4			29	35		0,6—L_5	0,4	0,6	0,6
5			29	33		0,8—L_5	0,3	0,8	0,8

1 Holotypus
2—5 Paratypi
S_3, S_4 ... Number of septa in the third, fourth, ... whorl
Število sept v tretjem, četrtem ... zavoju
L_2, L_3 ... Height increase in the second, third ... whorl
Prirastek višine v drugem, tretjem ... zavoju

Remarks. The new *Operculina* belongs to the granulated operculinas which have granules between the septa. Hottinger (1964, 1019) put into this group the species *Operculina marinellii marinellii* from Cuisian and *Operculina praespira* from Lower Lutetian. Between the two species transitional forms exist (*O. aff. praespira*). To the same group belongs also the *Operculina exiliformis* (Pavlovec, 1966) from the Middle Ilerdian.

All the forms mentioned above are similar regarding the course of the whorls, the shape of the septa and chambers, and the marginal cord. The

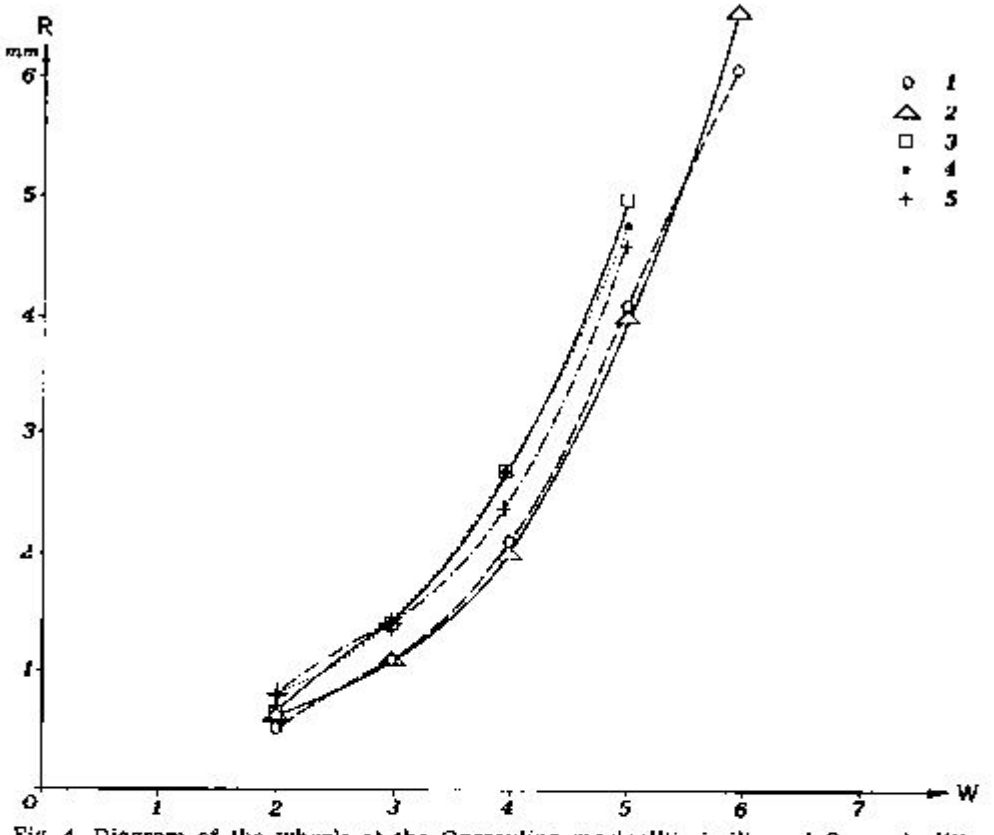


Fig. 4. Diagram of the whorls at the *Operculina marinellii similis* and *O. marinellii marinellii*, B forms

Sl. 4. Diagram zavojev pri podvrstah *Operculina marinellii similis* in *O. marinellii marinellii*, oblike B

1 Operculina marinellii similis (holotypus)
2 Operculina afl. marinellii (Drobne & Pavlovec, unpublished)
3 Operculina marinellii marinellii (Dainelli, 1915)
4 Operculina marinellii marinellii (Hottinger, 1984)
5 Operculina marinellii marinellii (Montanari, 1974)
R Radius, in millimetres — Polmer, izražen v milimetrih
W Number of whorls — Število zavojev

Operculina exiliformis has the smallest test among all of them, while the *O. praespira* has the largest. In between are the *Operculina marinellii marinellii* and *O. marinellii similis*. The maximum diameter of the type belonging to the form *Operculina marinellii marinellii* described by Dainelli (1915, 170) is 11 mm but most common occurrences are 5 to 6 mm. The maximum diameter of the *Operculina marinellii similis* is 13 mm, common being 10 to 12 mm. The whorls (W/R, fig. 4) increase slower than those of the form described by Dainelli (1915, 170), Hottinger (1984, 1020, and Montanari (1984, 59).

The type species as well as the species mentioned by Hottinger (1964, 1020) usually have five whorls whereas the present subspecies generally has six.

To the subspecies *Operculina marinellii similis* the *Operculina* aff. *marinellii* is to be assigned. This form has been found at Smrčun near Slovenj Gradec, northern Slovenia (Drobne and Pavlovec, unpublished). Its test has 6 ½ whorls, the diameter of 12,6 mm and the same rate of the whorls increase as the holotypus.

In the Ustje series of Vipava valley the *Operculina* cf. *marinellii* (De Zanche, Pavlovec and Proto Decima, 1967, 40) occurs. After having studied the original material it is evident that the *Operculina* from Ustje belongs to the subspecies *Operculina marinellii similis*.

The new subspecies is similar to the older *Operculina exiliformis*, which has somewhat thinner marginal cord, and to the *O. praespira* which is larger.

Table 4 — Tabela 4

Number of septa in *Operculina marinellii similis* and in some similar B forms
Število sept pri podvrsti *Operculina marinellii similis* in pri nekaterih sorodnih oblikah B

Species or subspecies Vrsta ali podvrsta	S_3	S_4	S_5	S_6	S_7	S_8
Operculina marinellii similis, Smrčun (Drobne and Pavlovec, unpublished)	18	22	27	33		
Operculina marinellii marinellii Friuli (Dainelli, 1915, pl. 16, fig. 28)	19	23	31			
Operculina marinellii marinellii (Hottinger, 1964, pl. 3, fig. 10a)	23	28	31			
Operculina marinellii marinellii (Montanari, 1964, pl. 16, fig. 15)	15	20	28			
Operculina exiliformis (Pavlovec, 1966, pl. 2, fig. 3)		20	31	38		
Operculina aff. *praespira* (Crni Kal, north Istria)	20	25	31	36		
Operculina praespira (Pavlovec, 1969, pl. 10)			23	28	40	55

S_3, S_4 ... Number of septa in the third, fourth ... whorl
Število sept v tretjem, četrtem ... zavoju

Stratigraphic remarks. In the locality of Podgrad *Operculina marinellii similis* appears in the biozone *Globorotalia formosa* and *Discoaster sublodoensis*, that is in the lower part of the Middle Cuisian. To the Middle Cuisian belongs also *Operculina marinellii similis* from Smrčun near Slovenj Gradec and the one from Ustje in Vipava valley. *Operculina marinellii marinellii* occurs in Friuli together with the species *Nummulites irregularis* Deshayes (Dainelli, 1915). As the associated fauna is not precisely determined, the stratigraphic level of Friuli locality is not clear. Hottinger (1964, 1020) too does not state the exact stratigraphic horizon for *Operculina marinellii marinellii*, while Kecskeméti (1970, 154) attributes this form to the Lower Lutetian, and Montanari (1964, 59) even to the Upper Lutetian.

Assilina laxispira De la Harpe et Rozlozsnik

1926 *Assilina placentula* Deshayes sp. vel *Assilina granulosa* D'Archiac var. *laxispira* n. var. — De la Harpe and Rozlozsnik, 92.
1951 *Assilina douvillei* Abrard & Fabre 1944 — Schaub, 212—214, figs. 323, 325—328, pl. 9, figs. 12—16.
1963 *Assilina laxispira* De la Harpe — Schaub, 293—294, fig. 5.
1966 b *Assilina laxispira* De la Harpe, 1926 — Schaub, 376, pl. 2, fig. 19.

Only one test of the microsphaeric form has been found.

The whorls grow regularly with the exception of the first three, which increase more slowly than the others. The thin septa are flat or slightly bending back, only in the upper part they are bent strongly. The chambers are higher than broad and only a few chambers approach the isometric form. The marginal cord increases proportionally.

The species *Assilina laxispira* belongs to the Middle Cuisian.

Nummulites aquitanicus Benoist

Plate 5, figs. 2 and 3

1951 *Nummulites aquitanicus* Benoist 1888 — Schaub, 182—185, figs. 257 — 266, pl. 7, figs. 1—13.
1966 *Nummulites aquitanicus* Benoist, 1889 — Schaub, 371, fig. 6, pl. 3, figs. 16—22.
1973 *Nummulites aquitanicus* Benoist, 1889 — Kapellos, 68—70, figs. 111—118, pl. 44, figs. 3—9.

B form. The test is thin and flat showing eight whorls. Its diameter is 8,5 mm. In the centre there are several irregular and clear granules which disappear somewhere near the half of the test. From there on only a little sinuous septal lines occur. At the septal lines trabecules transverses can be noticed.

The whorls in the inner part of the test increase regularly. The marginal cord is thick and comprises in some whorls almost one half of the whorl's height.

The septa in the inner whorls are slightly bent and inclined. In the outer whorls they are bent much more. Some of the septa are bent back strongly. All septa are coarse, the thickest being near the marginal cord.

