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NON-GENICULATE CORALLINE ALGAE (CORALLINALES, RHODOPHYTA) FROM THE LOWER OLIGOCENE OF POLJŠICA PRI PODNARTU (NORTHERN SLOVENIA)

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Abstract. Despite their increasing importance in sedimentology and palaeoecology, non-geniculate coralline algae remain virtually overlooked in Slovenia. Though these plants are present or even abundant in the Cretaceous and Cainozoic strata, they have never been studied in detail with notable exception of corallines from the Lower Oligocene beds in the area of Gornji Grad. Poljšica pri Podnartu is another locality where Lower Oligocene beds are exposed, considered as equivalent to the former. The studied profile consists of pebbly limestone, mudstone, sandstone and limestone. Limestones contain abundant non-geniculate coralline algae. Nine species from six genera of these corallines have been identified: *Lithoporella melobesioides* (Foslie) Foslie, 1909, *Neogoniolithon contii* (Mastrorilli) Quaranta et al., 2007, *Spongites* sp., *Lithothamnion* sp. 1, *Lithothamnion* sp. 2, *Mesophyllum* sp. 1, *Mesophyllum* sp. 2, *Mesophyllum* sp. 3 and *Sporolithon* sp. Some of these species are described from Slovenia for the first time.

Riassunto. Nonostante il loro crescente interesse in sedimentologia e paleoecologia, le alghe corallinacee non genicolate sono virtualmente trascurate in Slovenia. Sebbene questi vegetali siano presenti e talora abbondanti nel Cretaceo e nel Cenozoico, non sono mai stati studiati in dettaglio con l'eccezione delle corallinacee dell'Oligocene inferiore nell' area di Gornji Grad. Poljšica pri Podnartu rappresenta un'altra località dove gli strati dell'Oligocene inferiore affiorano e sono considerati correlabili con i precedenti. Il profilo studiato è costituito da una successione di calcari nodulari, calcari ed arenarie. I calcari contengono abbondanti alghe corallinacee non genicolate. Sono state identificate nove specie per sei generi, in particolare: *Lithoporella melobesioides* (Foslie) Foslie, 1909, *Neogoniolithon contii* (Mastrorilli) Quaranta et al., 2007, *Spongites* sp., *Lithothamnion* sp. 1, *Lithothamnion* sp. 2, *Mesophyllum* sp. 1, *Mesophyllum* sp. 2, *Mesophyllum* sp. 3 and *Sporolithon* sp. Alcune di queste specie sono descritte per la prima volta in Slovenia.

Introduction

Poljšica pri Podnartu (Fig. 1) has a long history of palaeontological research which started at the beginning of the 19th century. These studies focused on the fossil macrofauna and deal with the problem of the datation of the sedimentary succession (Morlot 1850; Lipold 1857; Fuchs 1874; Kinkelin 1890; Oppenheim 1896). Almost fifty years later this locality again attracted the interest of geologists. This still ongoing wave of research has focused mostly on microfossils and resulted in a more complete biostratigraphy (Papp 1959; Pavlovec 1961; Cimerman 1967, 1969; Pavšič 1983, 1985; Bricl & Pavšič 1991). Several extensive studies from the Gornji Grad area (Hemleben 1964; Born 1997; Bruch 1998; Bassi & Nebelsick 2000; Nebelsick et al. 2000; Schmiedl et al. 2002; Nebelsick et al. 2005) resulted in a more thorough understanding of the palaeogeography and palaeoenvironments of this area, which can be applied also for Poljšica. Mikuž (2002) recently investigated the fossil mollusc assemblage.

Oligocene sedimentary succession in the Northern Slovenia has been divided into four main units (Fig. 2) (Hemleben 1964; Bruch 1998; Nebelsick et al. 2000; Schmiedl et al. 2002): limno-fluviatile beds (Basal unit), brackish and normal marine beds ("Gornji Grad beds"), marlstone (Tegel unit) and marlstone mixed with the volcanoclastics (Tuffite unit). These beds were deposited in the Slovenian Paleogene Basin (Rögl 1998; Schmiedl et al. 2002) during long-term eustatic sea-level

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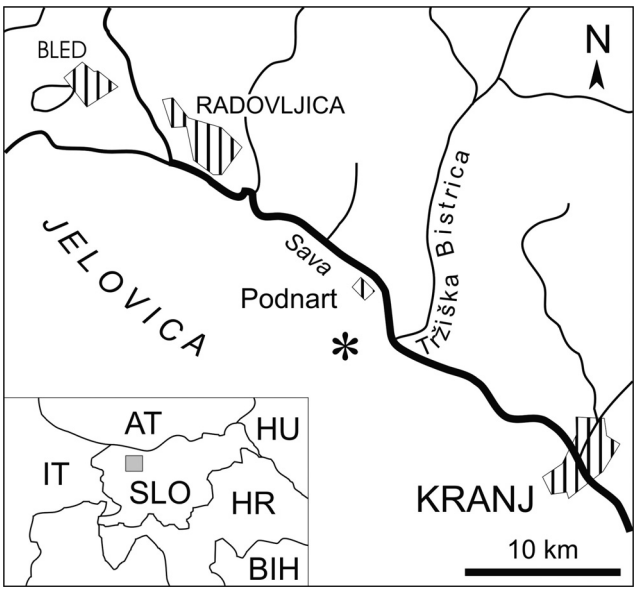


Fig. 1 - Location of Poljšica pri Podnartu (marked with an asterisk), northern Slovenia. GPS coordinates of the studied section are: GKY 442486 (46°16′41″), GKX 126278 (14°14′56″).

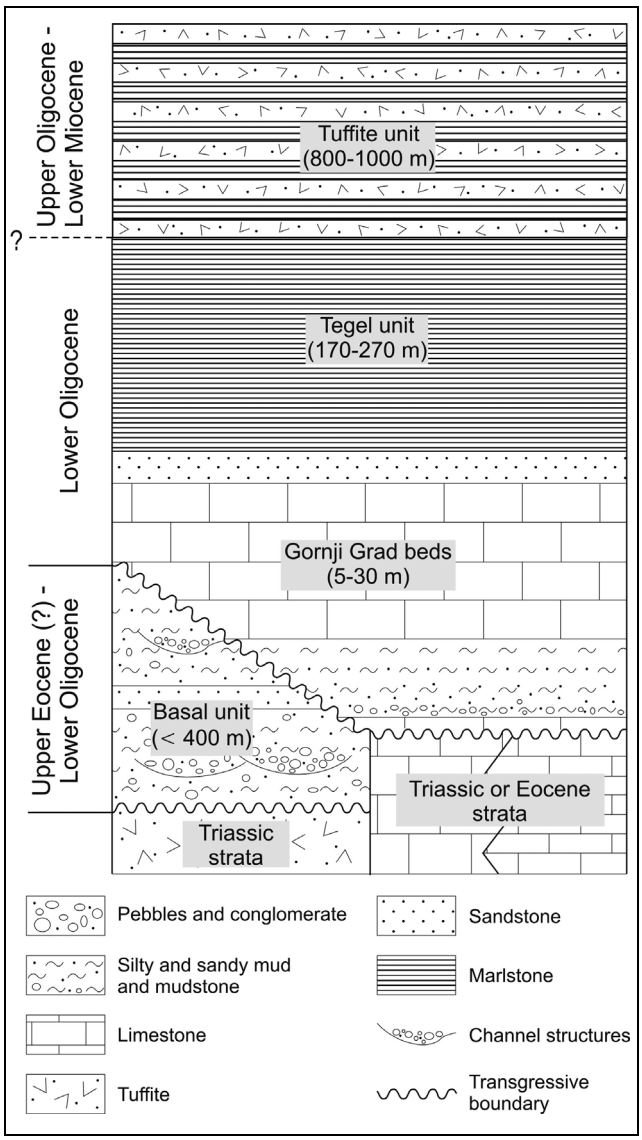


Fig. 2 - Generalized schematic stratigraphic column of the Upper Eocene (?) to Lower Miocene beds in Northern Slovenia. Not to scale.

rise, accompanied by a tectonic subsidence of the basin (Nebelsick et al. 2000; Schmiedl et al. 2002).

