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Pseudoclypeina? crnogorica RADOIČIĆ, 1972 – Stratigraphic revision and taxonomic note on a little known dasycladalean alga from Montenegro

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Abstract. *Pseudoclypeina? crnogorica* was first described in 1972 from the Lower, Cretaceous limestone of the Njegoš Mt. area, Montenegro, Dinaric Carbonate Platform. It differs from other species of the genus *Pseudoclypeina* by its calcification pattern, the shape and relative length of the first and second order laterals, and by the presence in the type-material (a thin section containing the holotype) of sections standing for the sterile portion of the thallus. This is why in this paper, the generic name is left in open nomenclature. On this occasion the species, whose presence is also reported from southern Iran, is re-described and better illustrated, based on material originating from other outcrops in Montenegro. The stratigraphic position is reviewed as well. *Pseudoclypeina? crnogorica* occurs in shallow water inner platform facies of early Neocomian age, along with *Selliporella neocomiensis*.

Key words: Dasycladalean (green algae), *Pseudoclypeina? crnogorica*, Neocomian, Dinaric Carbonate Platform, Montenegro.

Апстракт. Дазикладалеан *Pseudoclypeina? crnogorica*, описана 1972., потиче из доњокредних седимената Његош планине у Црној Гори (Динарска карбонатна платформа). *P.? crnogorica* разликује се од других врста рода *Pseudoclypeina* по типу калцификације, облику и димензијама примарних огранака као и присуством дијелова који одговарају млађем стерилном дијелу талуса. Стога је ова врста приказана у отвореној номенклатури генеричког имена. Дат је потпунији опис типског и другог материјала уз бројне илустрације. *P.? crnogorica* јавља се у плитководним фацијама неокома платформне унутрашњости, у слојевима у којима се јавља и *Selliporella neocomiensis*. Осим у Црној Гори, нађена је у седиментима исте старости у јужном Ирану.

Кључне ријечи: Dasycladalean (зелене алге), *Pseudoclypeina? crnogorica*, неоком, Динарска карбонатна платформа, Црна Гора.

Introduction

Lower Cretaceous, shallow water sediments of the southern Montenegro (NW–SE belt), Dinaric Carbonate Platform, contain an abundant flora of dasycladalean algae and subordinated foraminiferal fauna, especially in an interval covering part of the Neocomian. No less than six species of dasycladalean algae were originally described from this area. The aim of this paper is to revise the age and, based on yet unpublished material, provide new insights on the taxonomy of one of these species, the little known *Pseudoclypeina? crnogorica* RADOIČIĆ, 1972.

P.? crnogorica was originally described from undifferentiated Lower Cretaceous deposits, found in the Srijede area and forming the NE flank of the Njegoš Mt. anticline (Fig. 1). The core of the anticline consists of Jurassic and Cretaceous shallow water carbonates. The Jurassic succession, dated Lias to uppermost Malm (*Clypeina jurassica* Zone), includes a short stratigraphic gap laterally and partly corresponding to pre-Late Kimmeridgian bauxite deposits. The northeastern flank of the anticline is distorted by a longitudinal fault, along which late Malm and Neocomian Cretaceous sediments are in tectonic contact. The stratum typicum of *P.? crnogorica* is a limestone sampled at observation

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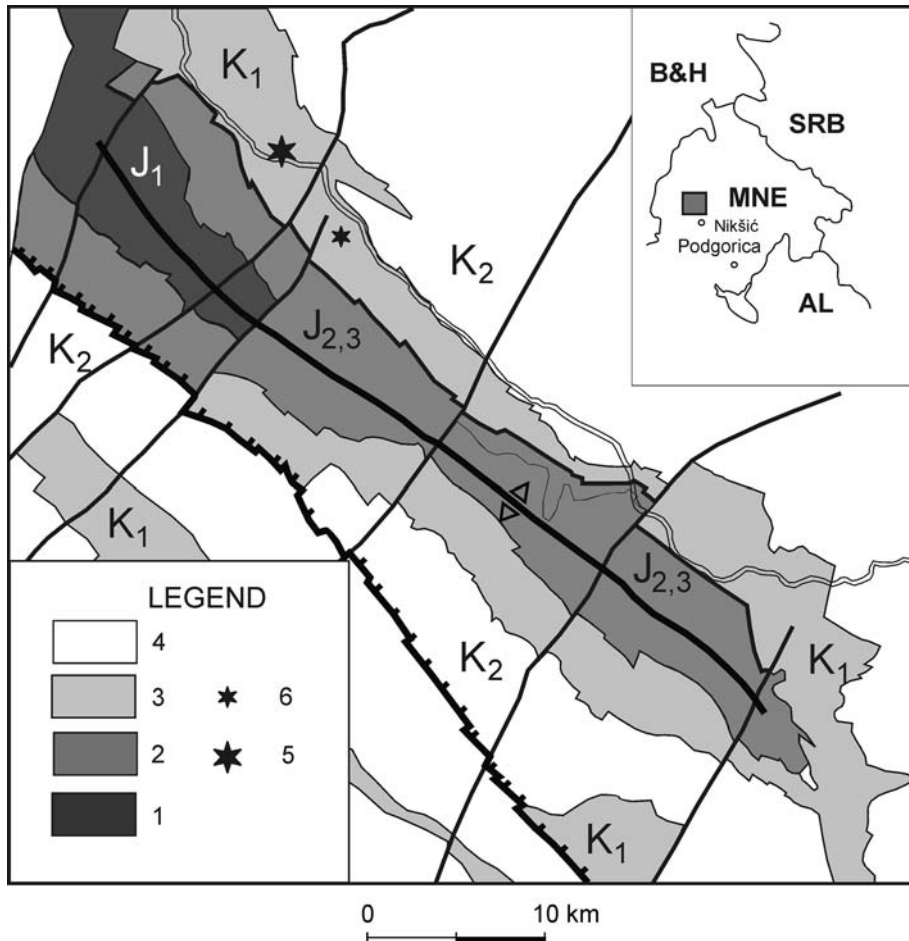


