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Upper Triassic Biostratigraphy and Algae from Žumberak (Croatia)

Tonći GRGASOVIĆ

Key words: Biostratigraphy, Foraminifera, Dasycladales, Upper Triassic, Croatia.

Ključne riječi: biostratigrafija, foraminifere, Dasycladales, gornji trijas, Hrvatska.

Abstract

In the Upper Triassic dolomite deposits of the Žumberak region (west of Zagreb, Croatia) the following local biostratigraphic zones are distinguished: *Clypeina besici* Taxon-range zone (Carnian), *Aulotortus sinuosus* Interval-zone (Norian), and *Triasina hantkeni* Taxon-range zone (Rhaetian). Dasycladal algae *Clypeina besici* PANTIĆ, *Griphoporella curvata* (GÜMBEL), *Physoporella jomdaensis* FLÜGEL & MU and *Aciculella* sp. are accurately described.

Sažetak

U području Žumberka (zapadno od Zagreba, Hrvatska) u dolomitnim naslagama gonjeg trijasa izdvojene su sljedeće lokalne biostratigrafske zone: rasponska zona *Clypeina besici* (karnik), interval-zona *Aulotortus sinuosus* (norik) i rasponska zona *Triasina hantkeni* (ret). Detaljnije su opisane dazikladalne alge *Clypeina besici* PANTIĆ, *Griphoporella curvata* (GÜMBEL), *Physoporella jomdaensis* FLÜGEL & MU i *Aciculella* sp.

1. INTRODUCTION

The Žumberak mountains lie to the west of Zagreb, in the border area with the Republic of Slovenia (Fig. 1). They are predominantly composed of Triassic dolomites, but Permian to Quaternary deposits also occur.

Owing to its proximity to Zagreb, Žumberak has been the subject of relatively numerous geological investigations. The first extensive work that included the stratigraphy of Triassic deposits of this region was written by GORJANOVIĆ-KRAMBERGER (1894). Short stratigraphic descriptions of particular localities were given by HERAK et al. (1965) and HERAK (1968). HERAK (1957) reported on the find of the alga *Sphaerocodium bornemanni* on Mt. Sv. Gera in Žumberak while BABIĆ (1970) established that this was not a fossil taxon but rather an oncoidal sedimentological structure. Working on the Basic Geological Map (scale 1:100.000), sheet Novo Mesto, PLENIČAR & PREMRU (1977) distinguished the Middle and Upper Triassic dolomites altogether, in which the only "fossils" are *Sphaerocodium*. On the Zagreb sheet, ŠIKIĆ et al. (1979) distinguished the Middle and Upper Triassic and reported the occurrence of a "several metre thick zone with interlayers of dark grey to black shales", for which they assumed a Carnian age, within the lower part of a thick succession of Upper Triassic dolomites. In the upper part of the dolomite deposits they recorded the alternation of dolomites, dolomitized limestones and limestones. Problematic algae including *Thaumatoporella parvovesiculifera*, *Aeolisaccus dunningtoni* and *Aeolisaccus* sp., and the foraminifera *Involutina* sp. and *Glomospira* sp. are the only mentioned fossils.

In the immediate vicinity, in the Samobor mountains, Triassic deposits have been investigated by HERAK (1956) and BABIĆ et al. (1980). GUŠIĆ & BABIĆ (1972) and GUŠIĆ (1975) wrote about the Upper Triassic and Liassic microfossils of the adjacent Medvednica, and FUČEK et al. (1995), KOROLIJA et al. (1995), PRTOLJAN et al. (1995) and SOKAČ & GRGASOVIĆ (1995) about the Upper Triassic sediments and fossils of Medvednica. ŠIMUNIĆ & ŠIMUNIĆ (1997) deals with the Triassic deposits of Hrvatsko Zagorje, and BUKOVAC & SOKAČ (1989) wrote about the Upper Triassic and Liassic of the adjacent region of Gorjanci (Slovenia).