The Upper Eocene - Lower Oligocene Basal unit consists of conglomerates, mudstones and sandstones (Hemleben 1964; Cimerman 1967; Bruch 1998; Bassi & Nebelsick 2000; Nebelsick et al. 2000; Schmiedl et al. 2002). Their thickness varies between few to 400 m (Hemleben 1964; Nebelsick et al. 2000). They lie discordantly over Triassic basement (Hemleben 1964) and were deposited in braided river (Born 1997) or deltaic (Schmiedl et al. 2002) environment.

The Gornji Grad beds transgressively overlie the Basal unit, the Eocene or the Triassic units (Hemleben 1964; Nebelsick et al. 2000; Schmiedl et al. 2002). They consist of brackish to shallow water marine marlstones, sandstones and limestones (Hemleben 1964), which belong to the SBZ 21, Lower Oligocene in age (Drobne et al. 1985). This succession is 5-30 m thick (Hemleben 1964; Nebelsick et al. 2000; Schmiedl et al. 2002) and was deposited in a mesotrophic environment of the photic zone on a carbonate-siliciclastic ramp (Nebelsick et al. 2000; Schmiedl et al. 2002). The high amount of terrigenous input probably hindered the growth of a larger and uniform coral ridge (Schmiedl et al. 2002).

Gornji Grad beds are followed by marine marlstone (Tegel unit), which varies between 170 and 270 m in thickness (Hemleben 1964). Transition between these two units can be sharp or gradual (Nebelsick et al. 2000). The Kiscellian and "Middle" Oligocene age of the Tegel unit has been determined on the basis of foraminifera (Cimerman 1967) and nannoplankton (Pavšič 1983, 1985; Bricl & Pavšič 1991) respectively. The deposition of the Tegel unit started earlier in the Western Slovenia (NP 24) than in the East (NP 22/23) (Pavšič 1983, 1985; Bricl & Pavšič 1991).

The succession of the Oligocene beds ends with an 800-1000 m thick unit of mica marlstone and tuffite of the volcanoclastic Tuffite unit, which in age reaches up to the Lower Miocene (Nebelsick et al. 2000).

The Gornji Grad beds are rich in fossils and non-geniculate coralline algae (Corallinales, Rhodophyta) can also be found. Although abundant in some of the localities, only the ones from the Gornji Grad area have been described so far (Bassi & Nebelsick 2000; Bassi et al. 2000).

This paper deals with the coralline algae from the Lower Oligocene "Gornji Grad beds" (informal lithostratigraphic unit) from Poljšica pri Podnartu. Nine spe-

cies from six genera are being described. Five of them (*Lithoporella melobesioides* (Fosile) Foslie, 1909, *Neogoniolithon contii* (Mastrorilli) Quaranta et al., 2007, *Spongites* sp., *Lithothamnion* sp. 1, *Mesophyllum* sp. 1) have already been described from the Gornji Grad area (Bassi & Nebelsick 2000). Reports on two species, which have so far not been known from Slovenia, are given. These are *Lithothamnion* sp. 2 and *Sporolithon* sp. Two species (*Mesophyllum* sp. 2 and *Mesophyllum* sp. 3) could not be ascribed to any known fossil species.

Methods

Stratigraphic succession of the Paleogene beds at Poljšica pri Podnartu has been reconstructed from five incomplete profiles, which could be correlated with the help of several marker horizons (Fig. 3). Apart from the rock samples for sedimentological analysis, around 30 kilograms of rock from the Gornji Grad beds were taken. From these, 142 thin sections 48x28 mm in size were made and analysed for non-geniculate coralline algae using optical microscope Jenapol Amplival pol U (Carl Zeiss). Eighty-one thalli in a proper orientation (Woelkerling 1988; Braga et al. 1993; Quaranta et al. 2007) were more thoroughly measured for species identification. Measurements were made as recommended by Bosence (1983). Taxonomy follows Harvey et al. (2003). Descriptive terminology for corallines follows Woelkerling (1988) and Woelkerling et al. (1993). Textural classification of Dunham (1962) is used for a general description of the limestones. According to Bosence (1983), the number of measurements (n), mean value (M), standard deviation (s.d.) and range for each measurable feature (cell and conceptacle or sporangial compartment dimensions) are given. Mean values and standard deviations were calculated using Microsoft Excell 2000. Photographs were taken with a digital camera Axiocam HRc mounted on an Axioplan 2 microscope. All material and thin sections are stored at the Department for Geology, Faculty of Natural Sciences and Engineering, University of Ljubljana, under the inventory number 6987.

Stratigraphic column

The succession of Paleogene beds at Poljšica pri Podnartu (Fig. 3) starts with the Basal unit, which is here over 200 m thick. Conglomerates discordantly overly Middle Triassic tuff (Grad & Ferjančič 1976; Ramovš 1983).