Fig. 1. Geological map of the Njegoš Mt. anticline, from the Geological Map Sheet Nišić, 1:100000 (VUJISIĆ & PALINKAŠEVIĆ, 1975), simplified. Legend: 1, Lias; 2, Middle and Upper Jurassic; 3, Lower Cretaceous; 4, Upper Cretaceous. Left star the type level.

point N° 1011b/1963 of the mapping team, on the Nikšić–Gacko road, NE flank of the anticline. Originally, it was erroneously assigned to the “Zone with *Salpingoporella melitae* and *Likanella danilovae* (Barremian–Lower Aptian)” [not “Barrémien–Aptien supérieur. Associée à *Salpingoporella melitae* et *Likanella ? danilovae*” (BASSOULLET *et al.* 1978, p. 217)], because the two species were found in some other observation points. At that time, data enabling to date the NE flank of the anticline from the Neocomian was missing.

In many areas of western Montenegro, the Jurassic–Lower Cretaceous stratigraphic column is more or less reduced due to frequent subaerial exposures of different duration, resulting in the presence of significant stratigraphic gaps corresponding or not to the presence of white bauxite (RADOIČIĆ & VUJISIĆ 1970; RADOIČIĆ 1993). One of such successions, with white bauxite ranging from the Neocomian to the Upper Albian–Cenomanian, is found in the Velimlje area, south of the Njegoš Mt. The lower–middle part of the Neocomian column, with numerous subaerial exposures consists, first of a limestone containing *Daturelina co-*

stata and *Campbelliella striata*, followed by a coprogenous limestone with *Salpingoporella annulata*, coprolites and rare foraminifers and, finally by a limestone with fragments of an unknown dasycladalean alga later identified as *Pseudoclypeina? crnogorica*.

In the region of Prekornica and Lebršnik Mts, in northern part of the Geological map sheet Titograd at scale 1:100000, the “Ttitonian–Valanginian” limestone-dolomite succession (“J/K”) is largely distributed, transgressive on the Upper Triassic or Triassic–Liassic deposits (Živaljević *et al.* 1971, 1973). Location is in the southernmost part of the large Nikšićka Župa bauxite bearing region, north of the Zeta intra-platform furrow. A Neocomian limestone containing *P.? crnogorica* was found on the road east of the Lebršnik Mt. Southward along the same road, two outcrops of a limestone containing *Sellioporella neocomiensis*, *Clypeina neretvae* and *P.? crnogorica* were sampled (the first sampling, near Lisac, is type locality of *S. neocomiensis*).

In all known localities of

Montenegro, *P.? crnogorica* occurs in Neocomian sediments, most probably dated Late Berriasian or Late Berriasian–Early Valanginian.

Genus *Pseudoclypeina* RADOIČIĆ, 1970.

Three species of the genus *Pseudoclypeina* have been described from southern Montenegro (Dinaric Carbonate Platform): *P. cirici* RADOIČIĆ 1975, non 1970, the genotype, *P. farinacciae* RADOIČIĆ 1975, non 1970, both from the Upper Kimmeridgian, and *P.? crnogorica* RADOIČIĆ 1972, from the “Barremian–Lower Aptian” (now dated Neocomian). Because *P. cirici* differs from the other two species in having three orders of branches, BASSOULLET *et al.* (1978), suggested that it would “préférable de signaler dans la diagnose du genre que *Pseudoclypeina* peut présenter deux ou trois ordres de ramification.” Which, at once, is accepted in the present paper.

A new species, *Pseudoclypeina distomensis*, was introduced by BARATTOLO & CARRAS (1990) from the Lower Kimmeridgian of the Parnassus Carbonate

Platform, Greece. According Barattolo and Carras “The ‘tertiary branch’, which Radoičić’s diagnosis of *Pseudoclypeina* is referred to, is not considered in such a manner for the following reasons: it originates without ramification (absence of ramification); it is on the same extension of the secondary branch; branches of a same order bearing narrowings are already known and have been accepted by former authors [e.g. *Palaeodasycladus mediterraneus* (PIA)]”.

In the opinion of the present first author (RR), the tertiary branch (lateral, segment) of *Pseudoclypeina cirici* (in prolongation of secondary which has integral inner calcification including mould of reproductive organ and the pore at the top) is rarely together preserved due to brittle joint with secondary. This part of the skeleton has the form to which term branch (lateral, segment) is more corresponding, in the same way as the term “narrowing” (constriction) more corresponds to *Pseudoclypeina distomensis*. Such distinction may be irrelevant if the biological function is the same, i. e. protection of the fertile organ.

Both species, *P. cirici* followed by *P. distomensis* occur in the shallow-water, Late Jurassic succession of the Distomon area, Parnassus Carbonate Platform. In the nearby Kallidromo Mt. they occur together as well (recent unpublished data, N. Carras). In the future, a detailed study may show to what extent the two species are reciprocally related.

***Pseudoclypeina? crnogorica* RADOIČIĆ, 1972**

Fig. 2; Pls. 1–3; Pl. 4, Figs. 1, 2, 6

1972 *Pseudoclypeina crnogorica* sp. nov. – RADOIČIĆ, p. 365, figs. 1a–c.

Diagnosis. Thallus cylindrical, relatively large, the main stem bearing regularly spaced shallow funnel-shaped whorls of numerous laterals. Primary laterals ovoid, bearing a tuft of 4–6, rather large and long secondary laterals, gradually widened outwards and no further ramified. Primary and second order laterals equally inclined upwards. Calcification articulated, individually coating the whorls of laterals. Reproductive organs (cysts) not observed, presumably located in the primary laterals (cladosporous type).

