

Calcareous nannoplankton zonation of the Cenomanian Stage in Central North Bulgaria

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Д. Синьовски, С. Шуменко — Зональное расчленение сеноманского яруса Центральной Северной Болгарии по известковому нанопланктону. Впервые на территории этой страны делается попытка для зонального расчленения верхнемеловых пород по известковому нанопланктону. Объектом исследования являются нанофоссилии из мергельных пород Санадиновской свиты (сеноман), обнажающиеся по правому берегу реки Осъма, между селами Новачене и Санадиново, северо-восточнее от города Плевен. Установлено присутствие трех нанопланктонных зон: зона *E. turrisseiffeli* (верхний альб — нижний сеноман), зона *L. acutum* (нижний-верхний сеноман) и зона *M. decoratus* (верхний сеноман).

Abstract. For the first time in this country calcareous nannoplankton zonation is made of the Upper Cretaceous rocks. The subject of the study are nanofossils from the sediments of the Sanadinovo Marl Formation (Cenomanian) which outcrop along the Osâm river between the villages of Sanadinovo and Novačene Northeastern from Pleven. Three nanofossil zones are described: *E. turrisseiffeli* Zone (Upper Albian-Lower Cenomanian), *L. acutum* Zone (Lower-Upper Cenomanian) and *M. decoratus* Zone (Upper Cenomanian).

Introduction

Calcareous nanofossils are one of the most useful groups for biostratigraphical subdivision of Cretaceous sediments. This study is the first attempt to make a coccolith zonation of Cretaceous rocks in Bulgaria.

Coccolith samples were collected from the Sanadinovo Marl Formation between the villages of Sanadinovo and Novačene in Central North Bulgaria (Fig. 1).

Бошев et al. (1958) and Страшимиров, Стоянова (1958) included this marl unit into the Albian Stage. Начев, Николов (1961) established that these rocks are Cenomanian in age. Цанков, Йовчева (1961) referred them to the Upper Cenomanian and Цанков et al. (1964) to the Lower Cenomanian. Султанов (1981) referred them to the Cenomanian Stage, too. Йолкичев (1987) erected a new official lithostratigraphical unit — Sanadinovo Marl Formation and divided it into three substages or ammonite zones: Lower Cenomanian (*M. mantelli* Zone), Middle Cenomanian (*A. rhotomagensis* Zone) and Upper Cenomanian (*C. naviculare* Zone). The nanofossil zones are correlated with ammonite zones (Fig. 2). The Lower Cretaceous — Upper Cretaceous boundary is marked by disappearance of

ammonite species belonging to the *S. dispar* Zone of the Upper Albian (И в а н о в et al., 1980).

The investigations were carried out on a light and scanning electron microscope. We are grateful to Dr M. M a l e e v and his assistants at the Institute of Applied Mineralogy for the use of a scanning electron microscope.

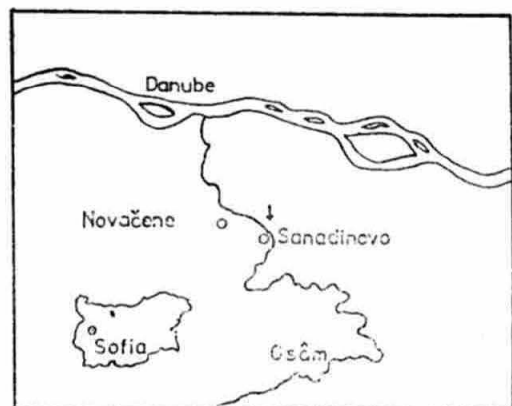


Fig. 1. Geographic location of the section studied

Nannofossil zonation

The zonation used in this paper incorporates zones first proposed by Thierstein (1971), Verbeek in Manivit et al., (1977) and Sissingh (1977).

Eiffellithus turriseiffeli NF Zone

Author: Thierstein (1971), emend. Manivit et al. (1977).

Definition: Interval from first occurrence of *Eiffellithus turriseiffeli* (Deflandre) Reinhardt to first occurrence of *Lithraphidites acutum* Verbeek & Manivit.

Age: Upper Albian — Lowest Cenomanian.