Table 5 — Tabela 5

The number of septa in the species *Nummulites aquitanicus*, B form
Število sept pri vrsti *Nummulites aquitanicus*, oblika B

Locality Nahajališče	S_2	S_3	S_4	S_5	S_6	S_7
Podgrad	18	22	26	25	33	34*
Rossboden (Schaub, 1951, fig. 265)		19	24*	24*	30*	32*
Rottenbach (Kapellos, 1973, fig. 113b)		19	24	29	30	
Höllbach-Schwyberg (Kapellos, 1973, fig. 112)	14	17	22*	28*	30*	30*

* The number of the septa has been calculated from one half of the whorls. — Število sept je bilo preračunano iz polovice zavojev.

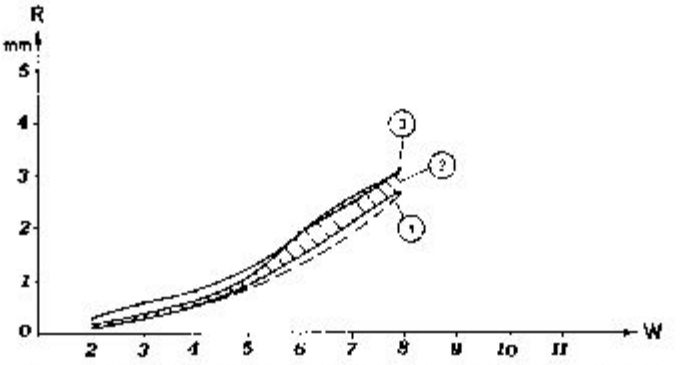


Fig. 5. Diagram of the whorls at the *Nummulites aquitanicus* and *N. jacquoti*, B forms

Sl. 5. Diagram zavojev pri vrstah *Nummulites aquitanicus* in *N. jacquoti*, oblike B

1 Nummulites jacquoti (Kapellos, 1973, fig. 116)
2 Nummulites aquitanicus (Kapellos, 1973, fig. 116)
3 Nummulites aquitanicus, Podgrad
R Radius, in millimetres — Polmer, izražen v milimetrih
W Number of whorls — Število zavojev

In the early whorls the chambers are heigher than broad. In the outer whorls they become longer so that they are nearly isometric. The upper parts of the chambers are slightly arched.

Remarks. At Ustje *Nummulites jacquioti* De la Harpe (De Zanche, Pavlovec and Proto Decima, 1967, 230), has been found. It resembles somewhat *Nummulites aquitanicus*, but the former has numerous distinct granules on the surface. The septal lines are smoother. The whorls increase also in the outer part (fig. 5) where the septa are slightly straighter and the chambers shorter.

The interesting morphological particularities have been pointed out already by Schaub (1951, 182—184). The tests of the *Nummulites aquitanicus* from the younger strata (from the biozone *Nummulites praelaevigatus)* resemble much more the species *N. laevigatus* than the typical form of *N. aquitanicus*. First of all they have somewhat lower whorls and longer chambers, even longer than the form from Podgrad. The sample on the figure 264 (Schaub, 1951) still resembles a little the species *Nummulites planulatus* if we compare the course of the whorls and the shape of the chambers. The *Nummulites* from Podgrad does not resemble this specimen. This means that the development from the species *Nummulites planulatus* towards *N. aquitanicus* and further on to *N. laevigatus* proceeded in the direction of lowering the whorls and lengthening the septa. There is no doubt that all these nummulites are not on the same evolutionary line. Anyway, the species *Nummulites praelaevigatus* does not show the normal continuation of the development as its exterior is closer to the species *Nummulites aquitanicus* while its septa and chambers resemble more those of the species *N. laevigatus*. It is also difficult to place *Nummulites buxtorfi* Schaub into this evolutionary line.

Into this group belongs also the specimen from Campo, Spain (Schaub, 1966b, pl. 3 and 4), determined as *Nummulites* aff. *aquitanicus*.

Age. Schaub (Hottinger, Lehmann and Schaub, 1964) ranges the species *Nummulites aquitanicus* in the transitional period from Lower to Middle Cuisian, or into the Lower and Middle Cuisian, respectively (Schaub, 1951). He establishes this species in the Middle Cuisian also later on (Schaub, 1965, 129), while in the Campo profile he does not decide clearly upon the age of this species. His similar form, the *Nummulites* aff. *aquitanicus*, has been reported from the Middle Cuisian (Schaub, 1966b, 358). Lately it was Kapellos (1973, 69—70) who made most interesting conclusions about the age. He has found a lot of *Nummulites aquitanicus* in the Lower and Middle Cuisian. Specimens on plates 112 and 113 show the characteristics mentioned already by Schaub. The Lower-Cuisian nummulites still has narrower chambers and somewhat higher whorls, while the Middle-Cuisian one has somewhat longer chambers and lower whorls.

Considering the equatorial section, the specimen from Podgrad could probably be attributed to another species, but its exterior is characteristic for the *Nummulites aquitanicus*. Anyway, it is by no means identical with Schaub's (1966b) Middle-Cuisian specimens *N.* aff. *aquitanicus*.

The conclusion arising from all this is that the *Nummulites aquitanicus* lived in the Lower and Middle Cuisian, and that it lived even a little longer than we thought up to now.

Nummulites ustjensis De Zanche et Pavlovec

Plate 6, figs. 1 to 3

1929 *Nummulina striata* (B) Bruguière — Rozlozsnik, 128, pl. 6, fig. 6.

1967 *Nummulites ustjensis* n. sp. oblika B — De Zanche, Pavlovec and Proto Decima, 232—233, pl. 8, fig. 3, pl. 9, figs. 1—2, pl. 10, figs. 1—2, pl. 11, fig. 1.

B form. In the flysch of Podgrad only the microsphaeric form has been found, so that we still do not know the megalosphaeric one. The test of the B form is very thin and has a rather sharp margin. On the surface there are numerous septal lines which are slightly bent. There are granules and also in the intermediate skeleton there are no bosses.

The whorls increase normally up to the fifth one, then they increase more quickly up to the tenth whorl. After that they remain of the same height or even decrease (fig. 6). The marginal cord is rather strong and sometimes comprises even more than one third of the whorl. It grows up to the ninth whorl then it remains unchanged till the end, or even gets thinner.

The septa are coarse. At the bases they have indistinct feet. In the first three or four whorls the septa are nearly flat. In the later whorls they are curved and thickened and strongly bent back close to the marginal cord.

The chambers in the early whorls are higher than broad but some of them are also rather isometric. In the later whorls the chambers are isometric and in some of them the length considerably exceeds the height.

In two best preserved samples the number of septa is as shown in the table 6.

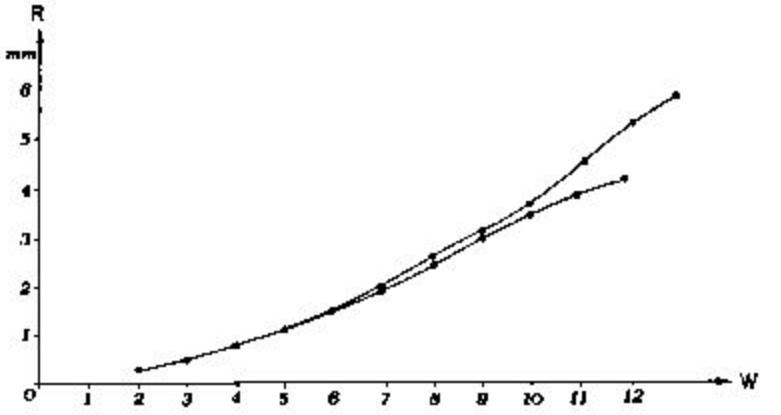


Fig. 6. Diagram of the whorls at the *Nummulites ustjensis*, B form. Podgrad

Sl. 6. Diagram zavojev pri vrsti *Nummulites ustjensis*, oblika B. Podgrad

R Radius, in millimetres — Polmer, izražen v milimetrih
W Number of whorls — Število zavojev

Table 6 — Tabela 6

The number of septa in the species *Nummulites ustjensis*, B form
Število sept pri vrsti *Nummulites ustjensis*, oblika B

Locality Nahajališče	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}
Podgrad	6	14	19	26	28	36	40	43	53	51	52	66
Podgrad			20	25	36	34	34	41	53	60	60	68
Ustje — holotypus		16	20	24	36	36	40	46	54	50	64	68

Remarks. Podgrad is the second locality of the species *Nummulites ustjensis* in Slovenia. But it has been found also in the locality of Brusaferri near the village Bolca (De Zanche, Pavlovec and Proto Decima, 1967, 233).

From Podgrad a form has been determined which shows a more quick increasing of the younger whorls (fig. 6). Somewhat similar course of the whorls occurs in *Nummulites striatus* Brugulère and *N.* aff. *ustjensis* from Ustje (De Zanche, Pavlovec and Proto Decima, 1967, 230—231, fig. 6) which we describe now as *Nummulites brkiniensis* n. sp.

Age. The flysch at Ustje with the species *Nummulites ustjensis* has been placed in the period of transition between the Lower and Middle Cuisian (De Zanche, Pavlovec and Proto Decima, 1967, 232)

Nummulites brkiniensis n. sp.

Plate 6, figs. 4 to 6, plate 7, figs. 1 and 2

1967 *Nummulites* aff. *ustjensis* n. sp. — De Zanche, Pavlovec and Proto Decima, 233, pl. 11, fig. 2.

Derivatio nominis: After the region of Brkini where the locality of the holotypus is situated.