Notes on the generic attribution. *Pseudoclypeina? crnogorica* differs from other species of the genus in the type of calcification, comparatively standard (originally aragonitic), made of an external coat of colorless sparry calcite. By contrast, in *Pseudoclypeina cirici*, *P. farinacciae* and *P. distomensis* an inner, yellowish coat of calcite is present, strongly recalling if not identical to the calcification pattern found in *Clypeina jurassica*. The thallus of *P.? crnogorica* is comparatively rather small, with a smaller number of laterals per whorl, noting that in *P. farinacciae* other biometrical values are incomplete because the skeleton is altered by dissolution. Finally the size

ratio between primary and secondary laterals is almost opposite, denoting a substantial difference. This is why in this paper we prefer to put the species in open nomenclature.

Quoting BUCUR (2013) “*P. crnogorica*, the fourth species of the genus *Pseudoclypeina*, differs from the other species not only in its calcification pattern, i.e., blocky sparite, but also in the size ratio between the primary and secondary laterals. The primary laterals are half the length of the secondary ones and ovoid in shape; this is not typical for the genus *Pseudoclypeina*, and makes the assignment doubtful. Based on the morphology and size ratio of the laterals, this species is more likely to be affiliated to *Selliporella*, as emended by BARATTOLO *et al.* 1988. The general morphology of the thallus broadly resembles that of *Selliporella neocomiensis* (see BUCUR & SĂȘĂRAN, 2003)”. In *P.? crnogorica* however, the secondary laterals are phloiophore (widening out), as compared to pirifere (the opposite) in *Selliporella*. A possible transfer to *Dissocladella* is all the same rejected, because of different morphology and primary to first – second order laterals length ratio. That is why we prefer, at the moment, to assign the species with doubt to the genus *Pseudoclypeina*, avoiding creating another genus based on insufficient data. For the moment this standpoint is shared (pers. comm.) by two algologists, namely Filippo Barattolo (Naples) and Ioan I. Bucur (Cluj).

Description and comparisons. Based on available material, *P. crnogorica* shows a moderate dimensional variability of the following characters. External diameter (D) 3.5–4.4 mm; inner diameter (d) 1–1.3 mm; spacing of whorls (h) 0.9–1.0 mm; dimension of primary laterals max. 0.40×0.30 mm (proximally compressed); length of secondaries (l’) 0.75–0.80 mm, with a distal diameter (p’) of 0.275 mm. Number of primaries per whorl (w) 20–22. Upward inclination (α) of the primary laterals approximately 40° to the horizontal plane.

Two singular sections are illustrated in Pl. 3: Fig. 4 shows the oblique section of a fragment of whorl with smaller primaries, sparse and long secondaries; Fig. 5 shows the tangential section of strongly tilted second order laterals in cup-like arrangement. Most probably, these two sections belong to the youngest, sterile portion of the thallus, in a way similar to some recent genera. In the studied material the calcified main stem is not preserved. Membranes of the primary and secondary laterals are seldom preserved as a thin micritic coat (Fig. 2, the holotype). Calcification, made of colorless sparry calcite enclosing the primary and secondary laterals, becomes thinner at the thallus periphery and is usually not preserved distally. Partial recrystallization occurs, stronger around the top of the primary and proximal portion of the secondary laterals. Seldom, all of a whorl or fragment of whorl is completely recrystallized (Pl. 2, Fig. 3; Pl. 4, Fig. 2).



Fig. 2. *Pseudoclypeina? crnogorica* RADOIČIĆ, 1972, the holotype. Sub-axial section cutting eight whorls. The micritic membrane coating the first and second order laterals is especially well preserved. Thin section RR1927. Sterile parts of the thallus: see Pl. 3, figs. 4, 5.

Located in the Srijede area, the type-level of *P. crnogorica* consists of an inhomogeneous limestone

(wackestone, packstone, peloidal limestone, grainstone containing micrite lithoclasts). The species mainly occurs as isolated whorls and fragments. From this bed, 11 thin sections were made from sample 07753a (RR1922-1925/1-1926/1-1930). Also six thin sections were made from sample 06230 (RR1794-1795/1-1798) originating from another, neighboring location. Finally, two thin sections were made from sample 03669 (RR1542,1543) originating from the Lebršnik Mt. area and one thin section from sample 03681a (RR1567) south of Lebršnik.

Algae labeled *Dasycladacea* sp. by FOURCADE *et al.* (1972, pl. 2, figs. 5–8) illustrates a specimen originating from the upper Barremian of Benizar–Otis area, southeast Spain, which has been included in *P. crnogorica* by BASSOULLET *et al.* (1978, p. 217). The same taxon, most probably, was illustrated by MASSE (1995, pl. 2, fig. 16) under the name of *Pseudoclypeina* sp., from the upper Barremian of Orgon, SE France. Compared to *P.? crnogorica* the calcification pattern of these specimens is the same but the shape of the primary laterals differs (elongated versus ovoid), and the length ratio of the first and second order laterals is the opposite, indicating a new taxon.

Stratigraphic and geographic distribution. In Montenegro, *Pseudoclypeina? crnogorica*, *Selliporella neocomiensis* and *Clypeina neretvae* occur in an inner platform limestone-early diagenetic dolomite interval presumably dated Upper Berriasian–Lower Valanginian. Besides the foregoing species, *P. crnogorica* is associated with common *Salpingoporella annulata*, *Salpingoporella* spp., *Clypeina* spp., some other small and undetermined species, fine algal debris, *Favreina* spp. and microgastropods. In southern Montenegro, locations form a discontinuous belt extending from northwest of Nikšić to the south-east, in the mountains area north of Podgorica (Titograd).

P.? crnogorica was presented by BERNIER *et al.* (1979, pl. 1, figs. 9–11) as *Pseudoclypeina* aff. *crnogorica* from Kimmeridgian–Portlandian of Mount Kanala, Gavrovo Massive, Greece, associated with foraminifer *Anchispirocyclina neumannae* n. sp. Than described the new foraminifer species *Anchispirocyclina neumannae* originates from “Portlandian supérieur (selon H. TINTANT, in M. RAMALHO 1971)” of Cap d’Espichel, south of Lisbon, Portugal.