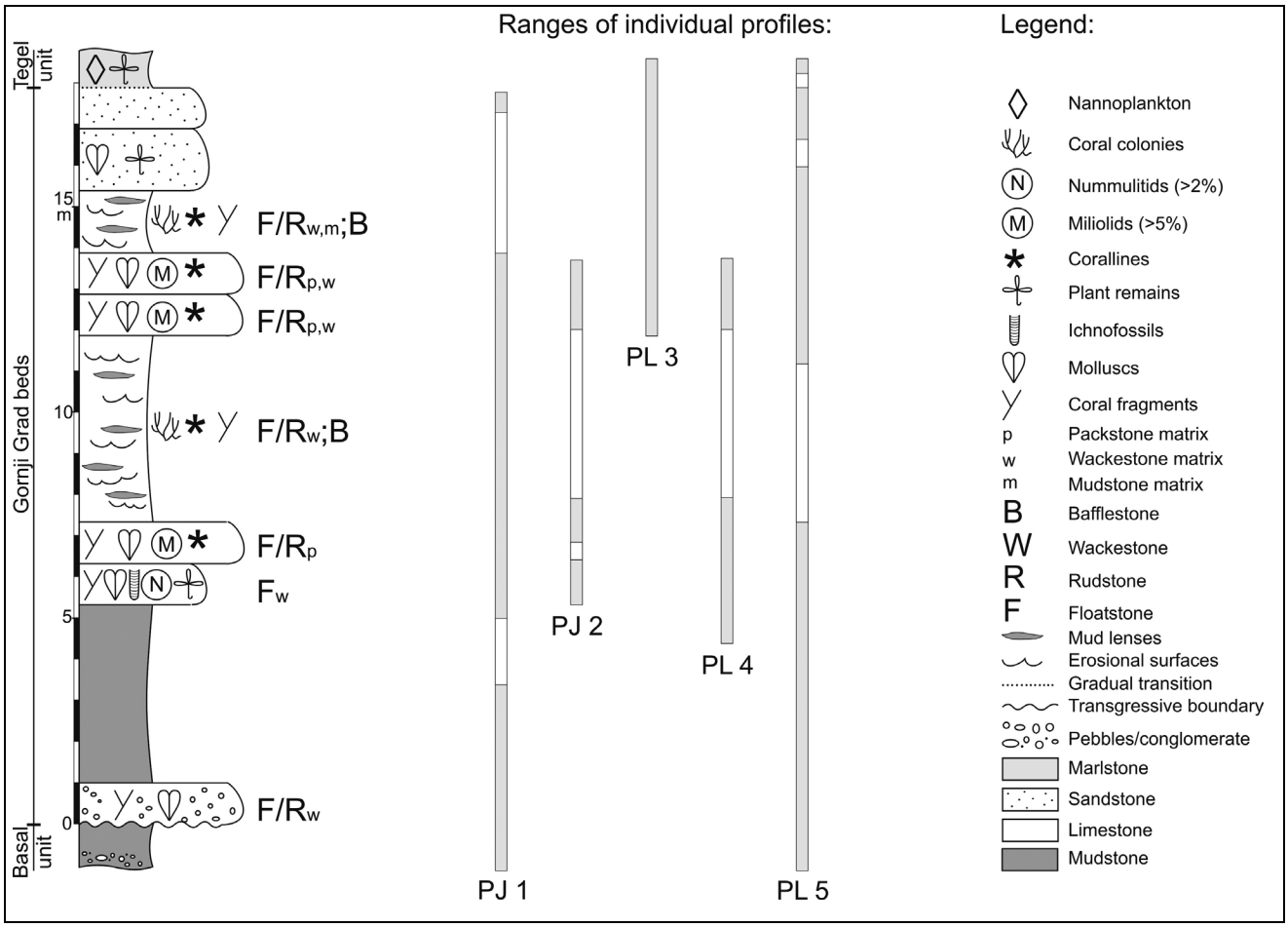


Fig. 3 - Sedimentological succession of the Paleogene beds from Poljšica pri Podnartu. The Upper Eocene - Lower Oligocene (Scherbacher 2000) Basal unit is followed by the Lower Oligocene (Drobne et al. 1985) Gornji Grad beds. Paleogene beds finish with the Tegel unit of the nannoplankton biozone NP 23 (Pavšič 1983, 1985; Bricl & Pavšič 1991). Vertical bars shows parts of the combined section visible in each of the profiles. White parts of the bars represent covered parts of the profiles. The distance between the profiles is (from left to right): 85 m (PJ 1 - PJ 2), 100 m (PJ 2 - PL 3), 20 m (PL 3 - PL 4) and 350 m (PL 4 - PL 5). The profile PL 5 is separated from the others by an apparently dextral strike-slip fault (estimated horizontal offset 120 m).

	Cells of primigenous layer				Cells of postigenous layer				Tetra/bisporangial conceptacles			
	Height (μm)		Length (μm)		Diameter (μm)		Length (μm)		Diameter (μm)		Height (μm)	
	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)
Lithoporella melobesioides	12-84	41±13.7 (110)	10-48	24±8.0; (110)	14-24	18±2.6 (13)	24-56	35.5±9.7 (13)	228-342	290±44.0 (5)	152-228	182.5±32.0 (5)

Tab. 1 - Cell and conceptacle dimensions for studied specimes of *Lithoporella melobesioides* (Foslie) Foslie, 1909.

A partly recrystalized floatstone/rudstone with well rounded pebbles and abundant remains of the coral *Stylophora* cf. *conferta* (Barta-Calmus 1973, pp. 98, pl. 1, fig. 4, 9) marks the transgression of the Gornji Grad beds over the Basal unit. The succession continues with sandy mud and mudstone with normal grading. These are followed by marly limestone and limestones with floatstone and rudstone structure, and packstone, wackestone and mudstone matrix. Bafflestone is also present. These beds are rich in fossils, especially in corals and non-geniculate coralline algae. The later are present as encrusters of hard particles, free growing, up to four square centimetres large planar crusts or up to two centimetres large branching forms, or fragments. These fragments represent a maërl deposit. In the upper part of the succession siliciclastics become dominant and the whole succession ends with sandstone, which gradually passes through several meters thick laminite horizon into the marlstone of the Tegel unit.

Systematic palaeontology

Division **Rhodophyta** Wettstein, 1901

Class **Rhodophyceae** Rabenhorst, 1863

Order **Corallinales** Silva & Johansen, 1986

Family Corallinaceae Lamouroux, 1812

Subfamily Mastophoroideae Setchell, 1943

Genus *Lithoporella* (Foslie) Foslie, 1909

Lithoporella melobesioides (Foslie) Foslie, 1909

Pl. 1, figs 1, 2; Tab. 1

1983 *Lithoporella melobesioides* - Bosence, p. 165-166, pl. 18, fig. 2.

1988 *Lithoporella melobesioides* - Studencki, p. 47, pl. 16, fig. 2.

1988 *Lithoporella melobesioides* - Woelkerling, fig. 111-116.

1995 *Lithoporella melobesioides* - Bassi, p. 91, pl. 1, fig. 8.

1999 *Lithoporella melobesioides* - Rasser & Piller, p. 73, pl. 1, fig. 1.

2000 *Lithoporella melobesioides* - Bassi & Nebelsick, p. 104, pl. 2, fig. 1.

2000 *Lithoporella melobesioides* - Nebelsick et al., pl. 32, fig. 3.

2004 *Lithoporella melobesioides* - Payri & Cabioch, p. 204, pl. 2, fig. 4.

2006 *Lithoporella melobesioides* - Sarma & Ghosh, p. 1279, fig. 3g.

Horizon and locality: Gornji Grad beds, Lower Oligocene (Kiscellian), Poljšica pri Podnartu (Kranj, Upper Carniola, Slovenia).

Material: Thin sections A1-1, A1-3, A1-8, A6-5, A9-2, A9-4, A9-5, A9-7, A9-13 and C11-6.

Morphology. Plants are encrusting to foliose in form.

Vegetative anatomy. Dimerous plants with primigenous filaments constituted by palisade cells, measuring 12-84 μm in height (M=41 μm; n=110; s.d.=13.7) and 10-48 μm in length (M=24 μm; n=110; s.d.=8.0). Postigenous filaments are rare, preserved only around conceptacles, with cells 14-24 μm in diameter (M=18 μm; n=13; s.d.=2.6) and 24-56 μm long (M=35.5 μm; n=13; s.d.=9.7). Cell fusion is abundant.

Reproductive structures. Rare tetra/bisporangial uniporate conceptacles (presumably asexual) are completely raised above the thallus surface. They measure 228-342 μm in diameter (M=290 μm; n=5; s.d.=44.0) and 152-228 μm in height (M=182.5 μm; n=5; s.d.=32.0). Conceptacle roof is 30-53 μm thick. No columella is present. Cells in the conceptacle roof measure 16-36 μm in length (M=24.5 μm; n=5; s.d.=7.2) and 8-19 μm in diameter (M=13.5 μm; n=5; s.d.=4.2).

Remarks. Uniporate tetra/bisporangial conceptacles, cell fusions and lack of trichocytes ascribe these plants to the genus *Lithoporella* (Woelkerling 1988; Braga et al. 1993). *Lithoporella melobesioides* is a well-known fossil and Recent species (Woelkerling 1988), possibly found already in the Lower Jurassic (Aguirre et al. 2000). It is also known from the Upper Eocene of the Northern Italy (Bassi 1995, 1998), from the Upper Eocene of Austria (Rasser & Piller 1999), from the Lower Oligocene of Slovenia (Bassi & Nebelsick 2000) and from the Oligocene of the Southern Germany (Rasser & Nebelsick 2003).

Genus *Neogoniolithon* Setchell & Mason, 1943

Neogoniolithon contii (Mastrorilli) Quaranta et al., 2007

Pl. 1, figs 3, 4; Tab. 2

1987 *Lithophyllum contii* Mastrorilli sensu amplo - Fravega & Vannucci, p. 226-230, pl. 25, fig. 1-4

1995 *Mesophyllum* sp. 2 - Bassi, p. 90, pl. 1, fig. 5, 6; text-fig. 8 B.

1999 *Neogoniolithon* sp. - Rasser & Piller, p. 73, pl. 1, fig. 2-4.

2000 *Neogoniolithon* sp. 1 - Bassi & Nebelsick, p. 104-108, pl. 2, fig. 2-8.

	Cells of core region				Cells of peripheral region				Tetra/bisporangial conceptacles			
	Length (μm)		Diameter (μm)		Length (μm)		Diameter (μm)		Diameter (μm)		Height (μm)	
	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)
Neogoniolithon contii	16-32	225±4.6 (27)	6-16	11±2.7	14-32	19±4.4 (20)	2-12	8.5±2.2 (20)	205-425	306±78.9 (7)	91-190	121.5±34.5 (7)

Tab. 2 - Cell and conceptacle dimensions for studied specimens of *Neogoniolithon contii* (Mastrorilli) Quaranta et al., 2007.

2007 *Neogoniolithon contii* (Mastrorilli) comb. nov. - Quaranta et al., p. 44-48, pl. 1, 2; tab. 1, 2.

Horizon and locality: Gornji Grad beds, Lower Oligocene (Kiscellian), Poljšica pri Podnartu (Kranj, Upper Carniola, Slovenia).
Material: Thin sections A9-3, A9-9B, A22-2A.

Morphology. Plants are encrusting to foliose. Thalli are up to 450 μm thick.