Holotypus: Inv. no. 3844, B form, Institute for Geology and Paleontology, University of Ljubljana.

Paratypi: Inv. no. 3845, 3846, 3847, 3848, all the B forms, in the same collection as the holotypus.

Locus typicus: The locality with nummulitins at Podgrad, Brkini, SW Slovenia.

Stratum typicum: Flysch, Middle Cuisian.

Diagnosis: *Nummulites* with a larger test, denser and highly bent septa as in the very similar species *Nummulites ustjensis*.

B form. The test is thin getting slightly thicker only at the centre. The margin is slightly rounded. On the surface there are thin, dense and rather sinuous septal lines which often split. Some samples show distinct trabecules transverses.

All whorls increase regularly, the older ones somewhat slowly, though the middle ones rather quickly and the younger ones much more slowly than the middle ones. The marginal cord is regular and strongest in the middle, that is at the highest whorls.

The septa in the early seven or eight whorls are nearly flat, slightly inclined and only at the top highly bent. In the following whorls they are more inclined and often regularly bent along the whole height. The chambers are usually higher than broad, only some chambers of the early whorls are nearly isometric. Where the chambers are longer their roof is only slightly arched while in the narrow and high chambers it is strongly arched.

The characteristic data of the new species are shown in table 7.

Table 7 — Tabela 7

Measurements of the species *Nummulites brkiniensis* n. sp., B form, from the locality Podgrad

Meritveni podatki za vrsto *Nummulites brkiniensis* n. sp., oblika B, iz nahajališča Podgrad

Sample — Primerek	Dm	W	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}
Holotypus														
inv. no. 3844	17	16	12	20	28	44	36	52	56	64	60	58	84	106
inv. no. 3845	11,4	11				36	36	40	52	60	60	60		

Dm Diameter, in millimetres — Premer, izražen v milimetrih

W Whorls number — Število zavojev

S_1, S_2 ... Number of septa in the first, second ... whorls — Število septa v prvem, drugem ... zavoju

Remarks. It is sometimes difficult to tell apart the species *Nummulites brkiniensis* from the species *N. ustjensis*. At Ustje it has been already distinguished the form *Nummulites* aff. *ustjensis* (De Zanche, Pavlovec and Proto Decima, 1967, 233, pl. 11, fig. 2), which was larger than the original *N.*

ustjensis. There is no doubt that this form belongs to the species *Nummulites brkiniensis*.

The species *Nummulites brkiniensis* differs from *N. ustjensis* mostly by its larger test. Furthermore *Nummulites ustjensis* has less bent septa, longer chambers and whorls increasing more regularly than in *N. brkiniensis*.

Age. *Nummulites brkiniensis* has been up to now found only in the flysch at Podgrad in the lower part of the Middle Cuisian beds and at Ustje in the period of transition between the Lower and Middle Cuisian (De Zanche, Pavlovec and Proto Decima, 1967).

Nummulites postbearnensis n. sp.

Plate 8, figs. 1 and 2

1967 *Nummulites* ex gr. *planulatus* — Gospodarič, Kolosváry, Pavlovec and Proto Decima, 45, fig. 4.

Derivatio nominis: The new species is similar to the species *Nummulites bearnensis* Shaub et Schweighauser but it is younger than *N. bearnensis*.

Holotypus: Inv. no 3850, B form, Institute for Geology and Paleontology, University of Ljubljana.

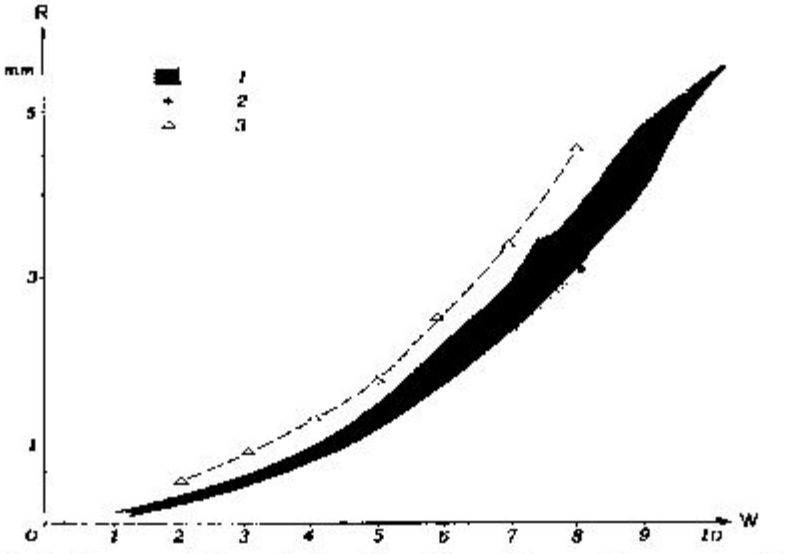


Fig. 7. Diagram of the whorls at the *Nummulites postbearnensis* and some similar B forms

Sl. 7. Diagram zavojev pri vrsti *Nummulites postbearnensis* in nekaterih podobnih B oblikah

1 *Nummulites aquitanicus* (Schaub, 1951, fig. 257)
2 *Nummulites jacquoti* (De Zanche, Pavlovec and Proto Decima, 1967, pl. 7, fig. 1)
3 *Nummulites postbearnensis* (holotypus). Podgrad

R Radius, in millimetres — Polmer, izražen v milimetrih
W Number of whorls — Število zavojev

Locus typicus: The locality of the nummulitins at Podgrad, Brkini, SW Slovenia.

Stratum typicum: Flysch, Middle Cuisian.

Diagnosis: *Nummulites postbearnensis* has a larger test and the septa are more bent than in *N. bearnensis*. The test is completely involute.

B form. The test is thin and it thickens a little only at the centre. The margin is rounded. The septal lines are somewhat sinuous and sometimes they break up sharply or even split.

The whorls increase quickly and regularly (fig. 7). The marginal cord is strong and proportionally thick. The septa are slightly but regularly bent along the whole length. Their lower parts are very thin and they get thicker in the upper parts. At their bases there are indistinct feet. The chambers are higher than broad and somewhat slightly arched.

The characteristics: Dm/W (test diameter: number of whorls) = 9/9, 11/11; D (test thickness) = 2 to 3 mm; number of septa S_4 = 18, S_5 = 22, S_8 = 28, S_7 = 30, S_9 = 40 and S_9 = 42.

Remarks. *Nummulites postbearnensis* has been determined from different localities in Slovenia. It has been found at Podgrad and Polok (both in Brkini, SW Slovenia). The *Nummulites* ex gr. *planulatus* (Gospodarič and others, 1967, 45, fig. 4) occurring in the breccia near the railway station of Postojna is actually *N. postbearnensis*. There it appears together with the *Nummulites praelucasi* Douvillé which lived according to Kapellos (1973, 55) from the Lower to the Upper Cuisian.

The new species got its name from the species *Nummulites bearnensis*, previously described as *N. planulatus bearnensis* (Schaub and Schweighauser, 1951, 237—239, figs. 1—3, 6—7) and later as *N. bearnensis* (Schaub, 1980, 446). Our forms differ from this Upper-Ilerdian species by their size (test diameter of the *N. bearnensis* is Dm = up to 6 mm), by the septa (in the new species the septa are more bent than in *N. bearnensis*), and by the involution. According to Schaub (1960, 446) *Nummulites bearnensis* has evolute younger whorls, while *N. postbearnensis* has a quite involute test. Considering the involute test the new species is closer to the species *Nummulites planulatus* Lamarck which has similarly shaped test and similar course of the septal lines. But the typical *Nummulites planulatus* has a thinner marginal cord, higher whorls and the septa are more bent. *Nummulites postbearnensis* differs also from the subspecies of the species *Nummulites planulatus* described by Schaub (1951) by the size of the test, the marginal cord and most frequently also by the whorls'height.

Nummulites postbearnensis is larger than *N. jacquoti* De la Harpe, has higher whorls, more bent septa and thinner septal lines. It differs from the *Nummulites aquitanicus* by its exterior where no granules have been developed, by its shorter chambers and by the septa which are thickened at their upper parts. *Nummulites postbearnensis* has lower whorls and denser, more bent septa than *N. exilis* Douvillé.

Close to the new species is also the form from Friuli, determined by Dainelli (1951, pl. 22, fig. 17) as *Nummulites pulchellus* Hantken. It differs from the species *Nummulites postbearnensis* mostly by the more bent and denser

septa. The Dainelli's form could most probably be attributed to the species *Nummulites planulatus*.

Schaub engaged himself in studying the nummulites cognated with the species *Nummulites postbearnensis*. He described the transitional form as *Nummulites exilis-planulatus* (Schaub, 1951, 170—171, figs. 231—232). This form resembles very much the species *Nummulites exilis* by its quickly increasing whorls, and by its appearance it resembles the species *N. planulatus*. It differs from the *N. postbearnensis* by the smaller test and above all by the less bent septa. Later on Schaub (1960, 444—446) described the Middle-Ilerdian species as *Nummulites cuisensis* D'Archiac which is very close to the species *Nummulites bearnensis*. Both have tests in which the younger whorl is not involute. As the *Nummulites postbearnensis* has a completely involute test it is closer to the species *N. planulatus*.

Schaub (1950, 244) places the subspecies *Nummulites planulatus cussacensis* Schaub phylogenetically after the type *N. planulatus planulatus*. In such a way it represents a transitional form towards the granulated species *N. jacquoti* and *N. buxtorfi* Schaub. It has otherwise higher whorls then the typeform (Schaub, 1951, 178) but the decreasing of the whorls is a regular appearance in the evolution (cf. Schaub, 1962 b, 288—289). The transitional form *Nummulites exilis-planulatus* has lower whorls than *N. exilis*. Therefore it is not probable that the *N. planulatus cussacensis* were a successor of the *N. planulatus planulatus*. We probably have here a special evolutionary line which might be a continuation of the one with the *Nummulites exilis-planulatus*. In this case, of course, the *Nummulites planulatus cussacensis* loses its meaning of the subspecies and becomes an independent species *Nummulites cussacensis* Schaub.