Besides Montenegro and Greece, specimens looking alike *P.? crnogorica* are found in the Zagros fold and thrust belt of Southern Iran, in an interval dated Late Berriasian–Early Valanginian (HOSSEINI *et al.* 2013).

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Резиме

***Pseudoclypeina? crnogorica* Radoičić, 1972 - стратиграфска ревизија и биљешка о таксономији мало познате дасикладалеан алге из Црне Горе**

Доњокредни плитководни седименти Динарске карбонатне платформе у јужној Црној Гори (појас СЗ–ЈИ), садрже бројну алгалну флору уз прилично сиромашну фораминиферску фауну, особито у једном интервалу неокома. Из доњокредних седимената овог подручја описано је шест нових дасикладалеанских врста. Предмет овог текста је стратиграфска ревизија и детаљнији приказ непубликованог материјала значајног за таксономију једне од ових врста - мало познате врсте *Pseudoclypeina? crnogorica*.

***Pseudoclypeina? crnogorica* RADOIČIĆ, 1972 Pl. 1–3, pl. 4, figs. 1, 2, 6**

1972 *Pseudoclypeina crnogorica* sp. nov. – RADOIČIĆ, стр. 365, сл. 1a–c.

Дијагноза. Цилиндричан, релативно крупан талус, са главном осом која носи правилно расподељене плитко-љевкасте пршљенове бројних грана. Примарни огранци овоидног облика дају 4–6 релативно крупних и дугих секундарних огранака који се поступно благо проширују према спољашњој површини, не гранајући се даље. Примарни и секундарни огранци истог су нагиба према централној оси. Калцификација артикулатна – пршљенови су појединачно обавијени. Репродуктивни органи (цисте) непознати, вјероватно смјештени у примарним огранцима (кладоспорни тип).

Упоређење и опис. *Pseudoclypeina? crnogorica* разликује се од других врста рода *Pseudoclypeina* по типу калцификације коју чини спољашњи спари-калцитски омотач. Друге врсте, *P. cirici*, *P. farinacciae* и *P. distomensis* карактерише унутрашњи омотач жућкастог калцита који је веома сличан ако не и идентичан калцификацији врсте *Clypeina jurassica*. *P.? crnogorica* има талус мањих димензија, са мањим бројем огранака. Поменуте разлике су разлог што се у овом тексту *crnogorica* оставља у у отвореној родовској номенклатури, да би се, за сада, избјегло увођење новог рода на основу недовољно података.

Два пресека приказана на табли 3, сл. 4 и 5 приписују се најмлађем стерилном дијелу талуса. Мембрана примарних и секундарних огранака ријетко је сачувана као танак микритски омотач (сл. 2, холотип). Калцификација безбојног спаритског калцита обухвата примарне и секундарне огранке, на површини талуса најчешће није очувана.

Прекристализација је обично јача у врху примарних и проксималном дијелу секундарних огранака, рјеђе су фрагменти пршљенова или читави дијелови талуса сасвим прекристалисали.

Географско и стратиграфско распрострањење. Приказани материјал потиче из четири локалитета у јужној Црној Гори. Типски локалитет и локалитет у његовој близини налазе се у подручју Сриједе на сјеверном крилу антиклинале Његош планине, сјеверозападно од Никшића (сл. 1). Друга два локалитета налазе се у планинској области сјеверно од Подгорице, западно и југозападно од Лебршника. У овим локалитетима, као и у неким другим у којима је препозната, *P.? crnogorica* јавља се у неокомским седиментима, највјероватније горњег беријаса или горњег беријаса-доњег валендиса.

Осим у Црној Гори, примјерци веома слични ако не и идентични врсти *P.? crnogorica* нађени су у седиментима горњег беријаса-доњег валендиса Загрос појаса у Јужном Ирану (HOSSEINI *et al.* 2013)

PLATE 1

Isotypes of *Pseudoclypeina? crnogorica* RADOIČIĆ, 1972

- Fig. 1. Tangential section of whorl with, in the proximal part, laterally slightly compressed primary laterals, elliptic in section. Note the calcified membrane of primary laterals (black micritic line). Thin section RR1926/1.
- Figs. 2–5. Oblique sections of whorls. In Figs. 2, 3 recrystallization is stronger around the top portion of the primaries and proximal portion of the secondaries. Calcification is thinner in Fig. 5. Thin sections RR1924, 1928, 1925/1, 1925/1.
- Figs. 6, 12. Tangential sections of the secondary laterals. Thin section RR1926.
- Fig. 7. Fragment of whorl showing the ovoid first order laterals and long gradually widening outward secondaries; the section plane follows the inclination of laterals.. Thin section RR1926.
- Figs. 8–11. Fragments, tangential-oblique sections cutting some of the primary and secondary laterals. Thin sections RR1928, 1951/1, 1927, 1929.