Vegetative anatomy. Dorsiventrally organized monomerous thallus with a coaxial core. Core filaments consist of 16-32 μm long (M=22.5 μm; n=27; s.d.=4.6) and 6-16 μm wide (M=11 μm; n=27; s.d.=2.7) cells, some of which are laterally connected by cell fusion. Cells of the peripheral filaments are 14-32 μm long (M=19 μm; n=20; s.d.=4.4) and measure 2-12 μm in diameter (M=8.5 μm; n=20; s.d.=2.2). Some cells of the contiguous filaments are connected by cell fusion. Seasonal growth is weakly expressed, with 4-6 cells in a band, measuring 45.5-61 μm in thickness. Trichocytes are absent. Epithallial cells are not preserved.

Reproductive structures. Presumably asexual tetra/bisporangial conceptacles are relatively rare, uniporate and sub-triangular in shape, raised above the thallus surface. Columella is absent. Conceptacle chambers are 205-425 μm in diameter (M=306 μm; n=7; s.d.=78.9) and 91-190 μm high (M=121.5 μm; n=7; s.d.=34.5). Roof thickness is 34 μm, pores are 129 μm long and 15 μm wide, lined with filaments subparallel to the thallus surface. Cells in the conceptacle roof measure 6-10 μm in length (M=8 μm; n=10; s.d.=1.8) and 4-6 μm in diameter (M=5 μm; n=10; s.d.=1.0).

Remarks. Uniporate tetra/bisporangial conceptacles, presence of cell fusions, absence of trichocytes, pore canal lined with filaments subparallel to the conceptacle roof, and coaxial core circumscribe the genus *Neogoniolithon* (Woelkerling 1988; Braga et al. 1993).

Our specimens have shorter cells of the core filaments, smaller conceptacle chambers, shorter pores and smaller cells in the conceptacle roof than *Neogoniolithon* sp. (Rasser & Piller 1999) from the Upper Eocene of Austria. Cells of the peripheral filaments are narrower and conceptacles smaller than in the Lower Oligocene *Neogoniolithon* sp. 1 from Slovenia (Bassi & Nebelsick 2000). Conceptacles are smaller than in *Neogoniolithon* sp. 1 and *Neogoniolithon* sp. 2 (Bassi 1998) from the Upper Eocene of the Northern Italy. Pores are shorter and narrower compared to *N.* sp. 2 (Bassi 1998). *Neogoniolithon contii* (Quaranta et al. 2007) from the Oligocene of north-western Italy has shorter cells of the peripheral filaments and narrower conceptacle chambers. However, according to Bassi and Nebelsick (2000), their *N.* sp. 1 is conspecific with *Mesophyllum* sp. 2 (Bassi 1995) and *N.* sp. 2 (Bassi 1998). Moreover, *M.* sp. 2 is probably conspecific with *Mesophyllum* cf. *rigidum* and *Lithophyllum giammarini* (=*Lithophyllum contii*) (Bassi 1995). Bassi and Nebelsick (2000) also pointed out a similarity of *N.* sp. 1 with *Lithophyllum pactum* and *N.* sp. (Rasser & Piller 1999). *L. contii* has been re-assessed by Quaranta et al. (2007) as *Neogoniolithon contii*. They also proved that *L. giammarinoi*, *Lithophyllum embergeri*, *Mesophyllum flexile* and *M. rigidum* are in fact younger heterotypic synonyms of *L. contii*. Although specimens of this genus from Poljšica pri Podnartu somewhat differ from *N. contii* (Quaranta et al. 2007), the measured parameters fall well inside the variability zone defined by other just mentioned examples of this species. Specimens from Poljšica pri Podnartu thus also belong to the species *Neogoniolithon contii* (Mastrorilli) Quaranta et al., 2007.

Genus *Spongites* Kützing, 1841

Spongites sp.

Pl. 1, fig. 5; Tab. 3

1999 *Spongites* sp. 2 - Rasser & Piller, p. 74, pl. 1, fig. 7, 8.
2000 *Spongites* sp. 2 - Bassi & Nebelsick, p. 108-110, text-fig. 5-8.

Horizon and locality: Gornji Grad beds, Lower Oligocene (Kiscellian), Poljšica pri Podnartu (Kranj, Upper Carniola, Slovenia).
Material: Thin sections A1-1, A6-1, A9-8 and A22-5.

Morphology. Thalli are encrusting, layered, warty or fruticose in shape, up to 2 mm large. Protuberances are up to 600 μm long.

Vegetative anatomy. Monomerous, dorsiventrally organized thallus with non-coaxial, 45-55 μm thick core. Cell filaments in protuberances are radially arranged.

Cells in the core region are 11-17.5 μm long (M=14 μm; n=10; s.d.=2.2) and 5-12.5 μm in diameter (M=6.5 μm; n=10; s.d.=2.7). Few cells are connected by cell fusion. Peripheral part of the plant is 2-3 times thicker than the core, with cells 7.5-24 μm long

(M=14 μm; n=14; s.d.=5.9) and 6-12 μm in diameter (M=9 μm; n=14; s.d.=1.7). Cell fusion is present. Growth bands are 96-140 μm thick (5-11 cells). Possible poorly preserved epithallial cells are flattened, 6-8 μm long (M=7 μm; n=3; s.d.=1.2) and 10-26 μm in diameter (M=16 μm; n=3; s.d.=8.7). Trichocytes are absent.

Reproductive structures. Presumably asexual tetra/bisporangial conceptacles are uniporate. Columella is sometimes present. Sporangial chambers measure 384-705 μm in diameter (M=503.5 μm; n=5; s.d.=139.2) and are 175-304 μm high (M=244 μm; n=5; s.d.=50.9). They are raised above the thallus surface or up to 15 μm (5 cells) embedded in the thallus. Roof thickness is 56-106 μm. Conceptacle roof cells measure 10-20 μm in length (M=14.5 μm; n=9; s.d.=3.6) and 4-12 μm in diameter (M=7 μm; n=9; s.d.=2.5).

Remarks. Uniporate tetra/bisporangial conceptacles, cell fusions, thallus composed of numerous layers of cells, absence of trichocytes and non-coaxial core define the studied plants as *Spongites* (Woelkerling 1988; Braga et al. 1993). Woelkerling (1988) considered *Hydrolithon* as a heterotypic synonym of *Spongites*. Penrose and Woelkerling (1992) proved that they could be distinguished on the basis of filament arrangement around conceptacle pores. Lack of pore observations thus allows a possibility that here described thalli belong to the genus *Hydrolithon*.

Spongites sp. is, according to the measured parameters, con-specific with *Spongites* sp. 2 from the Upper Eocene of Austria (Rasser & Piller 1999) and *Spongites* sp. 2 from the Lower Oligocene of Slovenia (Bassi & Nebelsick 2000). According to Bassi and Nebelsick (2000), this species is similar to the still unrevised *Lithophyllum ligusticum* Airoldi (1932) from the Oligocene of the Piedmont Basin and *Lithophyllum pactum* Ishijma.

Family Hapalidiaceae Harvey et al., 2003

Subfamily Melobesioideae Bizzozero, 1885

Genus *Lithothamnion* Heydrich, 1897 nom. cons.

Lithothamnion sp. 1

Pl. 1, figs 6, 7; Tab. 4

? 1988 "*Lithothamnium*" *saxorum* - Studencki, p. 29, pl. 8, fig. 5-6; pl. 13, fig. 7.

? 2003 *Lithothamnion* sp. A - Rasser & Nebelsick, p. 95-97; text-fig. 3 A, B.

Horizon and locality: Gornji Grad beds, Lower Oligocene (Kiscellian), Poljšica pri Podnartu (Kranj, Upper Carniola, Slovenia).

Material: Thin sections A9-8, A9-12 and A9-14.

Morphology. Thalli are lumpy and fruticose. Protuberances are up to 6.6 mm high.