Remarks: The lower boundary of this zone was not recovered.

Thierstein (1971) established it of the first occurrence of *E. turriseiffeli* (Deflandre) Reinhardt and this has been confirmed by many authors — Sissingh (1977), Manivit et al. (1977), Roth (1978), Cruix (1982), Haq (1984).

Only the upper part of the zone was studied. The zonal marker occur in the lowest sample of the section.

Lithraphidites acutum NF Zone

Author: Verbeek in Manivit et al. (1977).

Definition: Interval from first occurrence of *Lithraphidites acutum* Verbeek & Manivit to the first occurrence of *Microrhabdulus decoratus* Deflandre.

Age: Lower — Upper Cenomanian.

First occurrence: *Lithraphidites acutum* Verbeek & Manivit, *Corollithion kennedyi* Cruix, *Chiastozygus cuneatus* (Luljew a) Cepek & Hay.

Remarks: Verbeek in Manivit et al. (1977) used for the first time *L. acutum* as a zonal marker. The authors outlined this zonal level in the upper part of the Middle Cenomanian.

The first *L. acutum* Verbeek & Manivit (this study) appear somewhat above the Albian — Cenomanian boundary or in the lower part of the *M. mantelli* Ammonite Zone. This datum level coincides with the first occurrence of *Chiastozygus cuneatus* (Luljew a) Cepek & Hay and *Corollithion kennedyi* Cruix. Thus the stratigraphical interval of the *Lithraphidites acutum* NF Zone in this paper includes the upper part of the *Eiffellithus turriseiffeli* NF Zone as defined by Manivit et al. (1977) and coincides with *Chiastozygus cuneatus* NF Zone of Roth & Thierstein (1972).

Microrhabdulus decoratus NF Zone

Author: Sissingh (1977).

Definition: Interval from first occurrence of *Corollithion exiguum* Stradner or *Microrhabdulus decoratus* Deflandre to first occurrence of *Quadrum gartneri* Prins & Perch-Nielsen or *Tetralithus pyramidus* Gardet.

Age: Late Cenomanian.

First occurrence: *Corollithion exiguum* Stradner, *Microrhabdulus decoratus* Deflandre, *Gartnerago obliquum* (Stradner) Thierstein.

Last occurrence: *Lithraphidites acutum* Verbeek & Manivit, *Corollithion kennedyi* Cruix, *Podorhabdus albianus* Black.

Remarks: *Microrhabdulus decoratus* Deflandre is very rare and *Corollithion exiguum* Stradner is more abundant. They appear both in the sample CH-8 and this was used here as a zonal level for the lower limit of the *Microrhabdulus decoratus* NF Zone.

The upper limit of the zone was not recovered. Sissingh (1977) defined it by the first appearance of *Tetralithus pyramidus* Gardet. Manivit (1971) defined the upper limit of her *Corollithion exiguum* NF Zone by the first occurrence of *Micula staurophora* (Gardet) Stradner. Bukry (1974a, 1974b, 1975) defined the upper limit of his *Corollithion exiguum* NF Zone by the earliest occurrence of *Tetralithus pyramidus* Gardet or *Micula decussata* Vekshina (= *M. staurophora*). It is possible that these authors have included *Quadrum gartneri* Prins & Perch-Nielsen within their zonal species.

We failed in our attempts to find out any other stratigraphically important species for the Cenomanian Stage. *Gartnerago obliquum* (Stradner) Thierstein is absent and *Lithraphidites alatus* Thierstein is very rare. The former occur at the top of the Cenomanian Stage in North East Bulgaria, where *Podorhabdus albianus* Black, *Lithraphidites acutum* Verbeek & Manivit and *Corollithion kennedyi* Cruix are missing (unpublished data).

Systematic notes

Family ARKHANGELSKIACEAE Bukry, 1969

Genus *Broinsonia* Bukry, 1969

Broinsonia dentata Bukry, 1969

Pl. 1, fig. 1, 2

1969. *Broinsonia dentata* n. sp.; Bukry, p. 21, pl. 2, fig. 1—3.

1972. *Broinsonia dentata* Bukry; Roth & Thierstein, p. 480, pl. 14, fig. 6—13.