As part of recent investigations for the Geological Map of the Republic of Croatia (scale 1:50.000) detailed lithostratigraphic columns were measured through Triassic deposits on well exposed outcrops in the Slapnica creek, NW of Krašić. Based on the research results, a lithostratigraphic subdivision was made of the Triassic deposits into several formations and members (BUKOVAC et al., 1995; GRGASOVIĆ, 1995). The following units were separated within the Upper Triassic (Fig. 1): the Slapnica Formation is composed of early diagenetic

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Institute of Geology, Sachsova 2, P.O. Box 268, HR-10000 Zagreb, Croatia.

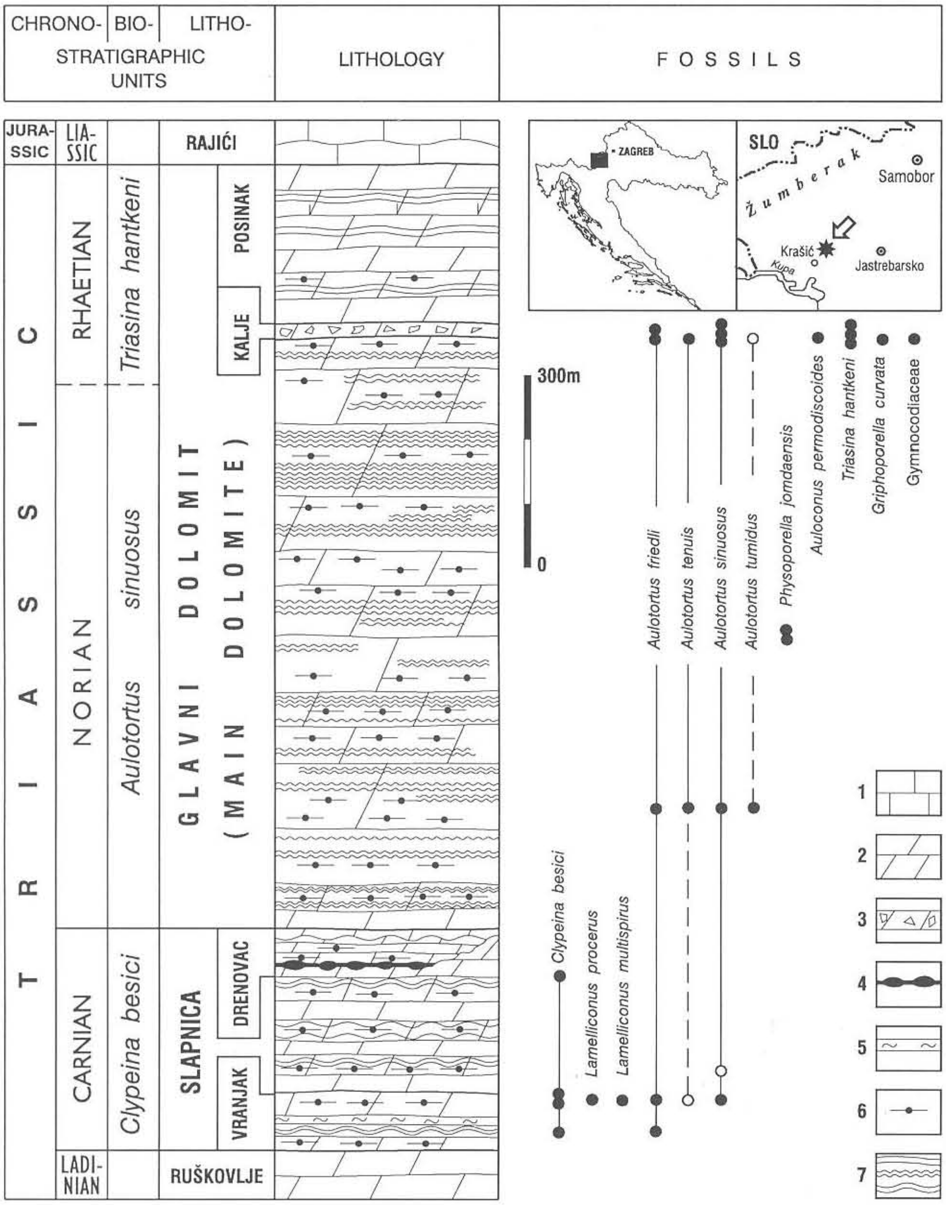

Fig. 1 Schematic stratigraphic column of the Upper Triassic deposits of Žumberak, with the geographical location of investigated outcrops in the Slapnica creek. Legend: 1) limestone; 2) dolomite; 3) dolomite intraformational breccia; 4) dolomicrite rich in organic matter; 5) shale; 6) fenestral fabric; 7) stromatolite.

dolomites, represented by more or less regular rhythms of dolomicrites, fenestral dolomicrites and dolomitic stromatolites. Beds are clearly distinguished and about 20-65 cm thick. These sediments were deposited in a peritidal environment showing a shallowing-upward tendency. Two members were separated within the Slapnica Formation. Within the rhythmic dolomites of the lower Vranjak member, milimetre to centimetre-thick yellow-green shales are intercalated. In the upper part the dolomites of Drenovac member (which have a high organic matter content) are very dark coloured. Very thin coal interlayers also occur as a result of the formation of anoxic lagoons. The upper part of the dolomitic succession is designated as the Main Dolomite Formation, which is characterized by the generally irregular lateral and vertical alternation of three main structural types of early diagenetic dolomites: dolomicrites, fenestral dolomicrites and dolomitic stromatolites with very fine undulating laminations. These stromatolites mostly belong to the type of so-called skeletal stromatolites whereas those of other units are of the agglutinated type (sensu RIDING, 1991). The real bedding planes