Nummulites rotularius Deshayes

Plate 9, figs. 1 and 2

1929 *Nummulina rotularia* Deshayes — Rozlozsnik, 103—106, 180 182 (partim), pl. 3, fig. 14, 19, 28.

1929 *Nummulina rotularia* (B) Deshayes *paucicamerata* n. var. — Rozlozsnik, 181, pl. 3, fig. 12.

1951 *Nummulites rotularius* Deshayes 1838 — Schaub, 125, fig. 111.

1961 *Nummulites rotularius* Deshayes — Nemkov and Barkatova, 69—72, pl. 6, figs. 12, 15—19.

1967 *Nummulites rotularius* Deshayes, oblika B — De Zanche, Pavlovec and Proto Decima, 221—223, pl. 2, figs. 1—2, pl. 3, fig. 1, pl. 4, fig. 2.

1973 *Nummulites rotularius* Deshayes, 1838 — Kapellos, 82, figs. 178—185, pl. 43, fig. 8, pl. 45, figs. 1—2.

B form. At Podgrad only the microsphaeric form of the species *Nummulites rotularius* has been found up to now. The test thickens quickly from the margin towards the centre so that it is not lenticular but somewhat globular. In the exterior there are slightly undulated or nearly flat septal lines and rather distinct trabecules transverses.

The whorls slowly and regularly increase (fig. 8), but several anomalies can be noticed. Some parts of the whorls are higher or lower than the normal ones.

The marginal cord is often very strong and comprises nearly one half of the whorl (plate 9, fig. 1).

The septa are highly bent, especially in the first whorls, so that they are nearly sickle-shaped. They are less curved in the later whorls. Everywhere they are inclined. The septa are thick along the whole length but they get thickest in the upper part.

The chombers are always longer than high but also some isometric ones appear. In longer chambers the roof is nearly flat while in the shorter ones it is slightly arched.

Remarks. The problem of the subspecies *Nummulites rotularius paucicameratus* has already been discussed (De Zanche, Pavlovec and Proto Decima, 1967, 223). Not long ago Kapellos (1973) described the species *Nummulites rotularius* from the Gurnigelflysch and showed some of these forms in figures 178 to 182. We are convinced that all presented forms do not belong to the species *Nummulites rotularius*. The variations of the characteristics are too obvious, though even Kapellos himself mentions anomalies in the whorls. The form of the figure 180 with its narrower chambers and quite regularly bent septa perhaps is closer to the *Nummulites* from the group of *Nummulites planulatus* or even *N. praelaevigatus*. Kapellos further mentions the lenticular forms but does not state the dimensions and the *Nummulites rotularius* has a comparatively thick test. The specimen in the figure 180 (Kapellos, 1973) comes from the bed Hö 26 of the Gurnigelflysch, which belongs, according to Kapellos, to the Upper Cuisian, while the characteristic samples of the species *Nummulites rotularius* are older.

Age. According to Hottinger, Lehmann and Schaub (1964, pl. 2) the species *Nummulites rotularius* lived sometime in the period of transition from the Lower to Middle Cuisian. In the Schlierenflysch it has been determined

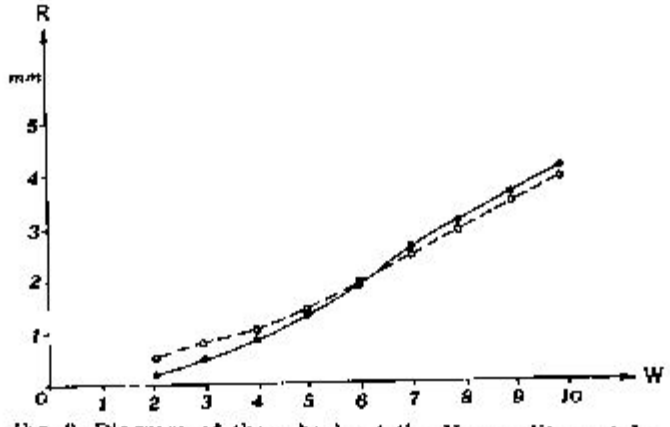


Fig. 8. Diagram of the whorls at the *Nummulites rotularius*, B form. Podgrad

Sl. 8. Diagram zavojev pri vrsti *Nummulites rotularius*, oblika B. Podgrad

R Radius, in millimetres — Polmer, izražen v milimetrih
W Number of whorls — Število zavojev

in the lower part of the Middle Cuisian, that is in the lower part of the biozone, together with the species *Discoaster lodoensis* (Schaub, 1965). Kapellos (1973, 82), on the other hand, found this nummulites in the Gurnigelflysch in the layers from the Lower to the Upper Cuisian. We already have given our remarks to these Upper-Cuisian specimens. At Ustje in the Vipava valley the beds with the species *Nummulites rotularius* belongs to the period of transition between the Lower and Middle Cuisian (De Zanche, Pavlovec and Proto Decima, 1967).

Nummulites aff. *partschi tauricus* De la Harpe

Plate 8, fig. 3

At Podgrad we found only one sample of the microsphaeric form with a thin, lenticular test, which has a depressed margin. On its surface there are sinuous septal lines on which granules appear scatteredly.

The whorls increase rather regularly. The marginal cord is extremely thin. In the older whorls are the thin septa slightly inclined in the lower part while in the upper half or third they are more apparently bent backwards. In the younger whorls the septa are higher drawn backwards in the upper part, so that they are often sickle-shaped. These septa are rather irregular. The chambers depend on the shape of the septa; in the older whorls are higher than broad, and in the younger whorls they are longer.

If we consider the described characteristics, the *Nummulites* from Podgrad partly resembles the species *Nummulites bactchisaraiensis* Rozlozsnik, and partly the subspecies *N. partschi tauricus* (fig. 9). These transitional characteristics are the following:

1. Considering the coiling of the whorls the *Nummulites* of Podgrad comes between the species *Nummulites bactchisaraiensis* and the subspecies *N. partschi tauricus*.

2. On the surface the granules are not placed spirally and that is the reason for its closer similarity to the species *N. bactchisaraiensis*.

3. The marginal cord is thin, which makes it closer to the species *N. partschi tauricus*.

4. The older whorls are a little higher than in *N. bactchisaraiensis*.

5. The chambers are longer and the septa are more drawn back, which are more characteristics for the subspecies *N. partschi tauricus*.

6. The septa are often irregular, which can be noticed also in the subspecies *N. partschi tauricus*.

Owing to the mentioned characteristics the *Nummulites* of Podgrad is closer to the subspecies *Nummulites partschi tauricus* than to the species *N. bactchisaraiensis*. In our opinion the subspecies *Nummulites partschi tauricus* differs so much from the *N. partschi partschi* De la Harpe that it should be made an independent species *N. tauricus*, as has already been made by Rozlozsnik (1929, 115).

Both forms, *Nummulites bactchisaraiensis* and *N. partschi tauricus*, appear in the Upper Cuisian in the biozone N. manfredi, that is in a younger horizon than at Podgrad.

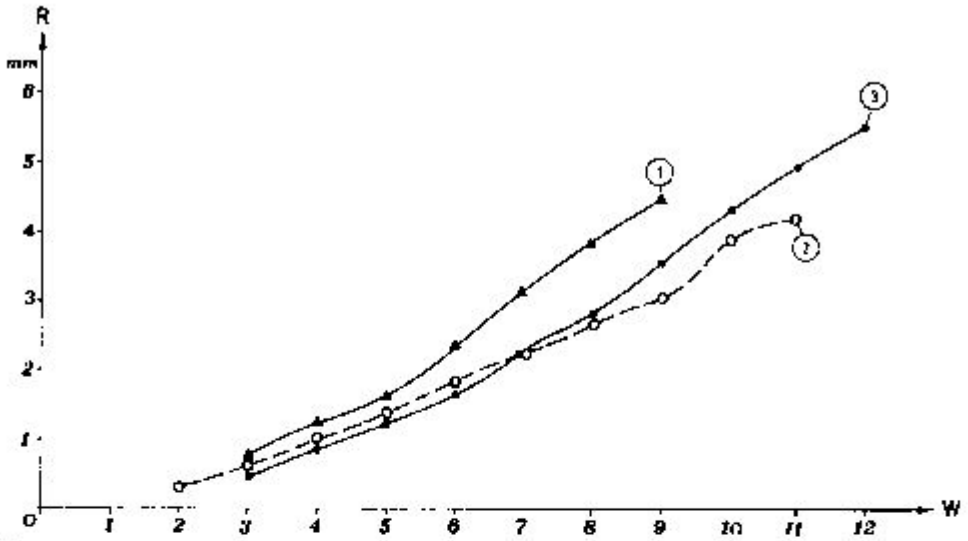


Fig. 9. Diagram of the whorls at the *Nummulites partschi tauricus* and some similar R forms

Sl. 9. Diagram zavojev pri podvrsti *Nummulites partschi tauricus* in pri nekaterih podobnih B oblikah

1 *Nummulites bactchisaraiensis* (Kapellos, 1973, fig. 222)
2 *Nummulites partschi tauricus* (Kapellos, 1973, fig. 222)
3 *Nummulites aff. partschi tauricus*, Podgrad

R Radius, in millimetres — Polmer, izražen v milimetrih
W Number of whorls — Število zavojev

Nummulites subdistans De la Harpe et Rozlozsnik

Plate 9, figs. 3 and 4

1926 *Nummulina subdistans* n. sp. — De la Harpe and Rozlozsnik, 21.