Vegetative anatomy. Thalli are monomerous, with non-coaxial core. Core filaments curve outwards on the dorsal side only. Core is 68-80 μm thick. Filaments in protuberances are radially organized and monomerous. Cells of the core filaments are 16-28 μm long (M=23.0 μm; n=18; s.d.=4.8) and 6-8 μm in diameter (M=8.0 μm; n=18; s.d.=0.6). Some are connected by cell fusion. Cells of the peripheral filaments measure 6-16 μm in length (M=10.5 μm; n=11; s.d.=3.3) and 6-10 μm in diameter (M=9.0 μm; n=11; s.d.=1.3). They are connected by cell fusion. 56-168 μm (5-10 cells) thick bands are evident. Trichocytes are absent. Epithallium is single layered, with rarely preserved rectangular and flattened cells. They are 1-4 μm long (M=2 μm; n=4; s.d.=1.4) and 6-12 μm in diameter (M=8.5 μm; n=4; s.d.=2.5).

Reproductive structures. Multiporate tetra/bisporangial conceptacle chambers are elliptical, 197.5-463.5 μm in diameter (M=359.5 μm; n=7; s.d.=95.3) and 106-167 μm high (M=142 μm; n=7; s.d.=25.1). Single conceptacle measures 900 μm in diameter and 285 μm in height. Conceptacle floor is up to 60 μm below the thallus surface. Conceptacle roof is 32-60 μm thick (M=41.5 μm; n=6; s.d.=10.2). Its cells are square, 6-12 μm long (M=9.5 μm; n=10; s.d.=1.8) and 6-8 μm in diameter (M=7 μm; n=9; s.d.=1.0). Pore canals are cylindrical, 36-60 μm long (M=49 μm; n=6; s.d.=7.9) and 10-12 μm in diameter (M=11.5 μm; n=6; s.d.=0.8).

Remarks. Multiporate tetra/bisporangial conceptacles, cell fusions, monomerous thallus composed of numerous layers of cells, non-coaxial core and monostromatic epithallium are characteristic for the genus *Lithothamnion* (Woelkerling 1988; Braga et al. 1993).

Although well preserved flat epithallial cells were observed, they are rather rare and no flared examples were found. According to Braga et al. (1993) monostromatic epithallium alone should be sufficient to distinguish genus *Lithothamnion* from similar genera *Clathromorphum* and *Phymatolithon*, but some authors consider flared epithallial cells to be the crucial factor (i.e. Rasser & Piller 1999; Bassi & Nebelsick 2000). Further studies on shape of epithallial cells are thus needed.

Few sufficient comparisons could be made from the more recent literature and no definite conclusions could be made about *L.* sp. 1, although "*L.*" *saxorum* (Studencki, 1988) shows the maximum similarity on the basis of cell dimensions. Unfortunately, only ranges for "hypothallic", "perithallic" cells and conceptacles are given. *Lithothamnion* sp. 1 can be further compared to *Lithothamnion* sp. A, described by Rasser and Nebelsick (2003), which has slightly shorter cells of the core region.

"*L.*" *saxorum* (Studencki, 1988) is also known from the Oligocene of Italy and from the Miocene of

Poland, Ukraine, Israel and Egypt (Studencki 1988). *Lithothamnion* sp. A (Rasser & Nebelsick 2003) is known from the Oligocene of Tyrol.

Lithothamnion sp. 2

Pl. 1, fig. 8; Tab. 4

1995 *Lithothamnion* sp. 1 - Bassi, p. 87-88, pl. 1, fig. 1, 2.

Horizon and locality: Gornji Grad beds, Lower Oligocene (Kiscellian), Poljšica pri Podnartu (Kranj, Upper Carniola, Slovenia).

Material: Thin sections A1-5 and A6-5.

Morphology. Only two fruticose thalli.

Vegetative anatomy. Filament organization in the planar part of the plant is monomerous. Core is non-coaxial and 40 µm thick. Organization in protuberances is radial and monomerous, with broad central core (206 µm in diameter).

Cells of the core filaments are 24-32 µm long (M=28 µm; n=4; s.d.=3.3) and 10-20 µm in diameter (M=13 µm; n=16; s.d.=2.8). Cell fusion is present. Cells of the peripheral filaments are 6-24 µm long (M=13.5 µm; n=22; s.d.=5.4) and 8-16 µm in diameter (M=10 µm; n=22; s.d.=2.2). They are connected by cell fusion. Bands 84-228 µm (4-9 cells) wide are clearly visible. Trichocytes are absent. Epithallial cells are flattened and flared. They measure 4-14 µm in length (M=6 µm; n=6; s.d.=4.1) and 2-12 µm in diameter (M=5.5 µm; n=6; s.d.=3.8).

Reproductive structures. Multiporate tetra/bisporangial conceptacles are 304-509 µm in diameter (M=392 µm; n=11; s.d.=55.9) and 114-228 µm high (M=164.5 µm; n=11; s.d.=30.3). They are raised above the thallus surface. Roof is 30.5-53 µm thick, with cells 4-8 µm long (M=6 µm; n=11; s.d.=1.7) and 6-10 µm in diameter (M=7.5 µm; n=11; s.d.=1.3). Conceptacle pores are 32-40 µm long (M=36 µm; n=2; s.d.=5.7) and 12 µm in diameter.

Remarks. Multiporate tetra/bisporangial conceptacles, cell fusions, thick monomerous thallus with non-coaxial core and flared epithallial cells are diagnostic for the genus *Lithothamnion* (Woelkerling 1988; Braga et al. 1993).

Large cells and conceptacle size are comparable with *Lithothamnion* sp. 1 (Bassi 1995) from the Upper Eocene of Northern Italy. Unfortunately, cell dimensions of the peripheral filaments are not known and the comparison is thus limited. *L.* sp. 1 (Bassi 1995) could be con-specific with *Lithothamnion aesitante* Conti, 1949 (Bassi 1995). Compared to *Lithothamnion* sp. 1, *L.* sp. 2 has bigger cells of the core and peripheral region, longer and narrower epithallial cells, slightly bigger tetra/bisporangial conceptacle chambers and shorter conceptacle pores and conceptacle roof cells (Tab. 4).

	Cells of core region				Cells of peripheral region				Tetra/bisporangial conceptacles				Epithallial cells			
	Length (µm)		Diameter (µm)		Length (µm)		Diameter (µm)		Diameter (µm)		Height (µm)		Length (µm)		Diameter (µm)	
	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)
Spongites sp.	11-17.5	14±2.2 (10)	5-12.5	6.5±2.7 (10)	7.5-24	14±5.9 (14)	6-12	9±1.7 (14)	384-705	503.5±139.2 (5)	175-304	244±50.9 (5)	6-8	7±1.2 (3)	10-26	16±8.7 (3)

Tab. 3 - Cell, conceptacle and epithallial cell dimensions for *Spongites* sp.

	Cells of core region				Cells of peripheral region				Tetra/bisporangial conceptacles				Epithallial cells			
	Length (µm)		Diameter (µm)		Length (µm)		Diameter (µm)		Diameter (µm)		Height (µm)		Length (µm)		Diameter (µm)	
	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)
Lithothamnion sp. 1	16-28	23±4.8 (18)	6-8	8.0±0.6 (18)	6-16	10.5±3.3 (11)	6-10	9±1.3 (11)	197.5-463.5	359.5±95.3 (7)	106-167	142±25.1 (7)	1-4	2±1.4 (4)	6-12	8.5±2.5 (4)
Lithothamnion sp. 2	24-32	28±3.3 (4)	10-20	13±2.8 (16)	6-24	13.5±5.4 (22)	8-16	10±2.2 (22)	304-509	392±55.9 (11)	114-228	164.5±30.3 (11)	4-14	6±4.1 (6)	2-12	5.5±3.8 (6)

Tab. 4 - Cell, conceptacle and epithallial cell dimensions for genus *Lithothamnion*.

Genus *Mesophyllum* Lemoine, 1928

Mesophyllum sp. 1

Pl. 2, fig. 1; Tab. 5

? 1988 *Lithophyllum simplex* - Studencki, p. 43-44, pl. 13, fig. 5.

1995 *Mesophyllum* sp. 1 - Bassi, p. 88-90, pl. 1, fig. 4; text-fig. 8a.

1998 *Mesophyllum* sp. 1 - Bassi, p. 15-16, pl. 3, fig. 1-3.

2000 *Mesophyllum* sp. 1 - Bassi & Nebelsick, p. 112-114, pl. 5, fig. 1-3.