are difficult to observe, while stylolites are clearly expressed. These deposits were formed in the peritidal - tidal flat environments on a stable carbonate platform. Two members were separated in the upper part of this formation. The Kalje member is composed of intraformational breccias with dolomicritic cement and fragments of the described dolomite types. BUKOVAC et al. (1995) and GRGASOVIĆ (1995) refer to this member as the Gmajna breccias but, since this name is used in a number of localities, the name Kalje after the near-by village has been adopted. The younger, Posinak member, is characterized by generally well stratified dolomicrites, and the rare occurrence of dolomitic limestones and limestones. Fenestral dolomicrites are less frequent and dolomitic stromatolites are mainly horizontally laminated and contain less numerous fenestrae. The sedimentary environment may be defined as peritidal with the prevalence of subtidal conditions. There is a continuous transition into Liassic limestones.

While detailed columns were recorded, a rich fossil content was found in several fossiliferous interlayers, which made it possible to define the age of discrete lithostratigraphic units and observe the fossils within fossil assemblages. These results as well as the observed differences in the fossil content at particular levels instigated the definition of a local biostratigraphic zonation for these Upper Triassic deposits, with a more extensive survey of dasyclad algae.

2. BIOSTRATIGRAPHIC ZONES

2.1. *Clypeina besici* TAXON-RANGE ZONE

Boundaries: Boundaries are defined by the occurrence and disappearance of the index species.

Fossil content: Besides frequent fragments and scarce whole skeletons of the dasyclad alga *Clypeina besici* PANTIĆ (Pl. II, Figs. 2, 4-7, 11-12, 16-19), there are numerous foraminifera including *Lamelliconus procerus* (LIEBUS) (Pl. I, Fig. 17), *Lamelliconus multispirus* (OBERHAUSER) (Pl. I, Figs. 15-16) and *Aulotortus friedli* (KRISTAN-TOLLMANN), and less frequently *Aulotortus sinuosus* WEYNSCHENK (Pl. I, Fig. 9; Pl. II, Fig. 5 pars) and *Aulotortus* cf. *tenuis* (KRISTAN). The problematical dasyclad alga *Aciculella* sp. was also found (Pl. II, Fig. 9).