Remarks: Small specimens were found in the Albian and Lower Cenomanian samples. It becomes very abundant in the samples CH-6 and CH-7.

Family PODORHABDACEAE Noël, 1965

Genus *Podorhabdus* Noël, 1965

Podorhabdus albianus Black, 1967

Pl. 1, fig. 7

1965. *Rhabdosphaera* sp.; Black, p. 133, fig. 10.

1967. *Podorhabdus albianus* sp. nov.; Black, p. 143.

1968. *Prediscosphaera? orbiculofenestra* new species; Gartner, p. 21, pl. 25, fig. 23—25; pl. 26, fig. 8.

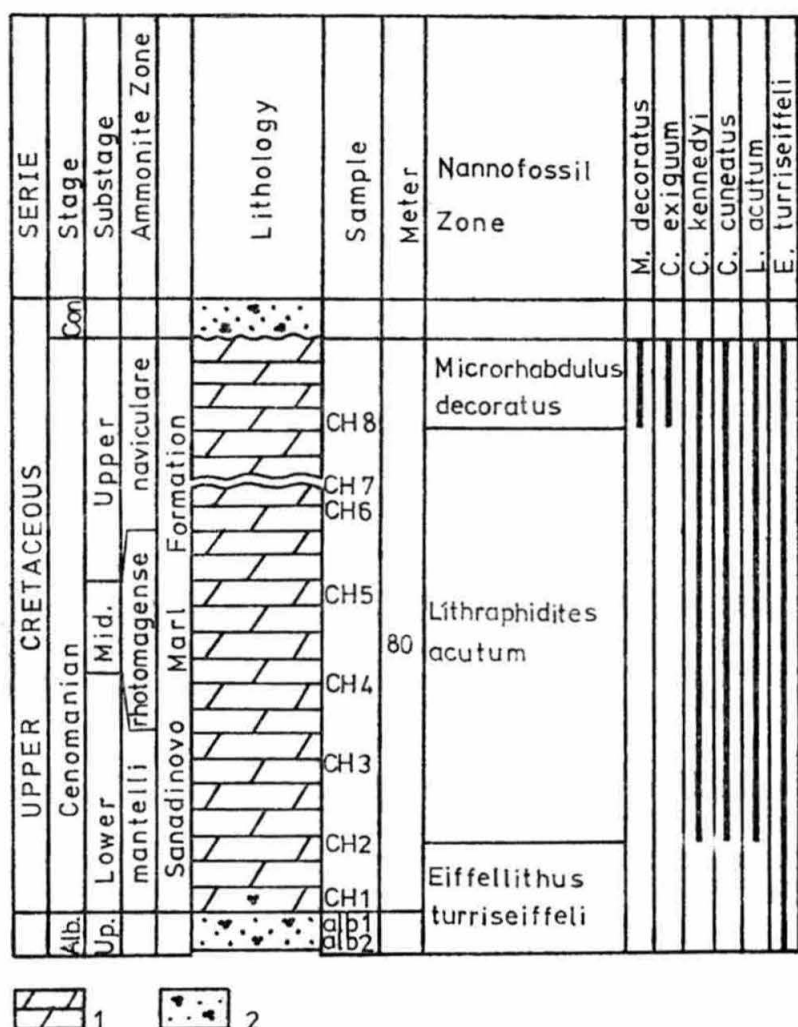


Fig. 2. Distribution of selected species of stratigraphic importance in the section between the villages of Sanadinovo and Novačene: 1 — marls; 2 — glauconitic sandstones

1971. *Podorhabdus orbiculofenestrus* Gartner; Thierstein, p. 478, pl. 8, fig. 9—17.
 1972. *Podorhabdus orbiculofenestrus* (Gartner) Thierstein; Roth & Thierstein, p. 464, pl. 6, fig. 1—7.
 1976. *Podorhabdus albianus* Black; Thierstein, p. 344, pl. 4, fig. 13, 14.

Remarks: This species differs from *Podorhabdus dietzmanni* (Reinhardt) Reinhardt by the regular disposition of the perforations in each quadrant of the central area and under crossed nicols in the light microscope by the division of each of the four bars into two parts.