1929 *Nummulina subdistans* De la Harpe — Rozlozsnik, 212, 215—216, pl. 2, figs. 16, 23, pl. 3, fig. 7, pl. 8, fig. 8.

1951 *Nummulites subdistans* De la Harpe (—Rozlozsnik) 1926, A-Form — Schaub, 197, figs. 291—293.

1973 *Nummulites subdistans* De la Harpe (—Rozlozsnik), 1926 — Kapellos, 91—92, figs. 224—229, pl. 42, fig. 14.

A form. The small nummulites has a lenticular test which slowly thickens towards the centre. The margin is rounded and rather wide. On the surface there are nearly straight, thin septal lines. In the centre of the test the septal lines unite in the indistinct boss.

Test diameter is 4,5 mm, the test has four whorls so that the relation W/R = 4/2,2 mm. This matches completely with Rozlozsnik's data (1929, 211) for the typical representatives of this species which have

$$Dm/R = \frac{4}{2{,}2 \text{ to } 2{,}8} \quad \frac{5}{2{,}6 \text{ to } 2{,}9} \quad \frac{6}{3{,}2}$$

The specimens described by Kapellos (1973, 91) have somewhat lower whorls i.e. W/R = 4/1,6 to 1,8; 3/1,3.

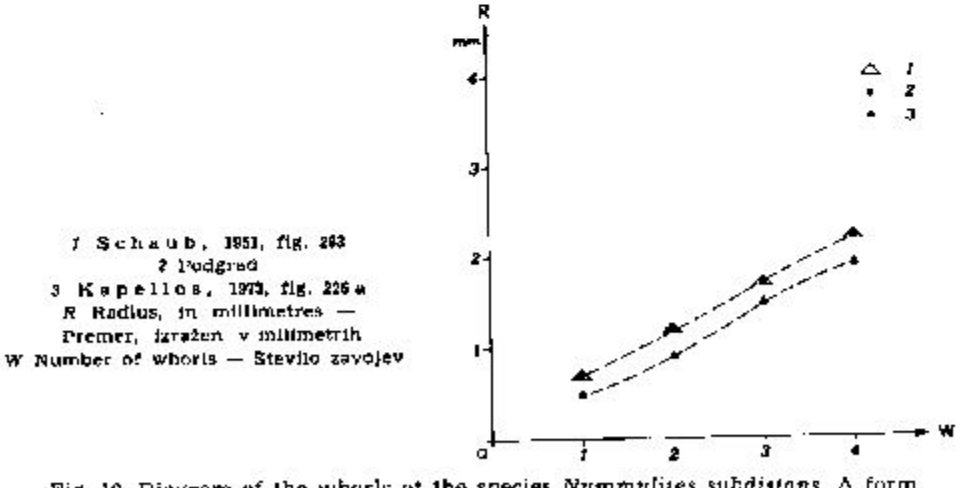
The protoconch is round and big, M 0,45 mm. According to Rozlozsnik (1929, 211) the protoconch diameter is 0.3 to 0.4 mm, while Kapellos (1973, 91) refers sizes 0,25 to 0,45 mm. In that case the sample from Podgrad comes among those with the biggest protoconch.

The first whorl is the highest. The rest increase quite slowly and the youngest is sometimes the lowest (fig. 10). The septa in the lower part are thin, slightly inclined to the marginal cord and a little bent or nearly straight. In the upper part they are strongly bent and thick. This rather remarkable thickening has been brought to attention also by Rozlozsnik (1929, 216). But there are considerable transitions from the less inclined and drawn back septa to such which are much more inclined and curved back. The number of septa is the following: $S_1 = 10$, $S_2 = 26$, $S_3 = 30$, $S_4 = 40$.

The chambers are higher than broad. Where the septa are strongly sickle-shaped the chambers are much longer in their upper parts. The marginal cord is strong and comprises from one quarter to one fifth of the whorl's height.

Remarks. The species *Nummulites subdistans* was first described by Rozlozsnik in 1926 after unpublished work of P. De la Harpe. In the publication both are cited as authors, though with the notes »d'aprés les manuscrits inédits de — Prof. Philippe De la Harpe«, and »rédigé par Paul Rozlozsnik«. Therefore we consider both as the authors of the species *Nummulites subdistans*.

To the species *Nummulites subdistans* certain nummulites are attributed which sometimes differ from the typical form. Schaub (1951) described two similar forms, *Nummulites subdistans* and *N. aff. subdistans*. The latter differs from the typical form of the species *Nummulites subdistans* by the smaller test.



1 Schaub, 1951, fig. 263
2 Podgrad
3 Kapellos, 1973, fig. 226 a
R Radius, in millimetres — Premer, izražen v milimetrih
W Number of whorls — Stevilo zavojev

Fig. 10. Diagram of the whorls at the species *Nummulites subdistans*, A form
Sl. 10. Diagram zavojev pri vrsti *Nummulites subdistans*, oblika A

not granulated surface, lower whorls, thinner septa and smaller protoconch. The mentioned characteristics give reason that a new species would be introduced.

Kapellos (1973) also found some samples in the Gurnigelflysch in Switzerland which he partly described as *N.* aff. *subdistans*. But this *Nummulites* aff. *subdistans* (Kapellos, 1973, fig. 223) is not identical with the equally described Schaub's form (1951, figs. 294—296). The sample from the locality of La Bi Gite (Kapellos, 1973, fig. 223) corresponds by its size with the typical forms of the species *Nummulites subdistans*, but its septa are too much sickle-shaped and not enough broken in the middle, which is a characteristic of the *Nummulites subdistans*. Its whorls increase more quickly than in the typical *N. subdistans*. There is another point that all forms described by Kapellos as the *Nummulites subdistans* does not show characteristic features of this species. Such are the forms originating from the Höllbach-Schwyberg section (figs. 227 and 228), and from the Rottenbach profile (fig. 229). All these forms appear in the Lower Cuisian beds, or in the Upper Cuisian (= *N.* aff. *subdistans*) respectively. In our opinion the typical samples of the species *Nummulites subdistans* occur in the Middle Cuisian beds of the Gurnigelflysch.

Nummulites subdistans is similar to the species *N. archiaci* Schaub. It can be distinguished from it by the lower whorls, smaller protoconch and less sickle-shaped septa.

Age. The *Nummulites subdistans* appears in the Schlierenflysch (Schaub, 1965, 129) in the upper part of the Lower Cuisian and in the lower part of the Middle Cuisian i.e. in the zone *Discoaster lodoensis*. Kapellos (1973, 92) mentioned this species from the Lower and Middle Cuisian beds.

Plate 4 — Tabla 4

Operculina marinellii similis n. ssp., B form — oblika B
1 inv. No. 3838, holotypus, Podgrad
2 inv. No. 3841, Podgrad
3 inv. No. 3842, Podgrad
4 inv. No. 3840, Podgrad (surface — površina)
5 inv. No. 3839, Podgrad (surface — površina)
6 inv. No. 840, Ustje
5 × enlarged — 5 × povečano
The photographs of the nummulitins made by M. Grm
Numulitine je fotografiral M. Grm

Plate 5 — Tabla 5

1 *Operculina marinellii similis* n. ssp., B form — oblika B
Smrčun near Slovenj Gradec (Slovenia, W Yugoslavia)
2, 3 *Nummulites aquitanicus* Benoist, B form — oblika B
Podgrad, inv. No. 3843
10 × enlarged — 10 × povečano

Plate 6 — Tabla 6

1, 2, 3 *Nummulites ustjensis* De Zanche et Pavlovec, B form — oblika B. Podgrad
1 inv. No. 3845
2 inv. No. 3848
3 inv. No. 3837

4, 5, 6 *Nummulites brkiniensis* n. sp., B form — oblika B. Podgrad
4 inv. No. 3845
5 inv. No. 3846
6 inv. No. 3847
5 × enlarged — 5 × povečano

Plate 7 — Tabla 7

Nummulites brkiniensis n. sp., B form — oblika B. Podgrad
1 inv. No. 3848
2 inv. No. 3844 (holotypus)
5 × enlarged — 5 × povečano