Stratigraphic range: Carnian.

Correlation: Since *Clypeina besici* PANTIĆ has a confirmed Carnian range (see Section 3), this zone may be correlated with other coeval foraminiferal zones, e.g. the *Paraophtalmidium carpathicum* Range-Zone (SALAJ et al., 1988a, b) or the *Pilamminella kuthani* Interval-Zone (SALAJ et al., 1983). The Carnian age of this zone is also confirmed by palynological data (JERINIĆ in BUKOVAC et al., 1995).

This stratigraphic zone fully coincides with the extension of the Slapnica lithostratigraphic unit. This coincidence may be the result of extension of the environment favourable for the survival of *C. besici*, as dasyclad algae show a pronounced environmental dependence (e.g. BERGER & KAEVER, 1992).

2.2. *Aulotortus sinuosus* INTERVAL ZONE

Boundaries: The lower boundary of this interval-zone is defined by the disappearance of *Clypeina besici* PANTIĆ, and the upper boundary by the appearance of *Triasina hantkeni* MAJZON.

Fossil content: Some foraminifera continue into this zone, including: *Aulotortus friedli* (KRISTAN-TOLLMANN) (Pl. II, Fig. 1 pars), *Aulotortus tenuis* (KRISTAN) and the index species *Aulotortus sinuosus* WEYNSCHENK (Pl. II, Fig. 1 pars), which is the most numerous. There are also occurences of: *Aulotortus tumidus* (KRISTAN-TOLLMANN), *Trochammina* sp., the coprolite ?*Parafavreina thoronetensis* BRÖNNIMANN et al. (Pl. I, Fig. 19) and the dasyclad alga *Physoporella jomdaensis* FLÜGEL & MU (Pl. II, Figs. 10, 14-15).

Stratigraphic range: Since the assemblage has a rather wide stratigraphic range, this zone is defined as an interval zone. The age is probably Norian.

Correlation: Due to insufficient material, no correlation can be made with other known biostratigraphic units.

This biozone with its range may be generally identified with the lower part of the Main Dolomite Formation, below the Kalje breccia member. Due to the small number of palaeontological data, the boundary with the overlying *Triasina hantkeni* zone is only approximate.

2.3. *Triasina hantkeni* TAXON-RANGE ZONE

Boundaries: Boundaries are defined by the occurrence and disappearance of the index species.

Fossil content: Together with numerous *Triasina hantkeni* MAJZON (Pl. I, Figs. 1-3; Pl. II, Fig. 3 pars), other foraminifera including: *Auloconus permodiscoides* (OBERHAUSER) (Pl. I, Figs. 12, 18) and *Aulotortus sinuosus* WEYNSCHENK (Pl. I, Figs. 8, 10?, 11 pars) also occur, and less frequently *Aulotortus friedli* (KRISTAN-TOLLMANN) (Pl. I, Figs. 4-5, 7; Pl. II, Fig. 3 pars), *Aulotortus tenuis* (KRISTAN) (Pl. I, Fig. 6) and *Trochammina* sp. (Pl. I, Fig. 11 pars), as well as the dasyclad alga *Griphoporella curvata* (GÜMBEL) (Pl. II, Figs. 8, 13). The association also contains numerous fragments and skeletons of a gymnocodiacean alga (Pl. II, Fig. 3 pars), previously unknown and described in SOKAČ & GRGASOVIĆ (1998 - in press).

Stratigraphic range: The stratigraphic range of this zone is determined by the range of the index species. Most authors maintain the range is Upper Norian-Rhaetian (e.g. ZANINETTI, 1976; PILLER, 1978; SALAJ et al., 1983; ORAVECZ-SCHEFFER, 1987), while others think it is only Rhaetian (e.g. CIARAPICA et al., 1987; SARTORIO & VENTURINI, 1988; DE CASTRO, 1990; RÖHL et al., 1991).