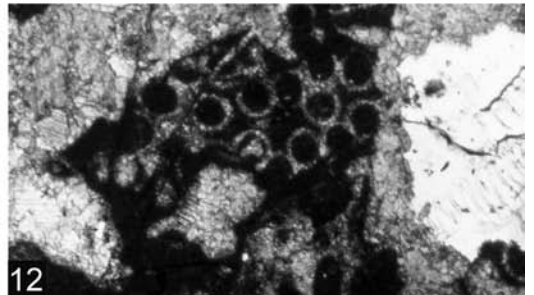
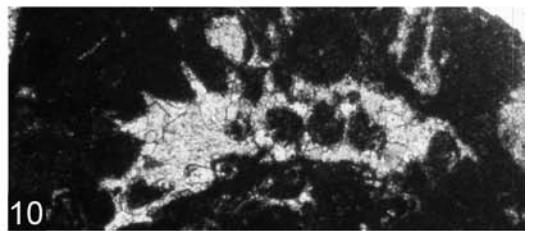
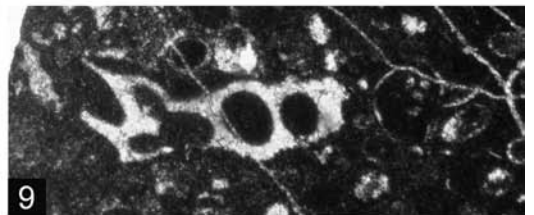
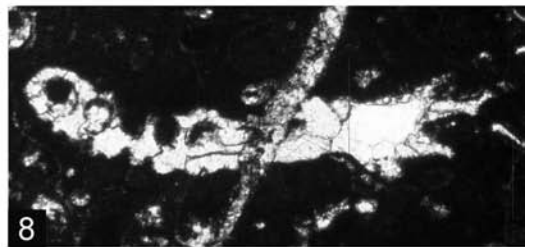
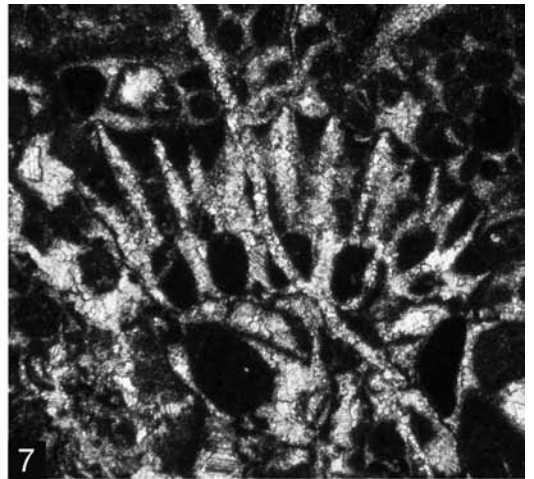
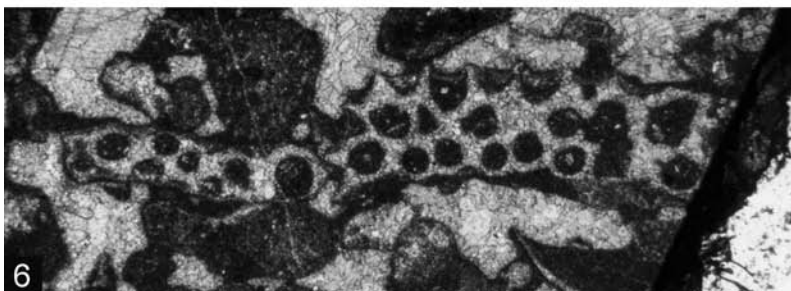
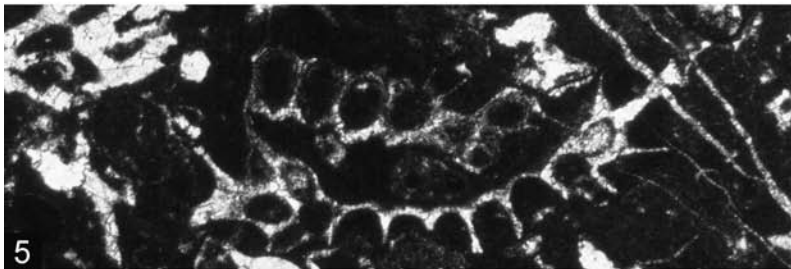
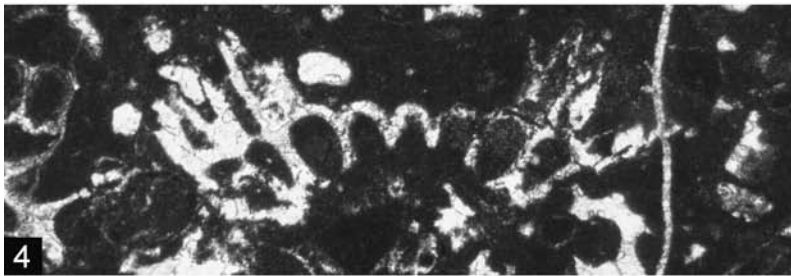
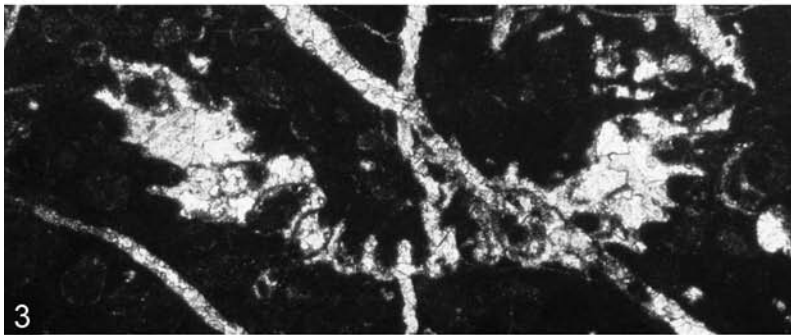
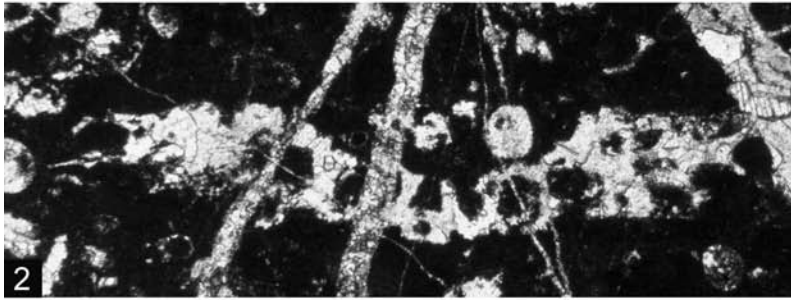
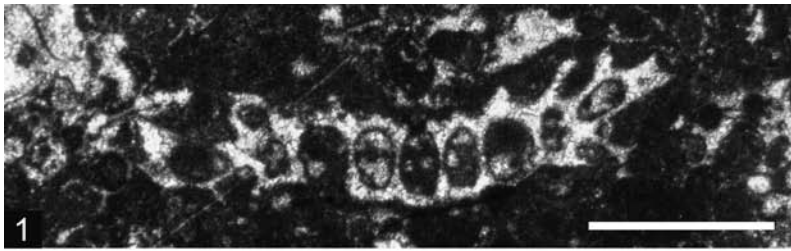