Family ZYGODISCACEAE Hay & Mohler

Genus *Chiastozygus* Gartner, 1968

Chiastozygus cuneatus (Luljewa, 1967) Ceprek & Hay, 1969

Pl. 1, fig. 3—6

1967. *Zygolithus cuneatus* sp. nov.; Люльева, с. 94, табл. 1, фиг. 13.
 1967. *Zygolithus contrarius* sp. nov.; Люльева, с. 94, табл. 1, фиг. 12.
 1969. *Chiastozygus cuneatus* Luljewa; Ceprek & Hay, p. 325, fig. 2, 4.
 1972. *Chiastozygus cuneatus* Luljewa; Roth & Thierstein, p. 476, pl. 12, fig. 1—6.
 1976. *Eifellithus trabeculatus* Gorka; Thierstein, partim, pl. 1, fig. 11, non pl. 1, fig. 12; pl. 4, fig. 9, 10.

Remarks: This species is distinguished from the other species of the genus *Chia-stozygus* by the presence of the short fifth bar parallel to the long axis, joining the four crossbars at the centre. Thierstein (1976) considered this form synonymous with *Eiffellithus trabeculatus* (Gorka) Reinhardt & Gorka. It is very difficult to distinguish them under crossed nicols but *C. cuneatus* (Luljew a) Cep ek & Ha y is without large cristal plates around the central area, which are typical for the genus *Eiffellithus* Reinhardt.

Genus *Eiffellithus* Reinhardt, 1965

Eiffellithus turriseiffeli (Deflandre, 1954) Reinhardt, 1965

Pl. 1, fig. 8, 9

1954. *Zygolithus turriseiffeli* cent. nov.; Deflandre in Deflandre & Fert, p. 149, text-fig. 65, pl. 13, fig. 15, 16.

1965. *Eiffellithus turriseiffeli* Deflandre; Reinhardt, p. 36.

Remarks: The specimens from the Albian samples are small and rare. In the sample CH-1 they become larger and occur more often.

Genus *Zygodiscus* Bramlette & Sullivan, 1961

Zygodiscus diplogrammus (Deflandre, 1954) Gartner, 1968

Pl. 1, fig. 11, 12

1954. *Zygolithus diplogrammus* cent. nov.; Deflandre in Deflandre & Fert, p. 34, text-fig. 57, pl. 10, fig. 7.

1968. *Zygodiscus diplogrammus* Deflandre; Gartner, p. 32, pl. 19, fig. 3; pl. 21, fig. 2; pl. 22, fig. 7; pl. 23, fig. 12—14; pl. 24, fig. 6; non pl. 14, fig. 18; pl. 17, fig. 4; pl. 25, fig. 17.

Remarks: This is the most abundant form in the samples studied with the exception of *Watznaueria barnesae* (Black) Perch-Nielsen.

Family STEPHANOLITHIONACEAE Black, 1968, emend Burky, 1969

Genus *Corollithion* Stradner, 1961

Corollithion exiguum Stradner, 1961

Pl. 1, fig. 10

1961. *Corollithion exiguum* nov. spec.; Stradner, p. 83, fig. 58—61.

Remarks: This species appear in the sample CH-8. It was used as a zonal marker for the lower limit of *M. decoratus* NF Zone.

Corollithion kennedyi Cru x, 1981

Pl. 1, fig. 15

1981. *Corollithion kennedyi* n. sp.; Cru x, p. 634, pl. 1, fig. 4, 5; pl. 2, fig. 4, 5.

1982. *Corollithion kennedyi* Cru x; Cru x, pl. 5.2, fig. 19, 20; pl. 5.9, fig. 11, 12.

Remarks: This species differs from *Corollithion signum* Stradner in the construction of the central area, which is occupied entirely by the central cross. In polarized light each of the crossbars is divided distinctly into two parts.

Family **MICRORHABDULACEAE** Reinhardt, 1966

Genus **Microrhabdulus** Deflandre, 1959

Microrhabdulus decoratus Deflandre, 1959

Pl. 1, fig. 13

1959. *Microrhabdulus decoratus* n. g. n. sp.; Deflandre, p. 140—141, pl. 4, fig. 9, 10.