Horizon and locality: Gornji Grad beds, Lower Oligocene (Kiscellian), Poljšica pri Podnartu (Kranj, Upper Carniola, Slovenia).

Material: Thin section A6-5.

Morphology. Thalli are foliose, 450 µm thick.

Vegetative anatomy. Thallus is dorsiventrally organized and monomerous, with coaxial core 165 µm thick. Cells of the core filaments measure 24-32 µm in length (M=26 µm; n=5; s.d.=3.5) and 10-14 µm in diameter (M=11.5 µm; n=5; s.d.=1.7). Some cells are connected by cell fusion. Peripheral part of the plant is thin. Cells are 12-18 µm long (M=15 µm; n=4; s.d.=2.6) and 10-12 µm in diameter (M=10.5 µm; n=4; s.d.=1.0). Cell fusions are present. Thin banding can be found, with bands 45.5 µm (4 cells) thick. Trichocytes are absent. Epithallial cells are not preserved.

Reproductive structures. One multiporate conceptacle was found. It is elliptical and measures 418 µm in diameter, and 152 µm in height. Conceptacle roof is 38 µm thick, with cells 8 µm long (n=1) and 6 µm in diameter (n=1). Conceptacle is completely raised above the thallus surface. Only one clearly visible pore measures 28 µm in length and 16 µm in width.

Remarks. Multiporate tetra/bisporangial conceptacles, cell fusions, monomerous thallus and coaxial core assign above described thalli to genus *Mesophyllum* (Woelkerling 1988; Braga et al. 1993).

Cell dimensions are approximately the same as for the species *Mesophyllum* sp. 1 (Bassi 1995) and *Mesophyllum* sp. 1 (Bassi 1998) from the Eocene of Italy. Bassi (1995) further compared his *M*. sp. 1 to the unrevised species *Lithophyllum simplex* Francavilla et al. 1970 and *Lithophyllum simetricum* Francavilla et al. 1970 from the Eocene of Italy, which should be transferred to the genus *Mesophyllum* (Bassi 1995). *L. simplex* (Studencki 1988) from the Eocene and Oligocene of Italy, the Oligocene of Algeria and from the Miocene of France and Poland could also belong to the genus *Mesophyllum*, as well as to the genus *Neogoniolithon*, as the reproductive structures are absent. *M*. sp. 1 (Bassi 1995), *M*. sp. 1 (Bassi 1998) and *M*. sp. 1 (this paper) are conspecific with *M*. sp. 1 (Bassi & Nebelsick 2000) from the Lower Oligocene of Slovenia.

Mesophyllum sp. 2

Pl. 2, fig. 2; Tab. 5

Horizon and locality: Gornji Grad beds, Lower Oligocene (Kiscellian), Poljšica pri Podnartu (Kranj, Upper Carniola, Slovenia).

Material: Thin sections A1-3, A1-7, A6-4, A9-9B and A33-3.

Morphology. Thalli are encrusting, layered, foliose, warty or fruticose.

Vegetative anatomy. Thallus is monomerous. Coaxial core is 76-120 µm thick. Peripheral filaments are mostly developed on the dorsal side of the thallus, rarely also ventrally. Cells of the core filaments measure 10-22 µm in length (M=16 µm; n=37; s.d.=2.6) and 6-12

PLATE 1

Fig. 1 - *Lithoporella melobesioides* (Foslie) Foslie. Dimerous thalli are layered and foliose (right). Cells of the primigenous filaments are palisade and connected by clearly visible cell fusion (arrowhead). Cells are filled with blocky calcite. Black spots are framboidal pyrite. Thin section A9-4; scale bar 200 µm.

Fig. 2 - *Lithoporella melobesioides* (Foslie) Foslie. Several layered and foliose dimerous thalli. Uniporate conceptacle is in tangential section and filled with blocky calcite. Postigenous filaments are developed only around conceptacle. Thin section A1-5; scale bar 150 µm.

Fig. 3 - *Neogoniolithon contii* (Mastrorilli) Quaranta et al. (2007). Coaxial core is followed by a layered peripheral part, which also bears some uniporate conceptacles. No columella is visible. Thin section A9-8; scale bar 200 µm.

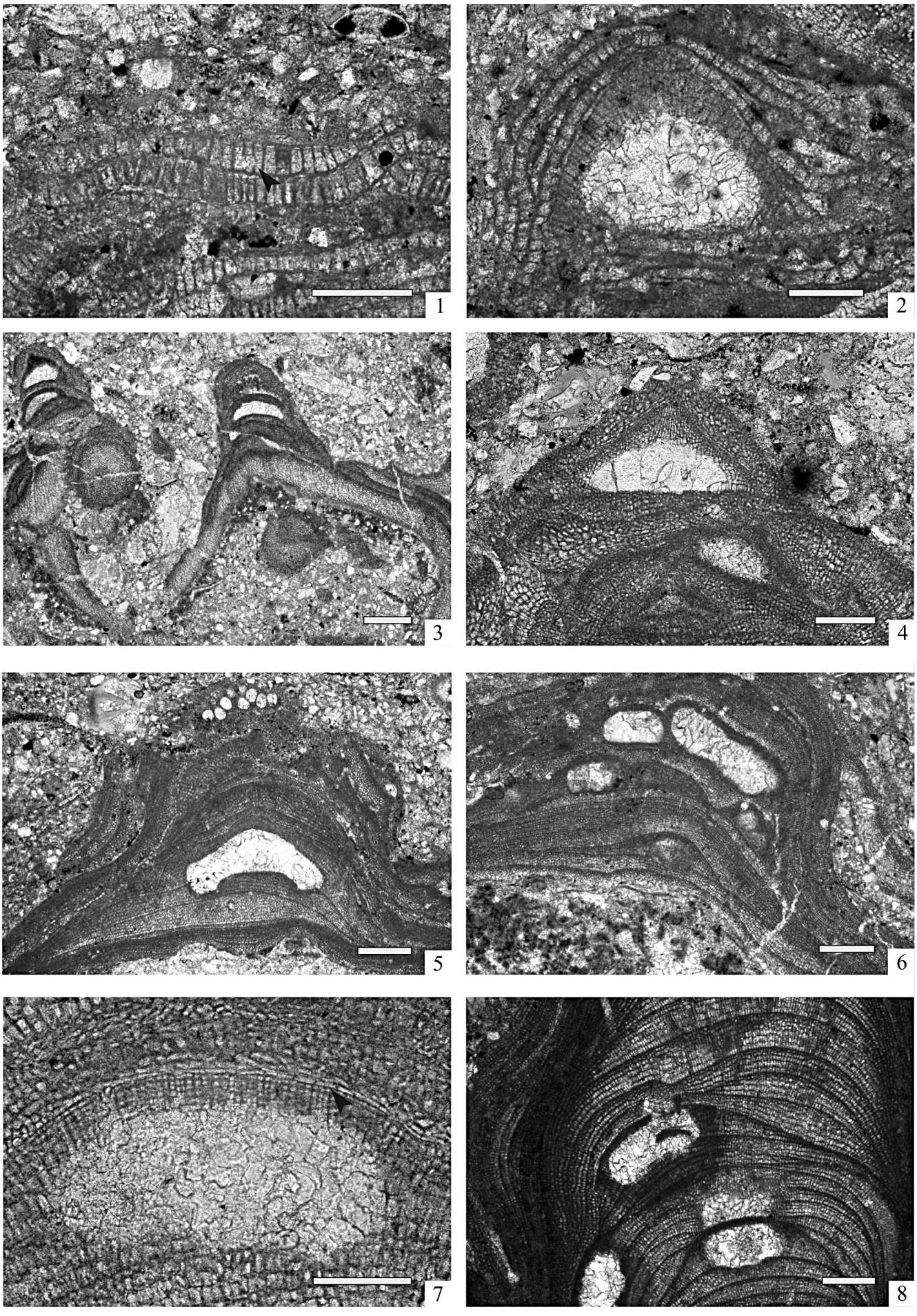
Fig. 4 - *Neogoniolithon contii* (Mastrorilli) Quaranta et al. (2007). Several thalli are layered to foliose. Section is not oriented, but coaxial core can be recognized on the left. Conceptacle is uniporate, without columella and roof thickened around the pore (itself not transacted). Thin section A9-3; scale bar 200 µm.