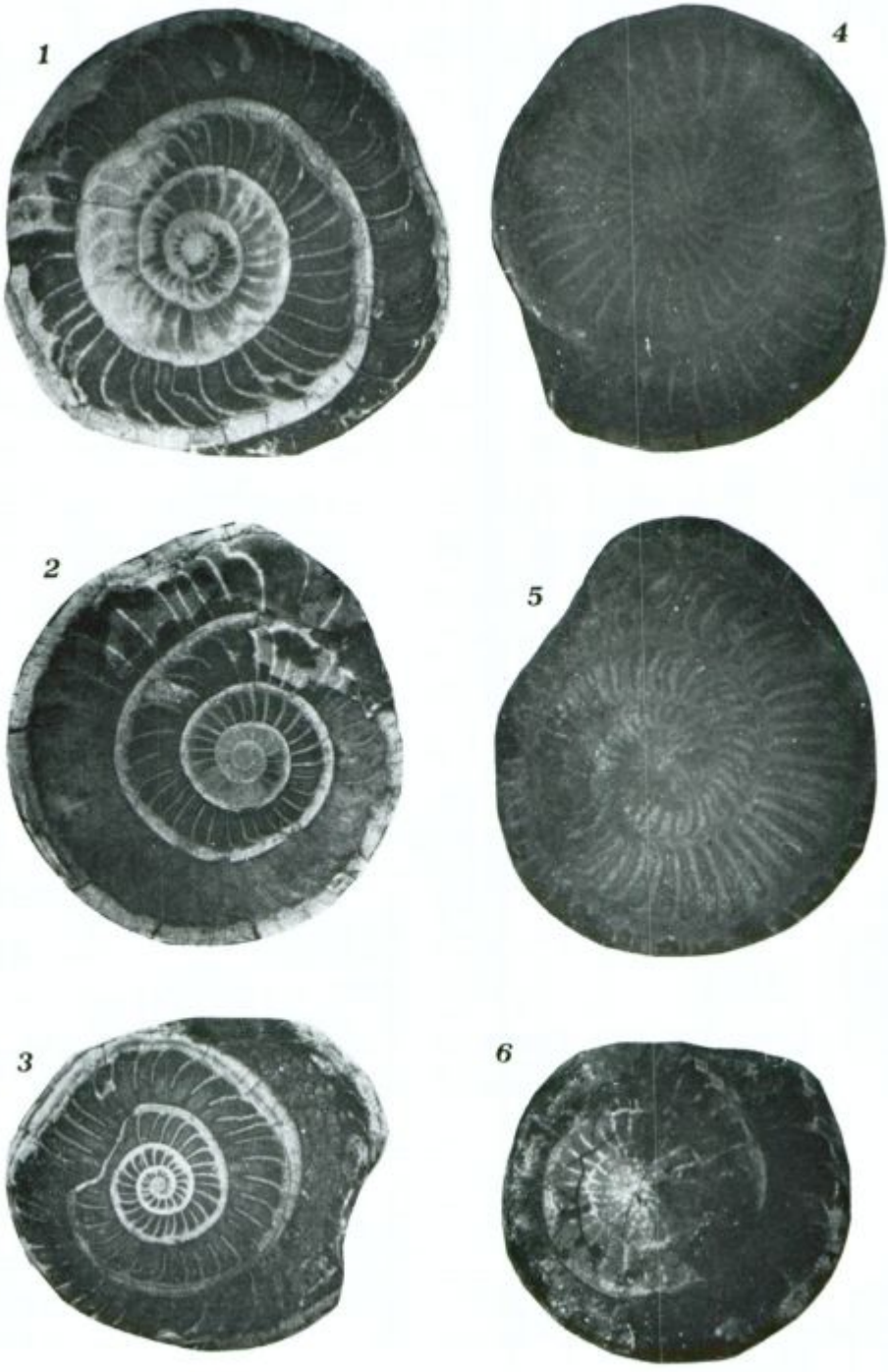
Plate 8 — Tabla 8

1 *Nummulites postbearnensis* n. sp., B form — oblika B. Podgrad, inv. No. 3850 (holotypus)
2 *Nummulites postbearnensis* n. sp., B form — oblika B. Podgrad, inv. No. 3851
3 *Nummulites aff. partschi tauricus*. B form — oblika B. Podgrad, inv. No. 3855
fig. 1. 10 × enlarged, figs. 2. and 3. 5 × enlarged
sl. 1. 10 × povečana, sliki 2. in 3. 5 × povečani

Plate 9 — Tabla 9

1, 2 *Nummulites rotularius* Deshayes, B form — oblika B. Podgrad
1 inv. No. 3852, specimen with the thick marginal cord — primerek z debelim zavojnim robom
2 inv. No. 3853, specimen with the thin marginal cord — primerek s tankim zavojnim robom
3, 4 *Nummulites subdistans* De la Harpe, A form — oblika A. Podgrad inv. No. 3854
10 × enlarged — 10 × povečano

Plate 4 — Tabla 4




1


2


3

Plate 6 — Tabla 6

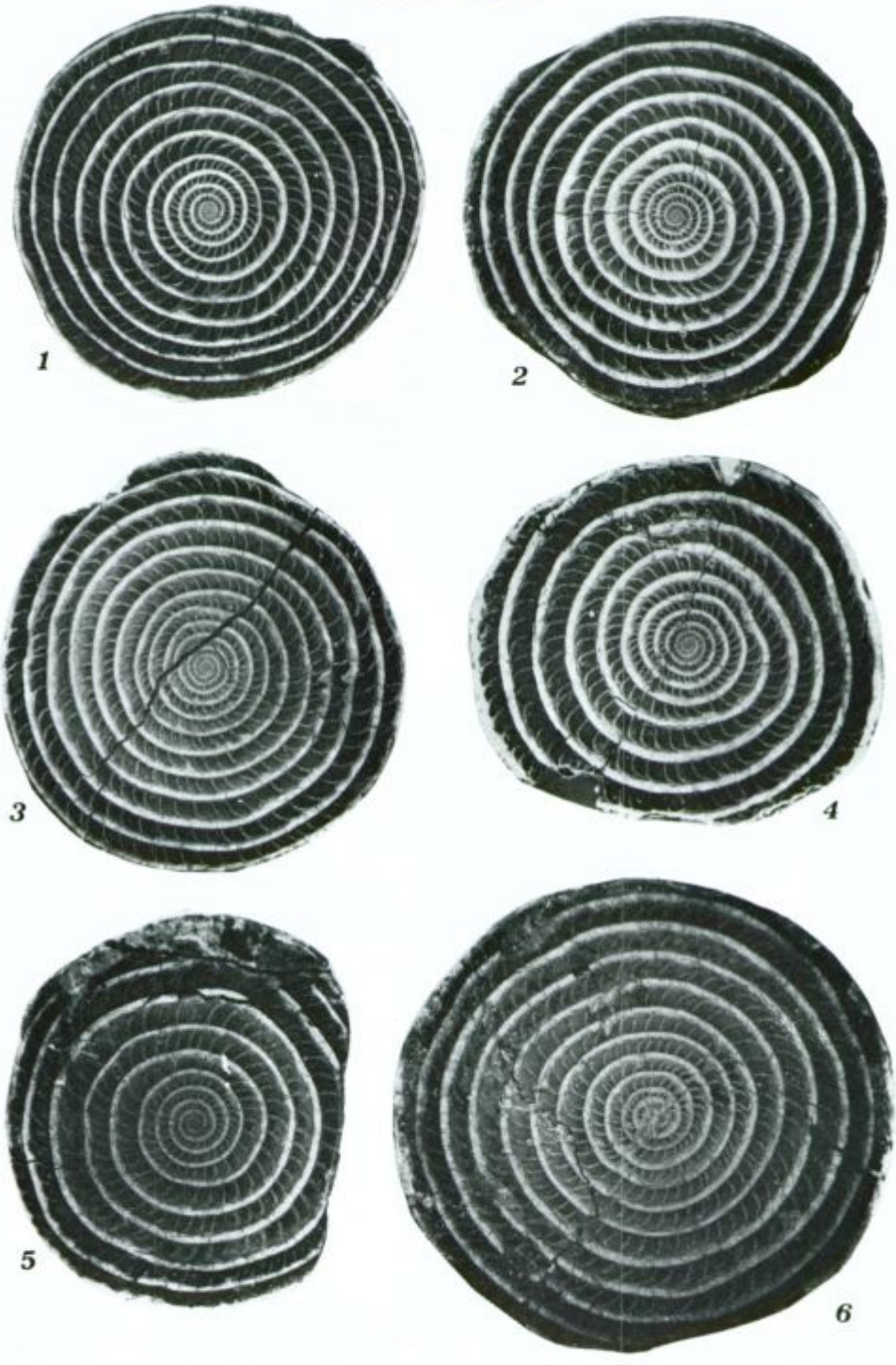
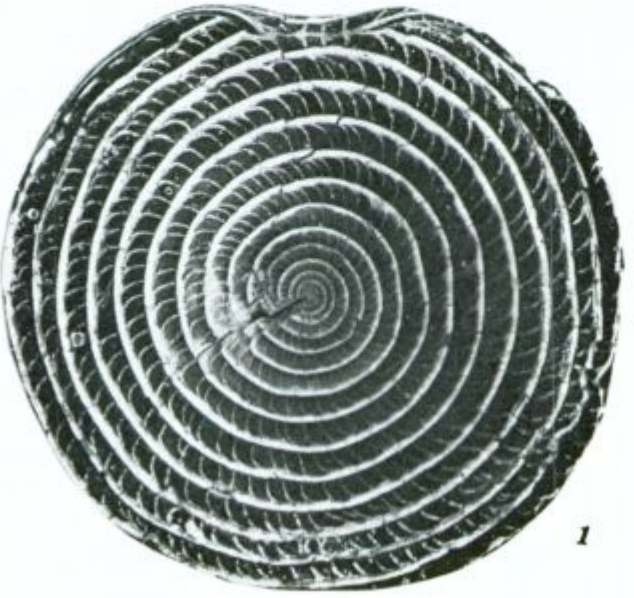


Plate 7 — Tabla 7

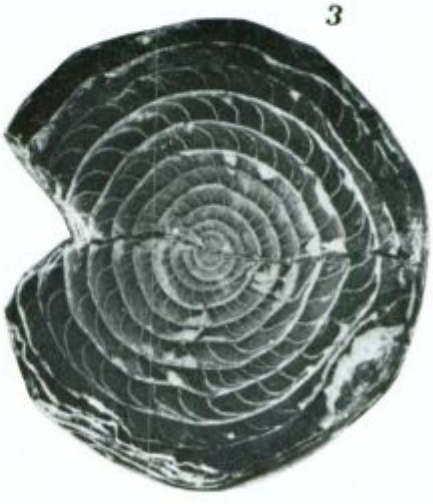


1

2

1

2



3

1

2

3

4

6. Conclusions

The flysch as well as the underlying calcareous beds in western Yugoslavia are of different age (cf. Pavlovec, 1963). At the same time there are only few group of beds recognized in detail or even ranged into biozones. This is, however, required for stratigraphic correlation of rock sequences from different basins. In our studies an attempt is made to demonstrate such a correlation of Podgrad and Ustje flysch from western Yugoslavia and of the corresponding biozones from Pyrenees (Kapellos and Schaub, 1973) and from Switzerland (Kapellos, 1973).