Correlation: The *Triasina hantkeni* range zone has been repeatedly determined in the Tethyan region (e.g. CIARAPICA et al., 1987; SALAJ et al., 1988a, b; VACHARD & FONTAINE, 1988; VACHARD et al., 1990; RÖHL et al., 1991) and may be well correlated with the zone separated in the Žumberak region.

This fossil assemblage is found in the beds immediately underlying the Kalje breccia and in fragments within breccias, so the *Triasina hantkeni* bio-zone seems to include part of the upper segment of the Main Dolomite Formation, the Kalje member and possibly the Posinak member. GUŠIĆ & BABIĆ (1970) have found *Triasina* cf. *hantkeni* in limestones south of Tisovec village, which probably belong to the Posinak member.

3. PALAEONTOLOGY

Order Dasycladales PASCHER 1931
Family Acetabulariaceae HAUCK 1885
Tribe Clypeineae ELLIOT 1968
Genus *Clypeina* (MICHELIN 1845) BASSOULLET et al. 1978
***Clypeina besici* (PANTIĆ 1965) PANTIĆ *in* GRANIER & DELOFFRE 1995**
Pl. II, Figs. 2, 4-7, 11-12, 16-19

Selected synonymy (page numbers only if there is a description or a comment on the species):

1965 *Clypeina bešići* n.sp. - PANTIĆ, p. 133-136 (137-141); Pl. I, Figs. 1-6; Pl. II, Figs. 1-7; Pl. III, Figs. 1-6; Pl. IV, Figs. 1-2; Pl. V, Figs. 1-3

1967 *Clypeina bešići* PANTIĆ - PANTIĆ, Pl. VII, Figs. 1-3

1967 *Clypeina* sp. - HOLZER, p. 77-79; Pl. 1, Figs. 1-2, 8 pars

1968 ?*Clypeina besici* PANTIĆ - ĐURĐANOVIĆ, Pl. I, Fig. 9

1972 Dasycladacea - KODRA, Pl. 3, Fig. 8

1972 *Clypeina* cf. *besici* PANTIĆ - OTT, p. 91-93; Figs. 2.1-2.13

1972 *Clypeina bešići* PANTIĆ - PANTIĆ, Pl. V, Fig. 1

1972 *Clypeina besici* PANTIĆ - PANTIĆ & RAMPNOUX, Pl. II, Fig. 4

1972 *Clypeina bešići* PANTIĆ - ČANOVIĆ & KEMENCI, Pl. III, Figs. 7-8

1974 *Clypeina besici* PANTIĆ - BUKOVAC, VELIĆ & SOKAČ, N.F.

1974 *Clypeina bešići* PANTIĆ - PANTIĆ, Pl. V, Figs. 1-2

1975 *Clypeina bešići* PANTIĆ - PANTIĆ, Pl. LXXI, Figs. 1-2; Pl. LXII, Fig. 1

1977 ? *Clypeina* sp. - FLAJS, p. 11; Pl. 17, Fig. 6

1980 *Clypeina besici* PANTIĆ - BABIĆ, GUŠIĆ, KRYSTYN & ZUPANIČ, N.F.

1980 *Clypeina besici* PANTIĆ - DRAGASTAN, Fig. 103

1983 ? *Clypeina* sp. - SCHÄFER & SENOWBARI-DARYAN, p. 119; Pl. 6, Fig. 6

1984 *Clypeina besici* - HENRICH, Pl. 9, Fig. 6.2; Pl. 15, Fig. 1.2

1995 *Clypeina besici* PANTIĆ - PANTIĆ in GRANIER & DELOFFRE, p. 57 & 62, choosing the lectotype between syntypes: Pl. I, Fig. 1 in PANTIĆ (1965)

The original description (PANTIĆ, 1965, p. 135) is translated from Serbian: "The fossilized thallus of this alga is made up of fertile whorls, shaped like a wide rimmed glass. Whorls are slightly overlapped. Whorl branches are thinner in the proximal part, getting slightly thicker towards the distal part. There are between 12 and 22 branches. They are fused along almost their entire length, except for a small free part at the distal end. Each branch is connected with the axial cavity through a tiny pore, situated near the whorl base."