Remarks: This species occurs very rare in the sample CH-8 and it was used as a biostratigraphical marker for the base of *M. decoratus* NF Zone.

Genus **Lithraphidites** Deflandre, 1963

Lithraphidites acutum Verbeek & Manivit, 1977

Pl. 1, fig. 14.

1974. *Lithraphidites alatus* Thierstein; Thierstein, p. 641, pl. 3, fig. 5—11.

1976. *Lithraphidites alatus* Thierstein; Verbeek, p. 77, pl. 2, fig. 5a, b.

1977. *Lithraphidites acutum* nov. spec.; Verbeek & Manivit in Manivit et al., p. 176, pl. 1, fig. 7, 8.

Remarks: This species differs from the other species of the genus by the four prominent processes which give a helical shape to this form. So far it has been reported from the Middle and Upper Cenomanian by many authors. Cruix (1982) reported it from the upper part of *M. Mantelli* Zone in England. In this study *L. acutum* Verbeek & Manivit appears a little above the Albian — Cenomanian boundary. It was used as a zonal marker for the *L. acutum* NF Zone.

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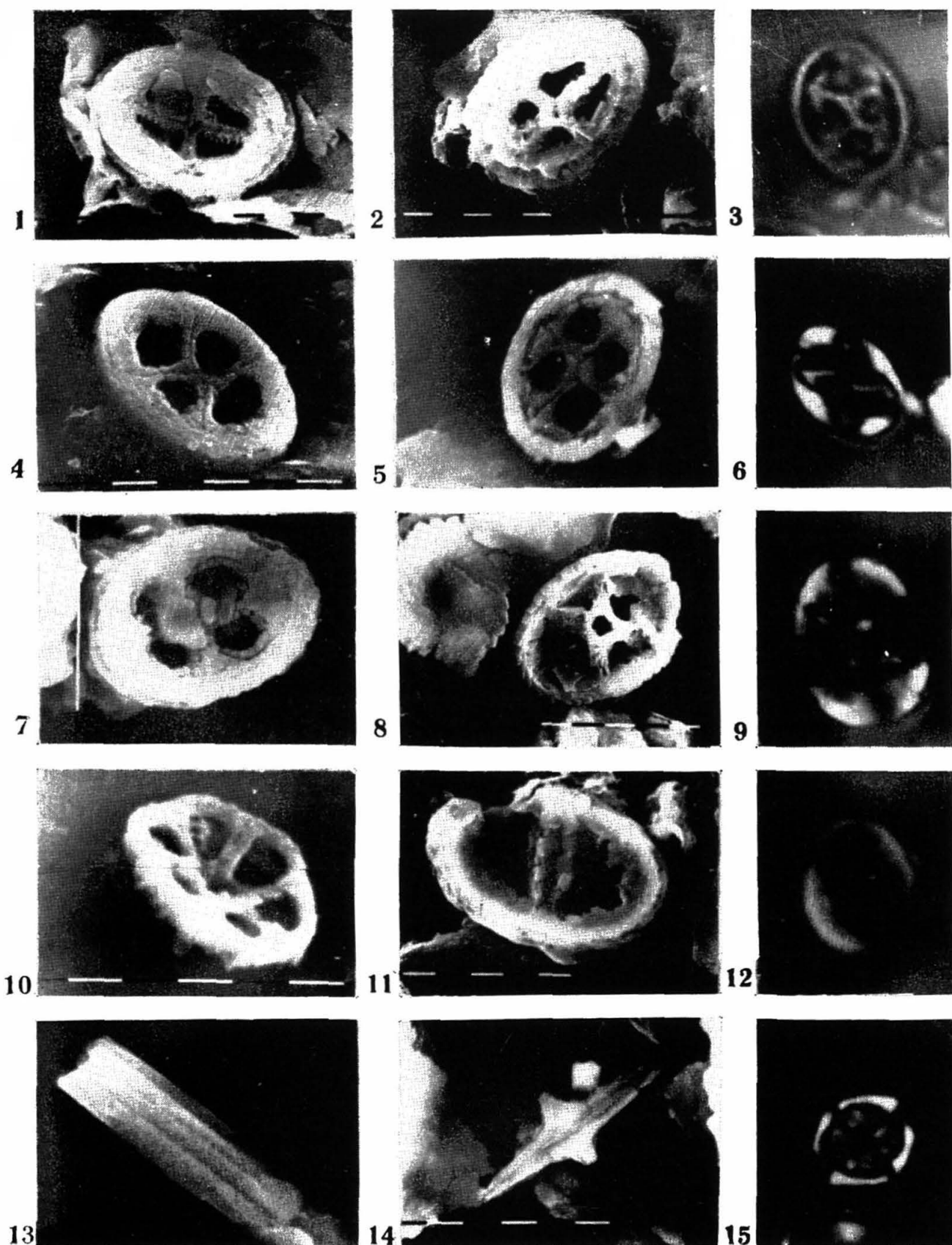