PLATE 2

Pseudoclypeina? crnogorica RADOIČIĆ, 1972

- Fig. 1. Tangential section of a partially recrystallized whorl. Note the micritic membrane in transverse sections of two primary laterals, and the more recrystallized proximal portion of the secondaries. Thin section RR1926/1, isotype.
- Fig. 2. Deep tangential section of a recrystallized whorl. Note the transverse sections of primary with micritic membrane. Thin section RR1796.
- Fig. 3. Transverse section of a recrystallized fragment of a whorl. Thin section RR1796.
- Fig. 4. Deep tangential-oblique section of a whorl. Thin section RR1796.
- Figs. 5, 6. Subaxial sections, partly recrystallized. Note the upward inclination of the primary laterals. Thin section RR1795/1.
- Fig. 7. Fragments of a whorl, fractured. Thin section RR1925, isotype.
- Fig. 8–10. Fragments of whorls showing the primary laterals and the proximal parts of the secondaries. Thin sections RR1795/1, 1795, 1796.
- Figs. 11, 12. Tangential sections of secondary laterals. Thin sections RR1725/1, 1926/1, isotype.
- Fig. 13. Tangential-oblique section cutting the distal parts of three whorls in advanced degradation process. Note the micritic membrane in some of the second order laterals. Thin section RR1794.

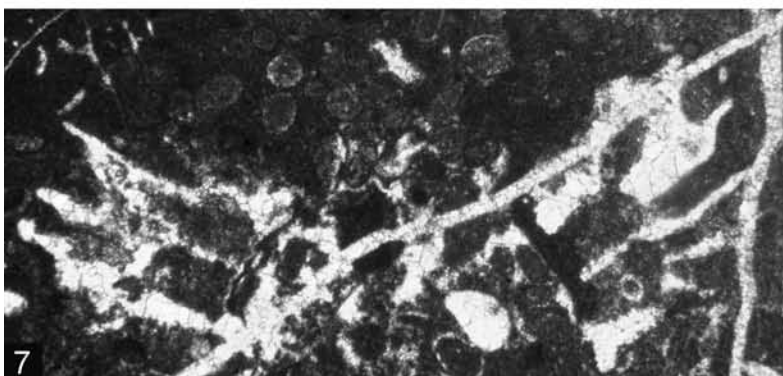
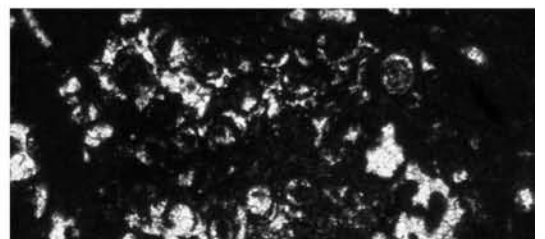
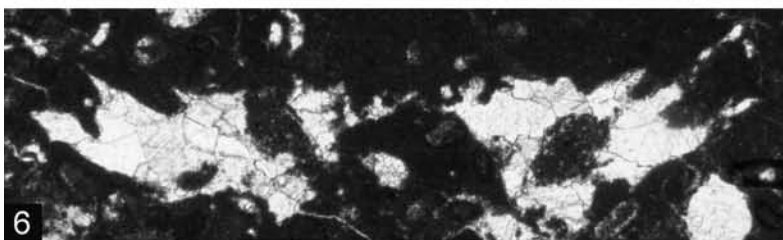
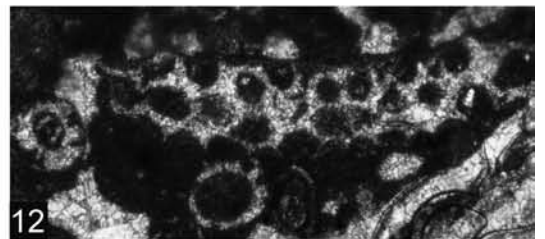
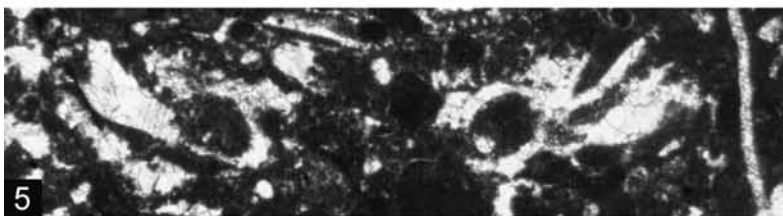
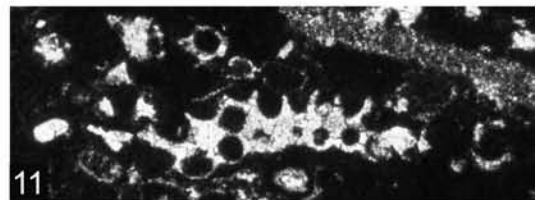
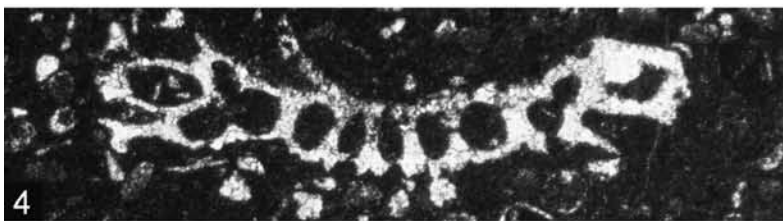
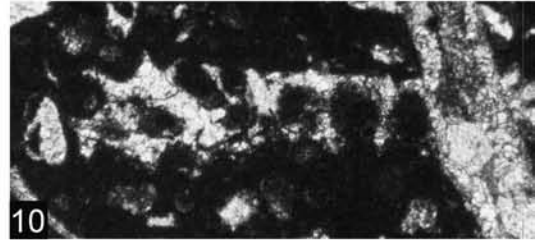
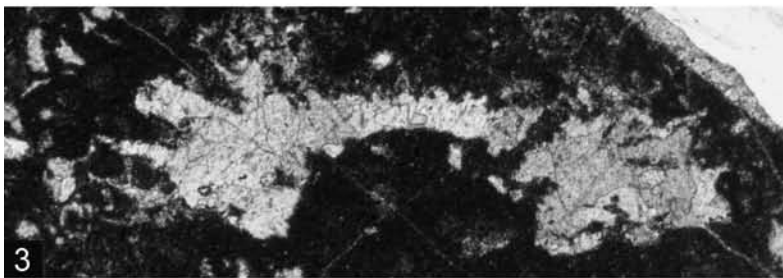
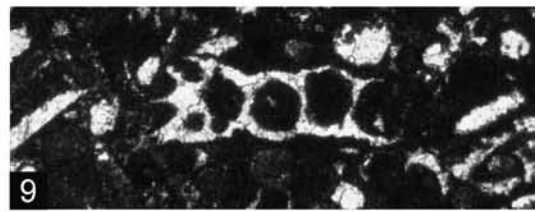
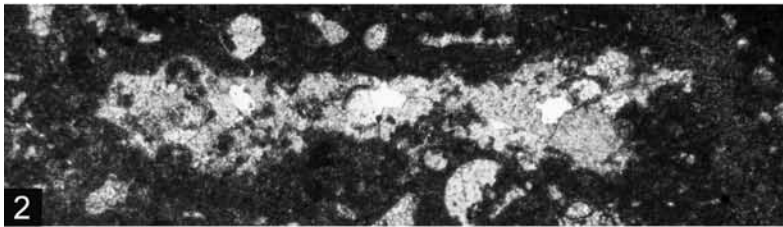
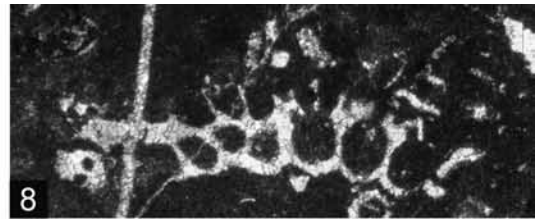