Fig. 5 - *Spongites* sp. Thin non-coaxial (plumose) core is followed by thicker periphery, where conceptacle with columella is developed. *Spongites* is overgrown by another non-geniculate coralline algae - *Sporolithon*, with characteristic plumose core and sporangial compartments in sori. Thin section A1-1; scale bar 300 µm.

Fig. 6 - *Lithothamnion* sp. 1. Thin non-coaxial core is followed by a thick periphery where banding is evident. Small protuberance carries multiporate conceptacles filled with blocky calcite. Space below the thallus is filled with spar and fecal pellets. Thin section A9-8; scale bar 200 µm.

Fig. 7 - *Lithothamnion* sp. 1. Multiporate conceptacle with flattened epithallial cells (arrowhead). The inside of the conceptacle is filled with calcite. Though conceptacle pores are not transacted, they can be visualized through the thinned cell layer. Thin section A9-12; scale bar 100 µm.

Fig. 8 - *Lithothamnion* sp. 2. Part of a branch showing evident banding, with bands up to seven cells thick. Multiporate conceptacles are filled with calcite. The upper one was probably damaged by a boring organism. Thin section A6-3; scale bar 200 µm.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µm in diameter (M=9 µm; n=37; s.d.=1.6). Cells of the peripheral filaments are 4-12 µm long (M=8 µm; n=24; s.d.=2.5) and 4-12 µm in diameter (M=7 µm; n=24; s.d.=2.0). Cell fusion is present. Seasonal growth with bands 23-76 µm (4-8 cells) thick was recognized. Trichocytes are absent.

Reproductive structures. Tetra/bisporangial conceptacles are multiporate, 180-357 µm in diameter (M=243 µm; n=14; s.d.=49.9) and 67-168 µm high (M=119.5 µm; n=14; s.d.=25.4). Single conceptacle is somewhat larger, 471 µm in diameter and 129 µm high. Conceptacle floor is 15-67 µm (3-4 cells) below the thallus surface. Pores are 53 µm long (n=4) and 23-30.5 µm wide (M=24.5 µm; n=4; s.d.=3.8). Conceptacle roof cells are 4-12 µm long (M=7 µm; n=18; s.d.=2.4) and 4-16 µm in diameter (M=7 µm; n=21; s.d.=3.0). Interestingly, very flattened cells were found on the surface of the conceptacles (Pl. 2, fig. 2).

Remarks. Multiporate tetra/bisporangial conceptacles, cell fusions, monomerous thallus and coaxial core ascribe these corallines to the genus *Mesophyllum* (Woelkerling 1988; Braga et al. 1993). No species that would fit stated measurements has been found among the revised species in the studied literature.

Compared to *M*. sp. 1, *M*. sp. 2 has smaller cells of the core and periphery, as well as cells in the conceptacle roof. It has smaller tetra/bisporangial conceptacles and larger pores in the conceptacle roof (Tab. 5).

Mesophyllum sp. 3

Pl. 2, fig. 3; Tab. 5

Horizon and locality: Gornji Grad beds, Lower Oligocene (Kiscellian), Poljšica pri Podnartu (Kranj, Upper Carniola, Slovenia).

Material: Thin sections A1-3, A6-3, A22-5, A22-9, A33-2, C11-1 and C11-11.

Morphology. Thalli are encrusting, layered, foliose, warty or fruticose. Protuberances are 150-1800 µm high.

Vegetative anatomy. Thallus is dorsiventrally organized and monomerous, with coaxial core. Core is 115-152 µm thick. Cells of the core filaments are 18-38 µm long (M=26 µm; n=59; s.d.=4.5) and 8-16 µm in diameter (M=11.5 µm; n=59; s.d.=1.8). Some cells are connected by cell fusion. Cells of the peripheral filaments are 16-26 µm long (M=21 µm; n=27; s.d.=2.7) and 8-24 µm in diameter (M=12 µm; n=27; s.d.=3.0). Cell fusion is present, as well as banded growth 30.5 µm (7 cells) thick.

Reproductive structures. Tetra/bisporangial conceptacles are multiporate and oval in shape. They measure 205-532 µm in diameter (M=305 µm; n=14; s.d.=98.9) and are 100-205 µm high (M=134.5 µm; n=14; s.d.=27.4). Conceptacles are completely raised

	Cells of core region				Cells of peripheral region				Tetra/bisporangial conceptacles				Pores in conceptacle roof			
	Length (µm)		Diameter (µm)		Length (µm)		Diameter (µm)		Diameter (µm)		Height (µm)		Length (µm)		Diameter (µm)	
	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)
Mesophyllum sp. 1	24-32	26±3.5 (5)	10-14	11.5±1.7 (5)	12-18	15±2.6 (4)	10-12	10.5±1.0 (4)	418	418±0.0 (1)	152	152±0.0 (1)	28	28±0.0 (1)	16	16±0.0 (1)
Mesophyllum sp. 2	10-22	16±2.6 (37)	6-12	9±1.6 (37)	4-12	8±2.5 (24)	4-12	7±2.0 (24)	180-357 *471	243±49.9 (14)	67-168 *129	119.5±25.4 (14)	53	53±0.0 (4)	23-30.5	24.5±3.8 (4)
Mesophyllum sp. 3	18-38	26±4.5 (59)	8-16	11.5±1.8 (59)	16-26	21±2.7 (27)	8-24	12±3.0 (27)	205-532	305±98.9 (14)	100-205	134.5±27.4 (14)	20-44	33.5±11.3 (8)	12	12±0.0 (8)

Tab. 5 - Cell, conceptacle and pore dimensions for genus *Mesophyllum*.

	Cells of core region				Cells of peripheral region				Sporangial chambers					
	Length (µm)		Diameter (µm)		Length (µm)		Diameter (µm)		Height (µm)		Diameter (µm)		Height/Diameter	
	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)	range	M±s.d. (n)
Sporolithon sp.	24-52	33±6.4 (24)	8-16	12±2.2 (24)	14-34	24±4.9 (31)	8-16	12±1.7 (31)	92-152	111±14.2 (24)	38-56	50±6.2 (24)	1.9-2.9	2.24±0.28 (24)

Tab. 6 - Cell and sporangial chamber dimensions for *Sporolithon* sp.

above the thallus. Roof is 28-48 μm thick and made of cells 6-10 μm long (M=8.0 μm; n=18; s.d.=1.7) and 4-8 μm in diameter (M=6.5 μm; n=18; s.d.=1.2). Pores are 20-44 μm long (M=33.5 μm; n=8; s.d.=11.3) and 12 μm wide (n=8).

Remarks. Multiporate tetra/bisporangial conceptacles, cell fusions and monomerous thallus with coaxial core point to the genus *Mesophyllum* (Woelkerling 1988; Braga et al. 1993).

Mesophyllum sp. 3 could not be sufficiently compared to any known species. It can be distinguished from *M*. sp. 1 on the basis of bigger cells of the peripheral filaments, slightly smaller conceptacles smaller cells of the conceptacle roof, and longer and narrower pores. It differs from *M*. sp. 2 in having bigger cells of the core and the peripheral filaments, and slightly narrower pores (Tab. 5).

Family Sporolithaceae Verheij, 1993

Genus *Sporolithon* Heydrich, 1897

Sporolithon sp.

Pl. 2, figs 5, 6; Tab. 6

1999 *Sporolithon* sp. 1 - Rasser & Piller, p. 75, pl. 3, fig. 1-6.

Horizon and locality: Gornji Grad beds, Lower Oligocene (Kiscellian), Poljšica pri Podnartu (Kranj, Upper Carniola, Slovenia).

Material: Thin sections A9-2, A9-5, A10-3, A22-8 and B60-1.

Morphology. Thallus is warty to fruticose in form.

Vegetative anatomy. Thallus is in planar parts dorsiventral and monomerous, with thin non-coaxial core (75-152 μm) and thick peripheral region on the dorsal side of the thallus. Core is thicker in protuberances. Filaments here are radially arranged and monomerous.