PLATE 1

Fig. 1, 2. *Broinsonia dentata* Bukr y, 1969.

Fig. 1. Proximal view, SEM, $\times 4000$; sample CH 8, *C. exiguum* NF Zone, Sanadinovo Marl Formation, Upper Cenomanian

Fig. 2. Distal view, SEM, $\times 4000$; sample CH 8, *C. exiguum* NF Zone, Sanadinovo Marl Formation, Upper Cenomanian

Figs 3—6. *Chiastozygus cuneatus* (L ul j e w a, 1967) C e p e k & H a y, 1969

Fig. 3. LM, $\times 2000$; sample CH 5, *L. acutum* NF Zone, Sanadinovo Marl Formation, Middle Cenomanian

Fig. 6. LM, $\times 2000$, $\times$ -nicols; the same specimen as Fig. 3

Fig. 4. Proximal view, SEM, $\times 6000$; sample CH 8, *C. exiguum* NF Zone, Sanadinovo Marl Formation, Upper Cenomanian

Fig. 5. Distal view, SEM, $\times 6000$; sample CH 8, *C. exiguum* NF Zone, Sanadinovo Marl Formation, Upper Cenomanian

Fig. 7. *Podorhabdus albianus* B l a c k, 1967. Proximal view, SEM, $\times 3400$; sample CH 8, *C. exiguum* Zone, Sanadinovo Marl Formation

Figs 8, 9. *Eiffellithus turriseiffeli* (D e i l a n d r e, 1954) R e i n h a r d t, 1965

Fig. 8. Distal view, SEM, $\times 4000$; sample CH 8, *C. exiguum* NF Zone, Sanadinovo Marl Formation, Upper Cenomanian

Fig. 9. LM, $\times 2000$, $\times$ -nicols; sample CH 3, *L. acutum* Zone, Sanadinovo Marl Formation, Lower Cenomanian

Fig. 10. *Corollithion exiguum* S t r a d n e r, 1961. Proximal view, SEM, $\times 6000$; sample CH 8, *C. exiguum* Zone, Sanadinovo Marl Formation, Upper Cenomanian

Figs 11, 12. *Zygodiscus dinlogrammus* (D e i l a n d r e, 1954) R e i n h a r d t, 1965

Fig. 11. Proximal view, SEM, $\times 4000$; sample CH 8, *C. exiguum* NF Zone, Sanadinovo Marl Formation, Upper Cenomanian

Fig. 12. LM, $\times 1750$, $\times$ -nicols; sample CH 2, *L. acutum* NF Zone, Sanadinovo Marl Formation, Lower Cenomanian

Fig. 13. *Microrhabdulus decoratus* D e i l a n d r e, 1959. Side view, SEM, $\times 6600$; sample CH 8, *C. exiguum* NF Zone, Sanadinovo Marl Formation, Upper Cenomanian

Fig. 14. *Lithraphidites acutum* V e r b e e k & M a n i v i t, 1977. Side view, SEM, $\times 4500$; sample CH 8, *C. exiguum* NF Zone, Sanadinovo Marl Formation, Upper Cenomanian

Fig. 15. *Corollithion kennedyi* C r u x, 1981. LM, $\times 2000$, $\times$ -nicols; sample CH 2, *L. acutum* Zone, Sanadinovo Marl Formation, Lower Cenomanian

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