In the flysch of Podgrad the *Discoaster lodoensis* is abundant but *D. sublodoensis* can also be found. As the former species originates from the Middle Cuisian and the later appears in the lower part of the Middle Cuisian, reaching also into the Upper Cuisian, it is possible to say — owing to the nannoplankton — that the flysch of Podgrad is of Middle Cuisian age.

The determined planktonic foraminifers (see table 2) come mostly from the biozone *Globorotalia formosa* (or *G. formosa-aragonensis*). A small number come also from the biozone *Globorotalia bullbrooki* overlying the biozone mentioned above and even less from the bizone *Globorotalia rex*, underlying the mentioned zone. Consequently the Middle Cuisian age of the beds from Podgrad is proved also by the planktonic foraminifers.

The determined macroforaminifers indicate the following: *Assilina laxispira* belongs to the Middle Cuisian. *Nummulites aquitanicus* is a Lower and Middle-Cuisian species, of the same age is also *N. subdistans* while *N. rotularius* belongs, according to Kapellos (1973, 82) to the Lower, Middle und Upper Cuisian. Among the determined nummulitins the only Upper-Cuisian form is *Nummulites partschi taurieus*, but at Podgrad this one has not been determined with certainty. *Nummulites ustjensis* appears at Ustje in the transitional beds from the Lower to the Middle Cuisian (De Zanche, Pavlovec and Proto Decima, 1967, 232).

The nummulitins thus undoubtedly indicate the Middle-Cuisian age of the beds at Podgrad, i.e. the biozone with the species *Nummulites praelaevigatus* and *Assilina laxispira*. Some of them (*Nummulites aquitanicus*, *N. subdistans* and *N. ustjensis*) indicate more the older part of the Middle Cuisian than its younger part.

All these facts lead us to the conclusion that the flysch of Podgrad belongs to the older part of the Middle Cuisian, i.e. to the lower part of the biozone with the species *Discoaster sublodoensis*. This age has been proved also by *Alveolina fornasinii* Checchia-Rispoli and *A. aff. canavarii* Checchia-Rispoli. We would like to take this opportunity and thank our colleague Dr. Katica Drobne for having determined these species.

The flysch of Ustje has been, by means of nannoplankton, planktonic foraminifers and macroforaminifers, ranged into the period of transition between the Lower and the Middle Cuisian (De Zanche, Pavlovec and Proto Decima, 1967). At Ustje and Podgrad there appear five identical species of nannoplankton, four common species of planktonic foraminifers and three species of nummulitins. Therefore the question arises, either there really two fossiliferous horizons of different age occur in the flysch of Yugoslavia or

Discoaster sublodoensis at Ustje has not been found. Consequently it is very probable that at Ustje and at Podgrad in Brkini the same Middle-Cuisian flysch horizon occurs, which might become an important stratigraphic level of western Yugoslavia.

While studing the microfossils from the neighbourhood of Podgrad we faced again the problem of correlation of the biozones of different fossil groups. During the study of Goriška Brda (Cimerman and others, 1974) the biozones were ranged somewhat differently as regards their age. This classification proved one self less satisfactory for the work of the neighbourhood of Podgrad, therefore we followed the mentioned Kapellos-Schaub (1973) classification for the present study.

These differences in the age classification of nannoplanktonic biozones arise mostly from different stratigraphical ranging of the nannoplankton biozones. Todesco (Cimerman and others, 1974, 23) believes that *Discoaster* cf. *sublodoensis* occurs in the younger part of profile of Goriška Brda. But this form does not indicate the biozone *Discoaster sublodoensis*. On the other hand the nummulitins from this profile point to the youngest Cuisian i. e. biozones *Assilina major* and *Nummulites manfredi*, which is a younger horizon than the biozone *Discoaster sublodoensis*. Furthermore in Goriška Brda as well as in Brkini several reworked nannoplanktonic forms could be found and therefore the biozones determination is rather a difficult work.

The result of the present study of the flysch from Podgrad agree in respect of age with the biozones of Kapellos and Schaub (1973). At Podgrad the nummulitins biozones correspond with the nannoplanktonic ones and also with the biozones of planktonic foraminifers.

Eocenski mikrofosili iz okolice Podgrada

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Iz starejših flišnih plasti pri Podgradu v Brkinih je bilo določenih 19 vrst in podvrst nanoplanktona, 10 planktonskih foraminifer in 9 nummulitin. Najdene so bile nove vrste in podvrste *Rhabdosphaera pirijormis*, *Operculina marinelli similis*, *Nummulites brkiniensis* in *Nummulites postbearnensis*. Plasti z opisanimi mikrofosili pripadajo srednjemu cuisiju in se stratigrafsko ujemajo s flišnimi plastmi pri Ustju v Vipavski dolini.

Nahajališče

Sl. 1 in 2

Približno kilometer NNE od Podgrada na južnem robu Brkinov (sl. 1) je razgaljen spodnji del fliša. V njem prevladujeta lapor in glinovec, ki se menjavata s peščenjakom ter mnogo redkeje s konglomeratom in brečo.

Nannoplankton

Uvod

Preučevanje nanofosilov se je skupaj z drugimi mikropaleontološkimi skupinami razvijalo vzporedno z razvojem optičnih in elektronskih pripomočkov. Ta skupina postaja vedno pomembnejša v biostratigrafiji mlajšega mezozoika in terciarja zlasti po uvedbi rastrskega elektronskega mikroskopa v raziskovalno tehniko. Zaradi kratke življenjske dobe posameznih vrst uporabljamo nanoplankton za razčlenitev stopenj in podstopenj na biocone. Te biocone imajo široko horizontalno razprostranjenost. V zadnjem času pripisujejo nanoplanktonu tudi velik pomen pri preučevanju paleogeografije, ker so drobni organizmi zelo občutljivi za spremembe okolja.

Priprava vzorcev za opazovanje

Kokoliti so najlepše ohranjeni v glini in laporju, medtem ko so v apnencu diagenetsko spremenjeni in jih je poleg tega težko izluščiti iz kamenine. Za pripravo vzorca potrebujemo le nekaj drobcev kamenin, ki jih raztopimo v destilirani vodi. Kalni raztopini dodamo nato nekaj kapljic vodikovega prekisa H_2O_2, da se kameninski delci med seboj ločijo. Vzorce smo obdelali tudi z ultrazvokom (pet minut). Z usedanjem in večkratnim prelivanjem raztopine dobimo delce željene velikosti. Pri pripravi vzorcev moramo biti zelo pazljivi, da jih ne okužimo z nanoplanktonom iz drugih vzorcev. Zato uporabljamo plastične cevke (slamice) kot pipete, ki jih po uporabi zavržemo. Z njimi odpipetiramo del pripravljene kalne raztopine in damo kapljico na krovno stekelce, ki jo nato posušimo na vroči plošči. Pri serijskih izdelavah preparatov moramo paziti, da plošča ni prevroča in da tekočina na stekelcu ne kipi, ker bi v tem primeru lahko nanoplankton preskočil iz enega na drug preparat. Če želimo izdelati trajni preparat, zalijemo prah na krovnem stekelcu s kanadskim balzamom. Pri orientacijskem opazovanju kapljico pokrijemo z objektnim stekelcem in preparat je pripravljen za opazovanje. Za nanašanje kanadskega balzama na objektno stekelce uporabljamo za vsak vzorec posebno leseno paličico, da se tako zavarujemo pred okužbo vzorca.

Pripravljen preparat opazujemo od 500-kratne povečave dalje. Z optičnim mikroskopom opazujemo navadno v polarizirani svetlobi ali pri faznem kontrastu, redkeje v navadni svetlobi. Naše vzorce smo opazovali z mikroskopom Leitz-Ortholux.

Sistematski del

Coccolithus pelagicus (Wallich)
Tabla 1, sl. 8 a, b
Chiasmolithus grandis (Bramlette et Riedel)
Tabla 1, sl. 9 a, b
Cyclococcolithus neogammation Bramlette et Wilcoxon
Tabla 1, sl. 4
Pontosphaera multipora (Kamptner)
Tabla 1, sl. 5 a, b
Pontosphaera plana (Bramlette et Sullivan)
Tabla 1, sl. 10 in 11

Blackites scabrosus (Deflandre)
Tabla 1, sl. 6 in 7
Rhabdosphaera piriformis n. sp.
Tabla 1, sl. 1 do 3
Micrantholithus flos Deflandre
Tabla 2, sl. 5 in 8
Sphenolithus radians Deflandre
Tabla 2, sl. 11
Discoaster barbadiensis Tan
Tabla 2, sl. 3, 6 in 9
Discoaster distinctus Martini
Tabla 2, sl. 1, 4 in 7
Discoaster lodoensis Bramlette et Riedel
Tabla 2, sl. 10 in 12, tabla 3, sl. 9
Discoaster sublodoensis Bramlette et Sullivan
Tabla 2, sl. 2, tabla 3, sl. 4 in 7
Discoaster saipanensis Bramlette et Riedel
Tabla 3, sl. 1
Marthasterites tribrachiatus (Bramlette et Riedel)
Tabla 3, sl. 8
Microrhabdulus decoratus Deflandre
Tabla 3, sl. 10 in 11
Neococcolithes dubius (Deflandre)
Tabla 3, sl. 2 in 3
Ellipsolithus distichus (Bramlette et Sullivan)
Tabla 3, sl. 6 a, b
Clathrolithus cf. ellipticus Deflandre
Tabla 3, sl. 5

Rhabdosphaera piriformis n. sp.