Discussion: HOLZER (1967) described as *Clypeina* sp. a form which is, except for its slightly larger dimensions, identical with *Clypeina besici* PANTIĆ in all of its characteristics. OTT (1972) described some nicely preserved specimens from Austria, displaying a thallus shaped like a string of ice-cream cornets, and compared them with those described by Holzer. SCHÄFER & SENOWBARI-DARYAN (1983) also compared their specimen with Holzer's. The table of dimensions (Table 1) shows that the specimens described in the present paper are generally smaller than those in the aforementioned works, but it also shows that the studied species manifests some variability in dimensions. As a taxonomic criterion, dimensions are much less important than the elements of algal structure: the shape and distribution of branches, shape and ornamentation of the thallus, etc. (BASSOULLET et al., 1977). Therefore, specimens from Žumberak, as well as those from other works cited in the synonymy, may be without reservation classified as belonging to *Clypeina besici*. Studying the calcification processes in algae, FLAJS (1977) points to the Upper Triassic *Clypeina* sp. (possibly *Clypeina besici*) as an example of preserved primary structure with calcification of a similar type to that of the recent *Cymopolia*.

The Žumberak specimens agree with the original description. Branches are densely disposed within the whorls and the whorls are widely spaced along the thallus. Because of their dense arrangement branches are sometimes horizontally flattened (Pl. II, Fig. 7). Proximal branches ascend steeply and then, bending convexely, abruptly expand (Pl. II, Fig. 5) and finally taper to a point (Pl. II, Figs. 12, 16). Formation of gametes (uncalcified) seems to have taken place in these expanded branch parts (cladosporous type). The basal pore of the branch is rarely visible (Pl. II, Figs. 6, 17). Each branch is fully covered by a thin regular calcareous envelope of an average thickness of 0.03 mm (Pl. II, Figs. 5, 7, 16, 18). The main axis is covered by a less regular and slightly thicker envelope (ca. 0.05 mm; Pl. II, Fig. 5). The internal thallus wall is entirely smooth (Pl. II, Figs. 2, 11, 17-18). Proximal parts of calcified branches are

Dimensions in mm	GRGASOVIĆ (1997)	PANTIĆ (1965)	HOLZER (1967)	OTT (1972)	SCHÄFER & SENOWBARI-DARYAN (1983)
Outer thallus diameter at the whorl level (Dmax)	0.44-1.06 (0.7) n = 14	0.896-1.84	1.25-2.68	0.95-1.7 (1.13) n = 7	2.8
Outer thallus diameter between whorls (Dmin)	0.21-0.55 (0.37) n = 14				
Inner thallus diameter (d)	0.09-0.36 (0.21) n = 15	0.56-0.672	0.42-0.64	0.24-0.36 (0.31) n = 6	1.2
The d/D relation in %	19.1-49.3 (31.5) n = 14		23.8-33.6	21.2-34.7 (28.2) n = 6	23
Distance between whorls (h)	0.47-0.51 (0.49) n = 3	0.56-0.672	1.07-1.43	0.43-0.79 (0.53) n = 5	2.8
The h/D relation in %	69.9-82.8 (77.9) n = 3	20-50? (35?)	23-35? (29?)	44.3-52.7 (47.5) n = 5	100
Diameter of pores (p)	0.05-0.10 (0.08) n = 12	0.06-0.128		0.06-0.10 (0.08) n = 6	
Number of branches per whorl (w)	10-15 (13) n = 8	12-22	10-12	15	