Core cells are 24-52 μm long (M=33 μm; n=24; s.d.=6.4) and 8-16 μm in diameter (M=12 μm; n=24; s.d.=2.2). Few are linked by cell fusion. Cells of the peripheral filaments are 14-34 μm long (M=24 μm; n=31; s.d.=4.9) and measure 8-16 μm in diameter (M=12 μm; n=31; s.d.=1.7). Some cells of the adjacent filaments are connected by cell fusion. Bands 99-390 μm (5-17 cells) thick can be seen. Trichocytes are absent. Epithallial cells are not preserved.

Reproductive structures. Sporangial compartments measure 38-56 μm in diameter (M=50 μm; n=24; s.d.=6.2) and 92-152 μm in height (M=111 μm; n=24; s.d.=14.2). Average H/D ratio of sporangial compartments is 2.24 (s.d.=0.28), ranging from 1.9 to 2.9. Sporangial compartments are separated by 4-9 paraphyses. These consist of 4 elongated cells, 24-48 μm long (M=37 μm; n=5; s.d.=9.1). Elongated cells at the base of the sporangial compartments are trapezoidal in shape, 12-30.5 μm long (M=20 μm; n=10; s.d.=6.5) and 8-23 μm in diameter (M=23.5 μm; n=10; s.d.=5.8).

Remarks. Calcified filaments between sporangial compartments, which are grouped in sori, monomerous thallus, non-coaxial core and cell fusions are characteristic for genus *Sporolithon* (Woelkerling 1988; Braga et al. 1993; Vannucci et al. 2000).

Sporolithon sp. is conspecific with *Sporolithon* sp. 1 (Rasser & Piller 1999) from the Eocene of Austria. It is comparable with the Lower Oligocen *Sporolithon* sp. 1 (Bassi & Nebelsick 2000) from Slovenia, which has only slightly shorter and wider cells of the core and peripheral region, but has markedly shorter sporangia.

Conclusions

The Lower Oligocene Gornji Grad beds from Poljšica pri Podnartu consist of marly limestone, mudstone, sandstones and various limestones. Non-geniculate coralline algae occur in the limestones. Nine species and six genera of Corallinales were determined. Five of these species are already known from the Gornji Grad area (Bassi & Nebelsick 2000), where similar development is present. These are: *Lithoporella melobesioides* (Foslie) Foslie, 1909, *Neogoniolithon contii* (Mastrorilli, 1967), *Spongites* sp., *Lithothamnion* sp. 1 and *Mesophyllum* sp. 1.

Lithothamnion sp. 2 and *Sporolithon* sp., which are known also from the Eocene and/or Oligocene beds of Italy, Austria or South Germany, are now also known from Slovenia. *Mesophyllum* sp. 2 and *Mesophyllum* sp. 3 could not be compared to any known and recently revised species.

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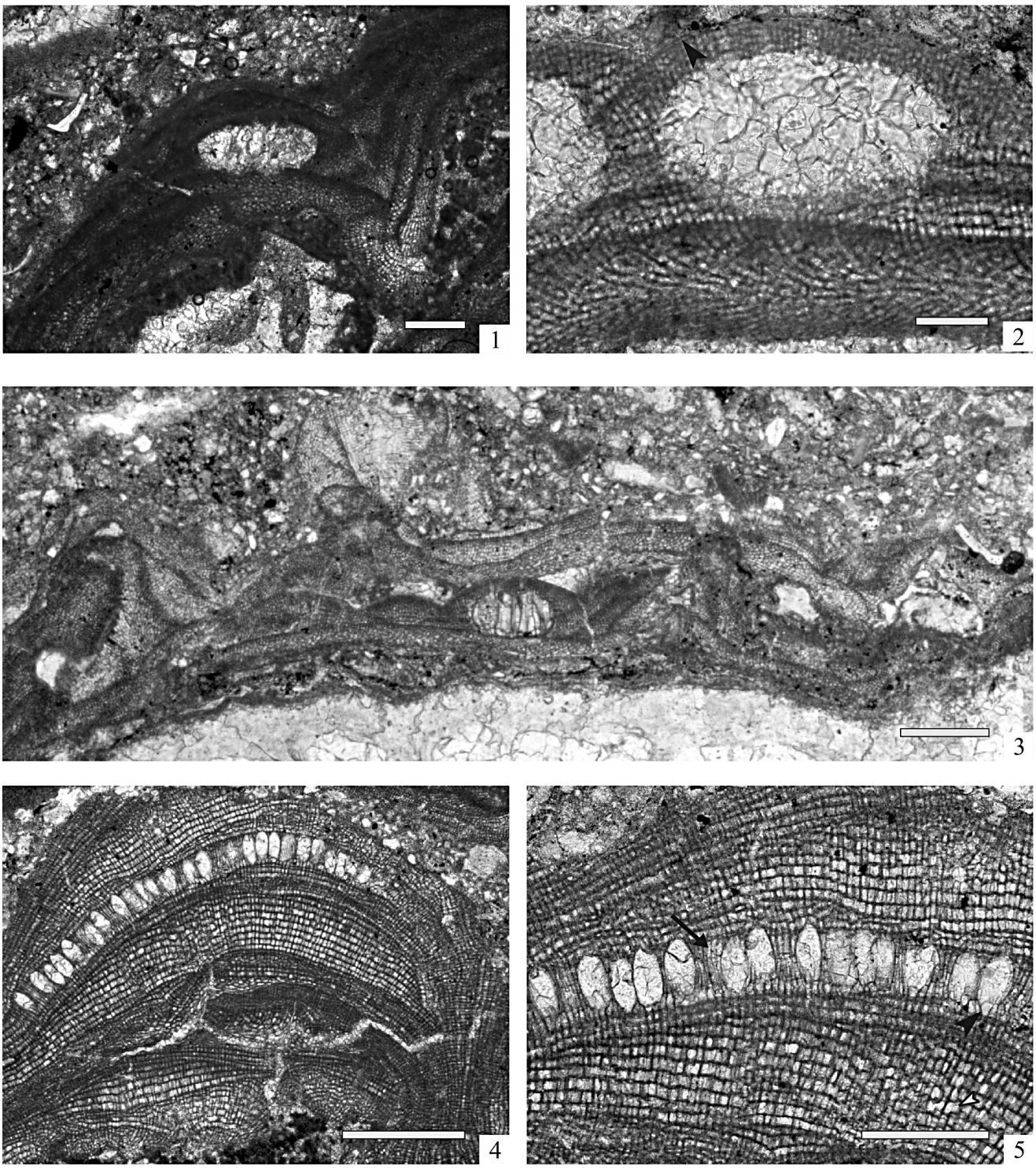

PLATE 2

Fig. 1 - *Mesophyllum* sp. 1 growing on a coral, showing coaxial core and periphery with some banding. Conceptacle is multiporate, filled with calcite. Pellets fill the space below the algae on the right. Thin section A6-5; scale bar 200 μm.

Fig. 2 - *Mesophyllum* sp. 2, showing coaxial core, periphery with some thin bands and multiporate conceptacles. Arrowhead points at the very flattened cells on the thallus surface. Conceptacle chambers are filled with sparry calcite. Thin section A6-4; scale bar 50 μm.

Fig. 3 - *Mesophyllum* sp. 3 growing on a coral. Thalli are layered and foliose. Coaxial core is followed by a relatively thin peripheral part with multiporate conceptacles. Thin section A9-8; scale bar 500 μm.

Fig. 4 - *Sporolithon* sp. Thallus is in longitudinal section, showing non-coaxial core on the ventral side of the thallus (lower part of the picture) and sporangial sorus in protuberance. Individual sporangial compartments are ellipsoidal and filled with calcite. Pellets fill the space below the thallus. Thin section A9-2; scale bar 400 μm.

Fig. 5 - *Sporolithon* sp. Detail from Fig. 4 showing sporangial sorus in longitudinal section. Elongated trapezoidal cells are situated at the base of the sporangial compartments (arrowhead). 1-7 paraphyses (arrow) with up to four elongated cells separate sporangial compartments. Cell fusion is very common in the periphery (small arrowhead). Thin section A9-2; scale bar 200 μm.

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