PLATE 3

Pseudoclypeina? crnogorica RADOIČIĆ, 1972

- Fig. 1. Ill-preserved, fractured fragment of a whorl. The section plane more or less follows the inclination of the laterals. Left: most of the primary laterals are visible, as well as the slightly deformed secondaries and corresponding swollen distal part (arrow). Thin section RR1930, isotype.
- Fig. 2. Tangential-oblique section progressively cutting three, partly recrystallized whorls. Only the primary laterals are visible in the upper, deeper cutting, whorl. Thin section RR1794.
- Fig. 3. Tangential section cutting three whorls showing different stages of preservation. Thin section RR1924, isotype.
- Figs. 4, 5. Two sections interpreted as cutting the upper, sterile part of the thallus (4) with smaller primaries and (5) top-most, cup-like part of the thallus. Thin section RR1927 also containing the holotype.
- Fig. 6. Fragment of whorl showing the primary laterals and poorly preserved proximal parts of the secondaries. Thin section RR1543.
- Fig. 7. Tangential, slightly oblique section. Note the micritic membrane coating the primary laterals. Thin section RR1542.

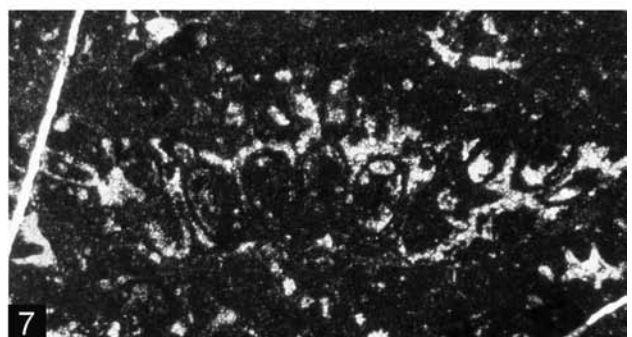
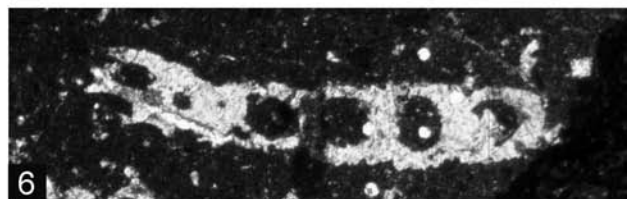