Table 1 Dimensions of *Clypeina besici* PANTIĆ. The mean value is given in parentheses and "n" refers to the number of measurements. Dimensions of specimens described by OTT (1972) were determined from the illustrations.

joined together, but they separate towards the distal part, giving a flower-like appearance in cross section (Pl. II, Figs. 2, 11-12, 18). Due to its characteristic shape, the thallus often disintegrates into discrete segments. An unusual section shown in Pl. II, Fig. 19 may indicate the top part of the thallus. The original skeleton mineralogy was aragonite (FLAJS, 1977, p. 74), which was replaced by mosaic dolomite crystals probably during early diagenesis.

Stratigraphic range: Most authors state a Carnian age for this alga (PANTIĆ, 1965, 1967, 1972, 1974, 1975; ĐURĐANOVIĆ, 1968; OTT, 1972; PANTIĆ & RAMPNOUX, 1972; ČANOVIĆ & KEMENCI, 1972; DRAGASTAN, 1980). Others state occurences in the Cordevolian along with *Poikiloporella duplicata* (PIA), but finding only in Wetterstein limestone may implies the facies dependance (HOLZER, 1967; OTT, 1972; HENRICH, 1984). Some uncertain finds were determined only as Upper Triassic (FLAJS, 1977; SCHÄFER & SENOWBARI-DARYAN, 1983). The Norian-Rhaetian age from KODRA (1972) is uncertain. In this paper, the age of beds with *Clypeina besici* PANTIĆ can also be defined as Carnian.

Geographical distribution: Albania (KODRA, 1972), Austria (HOLZER, 1967; OTT, 1972), Bosnia and Herzegovina (PANTIĆ, 1965), Croatia (BUKOVAC et al., 1974; BABIĆ et al., 1980 and present paper), Germany (HENRICH, 1984), Greece (SCHÄFER & SENOWBARI-DARYAN, 1983), Italy (FLAJS, 1977), Romania (DRAGASTAN, 1980), Slovenia (ĐURĐANOVIĆ, 1968) and Yugoslavia: Montenegro (PANTIĆ, 1965, 1975), Serbia (PANTIĆ, 1967, 1972; PANTIĆ & RAMPNOUX, 1972), Vojvodina (ČANOVIĆ & KEMENCI, 1972), and Kosovo (PANTIĆ, 1974).

Family Triploporellaceae (PIA 1920) BERGER & KAEVER 1992

Tribe Salpingoporelleae BASSOULLET et al. 1979

Subtribe Salpingoporellinae BASSOULLET et al. 1979

Genus *Griphoporella* (PIA in SPITZ & DYHRENFURTH 1915) BARATTOLO et al. 1993

***Griphoporella curvata* (GÜMBEL 1872) BARATTOLO et al. 1993**

Pl. II, Figs. 8, 13

Selected synonymy (page numbers only if there is a description or a comment on the species):

1872 *Gyroporella curvata* n. sp. - GÜMBEL, p. 280; Pl. D.IV, Fig. 2.a-d

1915 *Griphoporella curvata* (GÜMBEL) n.comb. - PIA in SPITZ & DYHRENFURTH, p. 62; Pl. I, Fig. 11

1920 *Griphoporella curvata* GÜMB. spec. - PIA, p. 90-92; Pl. III, Figs. 17-21

1925 *Griphoporella curvata* - DIENER, Pl. XXVIII, Fig. 4 = reconstruction

1964 *Griphoporella curvata* (GÜMBEL) - SOKAČ, NIKLER & IVANOVIĆ, Fig. 3.3-4

1965 *Griphoporella curvata* var. *curvata* n.var. - ZANIN BURI, p. 488-489; Pl. 62 pars; Pl. 63, Fig. 1 pars & 2-3

1965 *Griphoporella curvata* var. *cistiformis* n.var. - ZANIN BURI, p. 490-491; Pl. 62.a-c; Pl. 63, Fig. 1.a-c

1965 *Macroporella retica* n.sp. - ZANIN BURI, p. 465-467; Pl. 44; Pl. 45; Pl. 61, Figs. 5-6

1967 ? *Griphoporella* sp. - HOLZER, Pl. 1, Fig. 8 pars

1967 *Griphoporella curvata* (GÜMBEL) - HERAK, SOKAČ & ŠĆAVNIČAR, p. 199, N.F.