Derivatio nominis: Po hruškasti obliki rabdolita.

Locus typicus: Podgrad.

Stratum typicum: Spodnji del srednjega cuisija, spodnji del biocone *Discoaster sublodoensis*.

Holotypus: V preparatu »Podgrad 6« (tabla 1, sl. 3), v zbirki Katedre za geologijo in paleontologijo univerze v Ljubljani.

Paratypi: V preparatih »Podgrad 3 in 4« (tabla 1, sl. 1 in 2), v isti zbirki kot holotip.

Diagnosis: *Rhabdosphaera piriformis* je koničasti rabdolit s precej napihnjenim podaljškom, ki se odebeli takoj nad bazalno ploščo in kmalu doseže svoj največji premer.

Opis in primerjava: Rabdolit ima majhno bazalno ploščo s centralno perforacijo. Podaljšek (konica) je sferično odebeljen takoj nad osnovno ploščo. Po tem se nova vrsta loči od podobne vrste *Rhabdosphaera inflata*, ki se odebeli šele na koncu krajšega ali daljšega vratu. Po odebelitvi se podaljšek hitro zoži in konča z ostro konico. Na zunanji strani so stene različno rugozne.

Planktonske foraminifere

V flišu pri Podgradu je bilo najdenih deset vrst planktonskih foraminifer. Njihova stratigrafska razširjenost je prikazana na tabeli 2. Določene so bile naslednje vrste:
Globigerina linaperta Finlay
Globigerina taroubaensis Bronnimann
Globigerina triangularis White
Globigerina turgida Finlay
Globorotalia aragonensis Nuttal
Globorotalia convexa Subbotina
Globorotalia crassaformis (Galloway et Wissler)
Globorotalia interposita Subbotina
Globorotalia pseudotopilensis (Subbotina)
Globorotalia rotundimarginata (Subbotina).

Numulitine

V nahajališču pri Podgradu nastopa zanimiva numulitinska favna. Določenih je bilo devet vrst in podvrst. Med njimi so kar tri nove, vse tri pa nastopajo tudi drugod v Sloveniji. Našli smo naslednje numulitine:
Operculina marinellii similis n. ssp.
Tabla 4, sl. 1 do 6, tabla 5, sl. 1
Assilina laxispira De la Harpe et Rozlozsnik
Nummulites aquitanicus Benoist
Tabla 5, sl. 2 in 3
Nummulites ustjensis De Zanche et Pavlovec
Tabla 6, sl. 1 do 3
Nummulites brkiniensis n. sp.
Tabla 6, sl. 4 do 6, tabla 7, sl. 1 in 2
Nummulites postbearnensis n. sp.
Tabla 6, sl. 1 in 2
Nummulites rotularius Deshayes
Tabla 9, sl. 1 in 2
Nummulites aff. *partschi tauricus* De la Harpe
Tabla 8, sl. 3
Nummulites subdistans De la Harpe et Rozlozsnik
Tabla 9, sl. 3 in 4.

Operculina marinellii similis n. ssp.

Derivatio nominis: Nova podvrsta je podobna obliki *Operculina marinellii marinellii*.

Holotypus: Oblika B v zbirki Katedre za geologijo in paleontologijo univerze v Ljubljani, inv. št. 3838.

Paratypi: Oblike B v isti zbirki kot holotip.

Locus typicus: 1 km NNW od Podgrada, Brkini.

Stratum typicum: Spodnji del srednjega cuisija.

Diagnosis: Od podvrste *Operculina marinellii marinellii* se loči po večji hišici s 6 do 6 ¼ zavoji, ki nekoliko hitreje naraščajo.

Hišica mikrosferične oblike je okrog 1 mm debela in ima premer 13 mm. Na površju se odraža notranja struktura. Med grebeni, ki sledé septam, so granule. Zavojni rob se na površju hišice kaže kot majhen greben.

Zavoji se hitro višajo. Septa so gosta, v zadnjem zavoju jih je 33 do 35. Navadno so pravokotna na zavojni rob in skoraj ravna. So tanka in se odebelijo v zgornjem delu.

Število sept in prirastki zavojev so navedeni v tabeli 3, diagram zavojev pa na sl. 3.

Nummulites brkiniensis n. sp.

Derivatio nominis: Po pokrajini Brkini, kjer je nahajališče holotipa.

Holotypus: Oblika B v zbirki Katedre za geologijo in paleontologijo univerze v Ljubljani, inv. št. 3844.

Paratypi: Oblike B v isti zbirki kot holotip.

Locus typicus: 1 km NNW od Podgrada, Brkini.

Stratum typicum: Spodnji del srednjega cuisija.

Diagnosis: Numulit, ki se loči od vrste *Nummulites ustjensis* po večji hišici ter gostejših in bolj usločenih septah.

Tanka hišica se le v sredini nekoliko odebeli. Zunanji rob hišice je rahlo zaokrožen. Na površju so tanki in gosti septalni podaljški, ki so nekoliko valoviti. Večkrat se cepijo. Na nekaterih primerkih so jasne »trabecules transverses«.

Vsi zavoji se enakomerno višajo, vendar notranji nekoliko počasneje, srednji precej hitreje, zunanji pa znatno manj kot srednji. Zavojni rob je pravilen, najmočnejši je v srednjih zavojih.

Septa so v notranjih sedmih ali osmih zavojih skoraj ravna, malo nagnjena in močneje upognjena šele neposredno ob vrhu. V naslednjih zavojih so bolj nagnjena in usločena. Kamrice so večinoma bolj visoke kot dolge, samo v notranjih zavojih so pri nekaterih primerkih skoraj izometrične. Tam, kjer so kamrice daljše, je njihova streha samo malo usločena, medtem ko je pri ozkih in visokih kamricah streha močno usločena.

Nummulites brkiniensis je bil doslej najden samo v flišu pri Podgradu in Ustju v Vipavski dolini, torej v plasteh, ki so nastajale v spodnjem delu srednjega cuisija.

Nummulites postbearnensis n. sp.

Derivatio nominis: Nova vrsta je podobna vrsti *Nummulites bearnensis*, vendar je mlajša od nje.

Holotypus: Oblika B v zbirki Katedre za geologijo in paleontologijo univerze v Ljubljani, inv. št. 3850.

Locus typicus: 1 km NNW od Podgrada, Brkini.

Stratum typicum: Spodnji del srednjega cuisija.

Diagnosis: *Nummulites postbearnensis* ima večjo hišico in bolj upognjena septa kot *N. bearnensis*. Hišica je popolnoma involutna.

Tanka hišica mikrosferične oblike se proti sredini malo odebeli. Zunanji rob je zaokrožen. Septalni podaljški so rahlo srpasto zaviti, včasih se ostro lomijo ali celo cepijo.

Zavoji naraščajo hitro in precej enakomerno. Zavojni rob je močno in precej enakomerno debel.

Septa so rahlo upognjena po vsej dolžini. V zgornjem delu se odebelijo, nekako v sredini se stanjšajo, tako da je njihov spodnji del zelo tanek. Na bazi imajo neizrazito nogo.

Kamrice so bolj visoke kot dolge in imajo rahlo usločen ali skoraj raven strop.

Razmerje med premerom hišice (Dm) in številom zavojev (W) je 8/9 in 11/11. Debelina hišice je 2 do 3 mm. Število sept od četrtega zavoja naprej je naslednje: $S_4 = 18$, $S_5 = 22$, $S_6 = 28$, $S_7 = 30$, $S_8 = 40$ in $S_9 = 42$.

Povzetek

Fliš pri Podgradu vsebuje vrsti *Discoaster lodoensis* in *D. sublodoensis*. Prva sega iz spodnjega v srednji cuisij, druga pa nastopi v srednjem cuisiju in sega v zgornjega. Zato sklepamo po nanoplanktonu na srednjecuisijsko starost fliša pri Podgradu.

Vse planktonske vrste iz Podgrada pripadajo biocoru *Globorotalia formosa* (oziroma *G. formosa-aragonensis*), manj jih je znanih pod to biocono in po njej. Zato tudi planktonske foraminifere kažejo na srednji cuisij. *Assilina laxispira* je srednjecuisijska, *Nummulites aquitanicus* in *N. subdistans* pa sta spodnje in srednjecuisijski vrsti. *N. rotularius* sega še v zgornji cuisij. Med numulitinami pri Podgradu je tudi zgornjecuisijski *Nummulites partschi tauricus*, vendar ta podvrsta pri Podgradu ni zanesljivo določena. *Nummulites ustjensis* nastopa v flišu pri Ustju na meji med spodnjim in srednjim cuisijem. Numulitine torej kažejo na srednji cuisij, to je na biocono *Assilina laxispira* oziroma *Nummulites praelaevigatus*.

Iz vsega tega sledi, da so flišne plasti blizu Podgrada nastajale v starejšem delu srednjega cuisija.

Primerjava mikrofosilov iz Podgrada in iz Ustja kaže pet skupnih nanoplanktonskih vrst, štiri skupne vrste planktonskih foraminifer in tri iste vrste oziroma podvrste numulitin. Zato je vprašanje, ali sta obe nahajališči res nekoliko različno stari (Podgrad spodnji del srednjega cuisija, Ustje prehod med spodnjim in srednjim cuisijem), ali pa gre za isti fosiliferni flišni horizont.

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