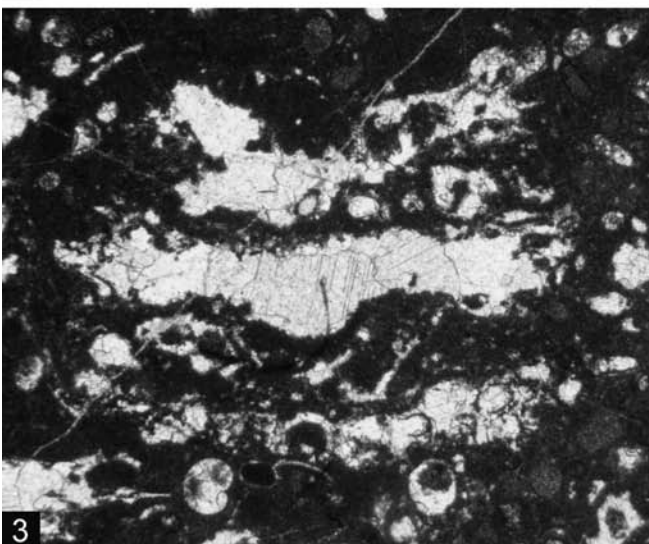
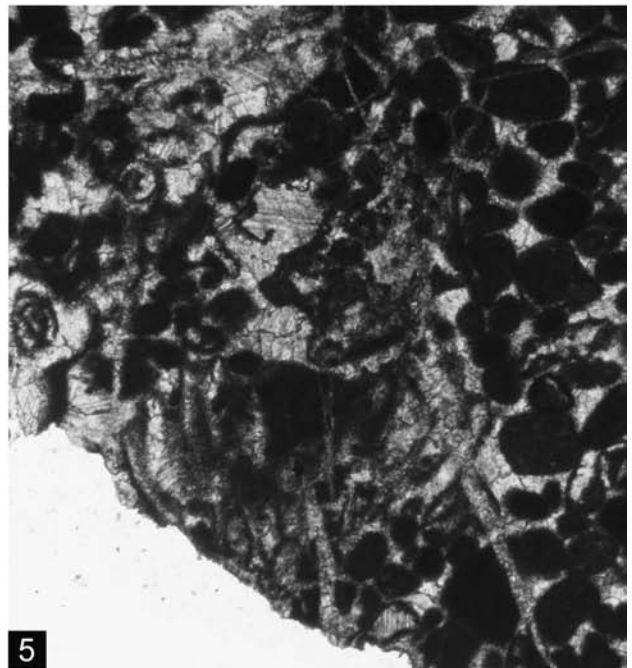
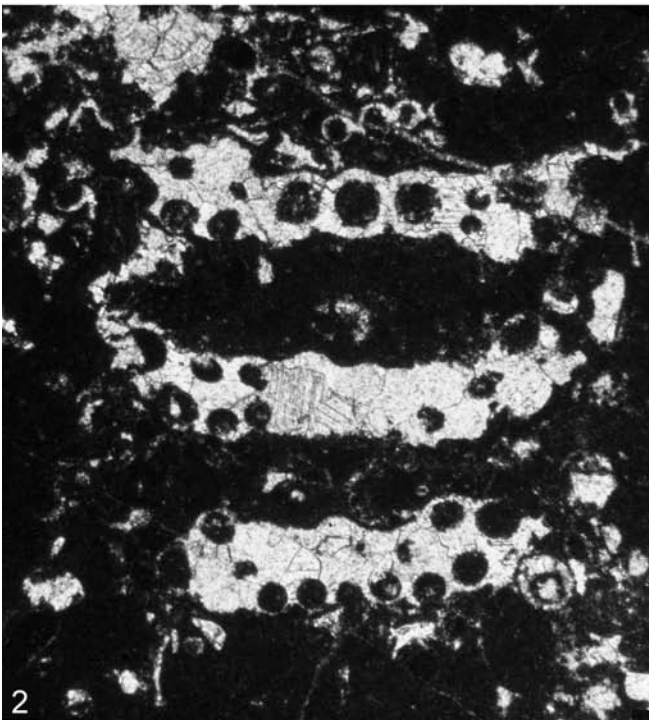
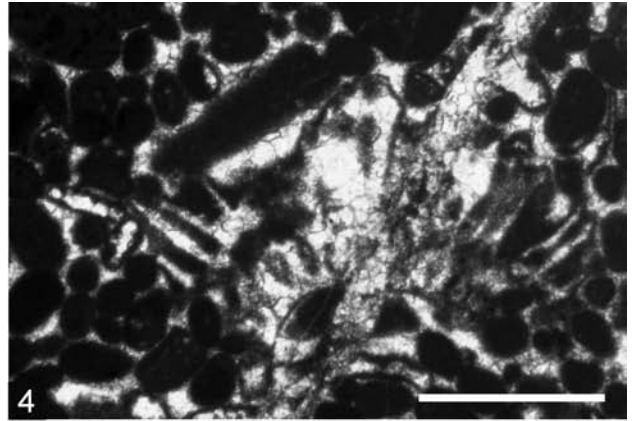
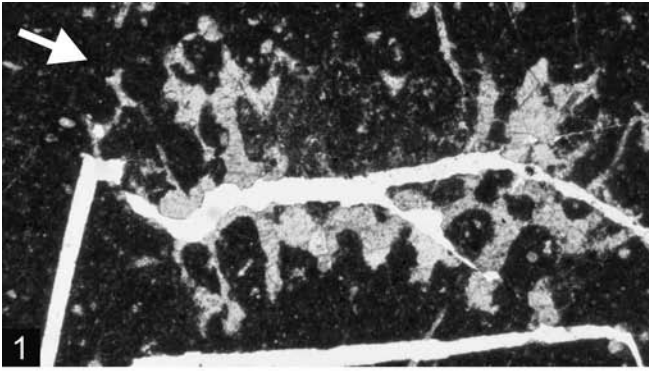


PLATE 4

- Fig. 1. Isotype of *Pseudoclypeina? crnogorica* RADOIČIĆ, 1972. Deformed, partly disintegrated and recrystallized part of a skeleton showing six whorls. Noteworthy, in this case some pores of the primary laterals are circular in section. Thin section RR1928.
- Fig. 2. *P.? crnogorica*. Fractured, deformed and completely recrystallized (large blocky calcite grains) of a specimen showing four whorls. Thin section RR1567.
- Figs. 3, 4. Dasycladalean alga NK1 n. gen.?, n. spec. (informal designation). Arrows: dichotomous branching of the laterals. Thin sections RR1794, 1795/1, also containing *P.? crnogorica*.
- Fig. 5. Presumably Dasycladalean alga NK1. The axial cavity covers part of the primary laterals, which are recrystallized and dichotomously branched at periphery. Thin section RR1924.(containing isotypes *P.? crnogorica*).
- Fig. 6. Isotype of *P.? crnogorica*. Transversal-oblique section of a partly recrystallized piece of thallus. Thin section RR1925/1.
- Fig. 7. *Clypeina* sp. Thin section RR1795.