1967 *Griphoporella curvata* (GÜMBEL) PIA - OTT, p. 222-223; Pl. 13, Fig. 4

1972 ? Dasycladaceen-Resten - GUŠIĆ & BABIĆ, Pl. I, Fig. 4

1975 *Griphoporella curvata* (GÜMBEL) - FLÜGEL, p. 325-327; Pl. 4, Fig. 6

1986 *Griphoporella curvata* (GÜMBEL) - BRAGA, p. 245-246; Pl. 2.I

1987 *Griphoporella curvata* (GÜMBEL) - CIARAPICA et al., p. 366 & 368; Pl. XXIV, figs. 1-8; Pl. XXV, figs. 3.b & 7.a; Pl. XXVI, figs. 2 & 5

1987 *Gyroporella vesiculifera* GÜMBEL - CIARAPICA et al., p. 368; Pl. XXIII, figs. 1-10; Pl. XXV, fig. 1.a (= XXIII, fig. 5); Pl. XXV, figs. 1.b, 3.a, 4.a, 5.a & 6.a

1987 *Macroporella retica* ZANIN BURI - CIARAPICA et al., p. 364; Pl. XXII, figs. 1-8; Pl. XXV, figs. 2.c & 6.b; Pl. XXVI, figs. 1, 3 & 7-8

1987 Dasycladaceae gen.ind. - CIARAPICA et al., Pl. XXVII, figs. 1-6

1988 *Griphoporella curvata* (GÜMBEL) - SARTORIO & VENTURINI, p. 40-41 (= p. 56, centre)

1988 *Macroporella retica* ZANIN BURI - SARTORIO & VENTURINI, p. 56, bottom

1993 *Griphoporella curvata* (GÜMBEL) PIA emend. - BARATTOLO, DE CASTRO & PARENTE, p. 23-45 (complete synonymy); Pl. 1, figs. 1-10; Pl. 2, figs. 1-8; Pl. 3, figs. 1-5; Pl. 4, figs. 1-6; Pl. 5, figs. 1-4; Pl. 6; Pl. 7

1995 *Macroporella retica* ZANIN BURI = *Griphoporella curvata* (GÜMBEL) PIA - PUGLIESE, p. 537-546; Pl. 1, figs. 1-6; Pl. 2, figs. 7-11; Pl. 3, figs. 12-17

1997 *Griphoporella curvata* (GÜMBEL) PIA - PUGLIESE, p. 76; Pl. 2, figs. 6-9

Diagnosis (BARATTOLO et al., 1993, p. 33): "Cylindrical to slightly club-shaped simple thallus. Primary branches only, arranged in very close, alternate whorls. The branches are phloiophorous, with a subterminal narrowing; their transverse section is subcircular. The inclination of the branches is 45-60° in the proximal portion, then gradually increases outwards up to 70-80°. The distal portion of the branches form a cortex with polygonal meshes horizontally compressed. Reproductive organs unknown (not calcified), probably situated in the central stem or in the primary branches (endospore or cladospore). The calcification constitutes a calcareous skeleton continuous, very thin, enveloping to a various degree different portions of the primary branches. As a consequence the pores show different morphologies both in different specimens and in different portions of the same specimen."

Discussion: Though not so well preserved, the Žumberak specimens (Table 2) show characteristics typical of this species, which were thoroughly studied and revised by the above mentioned authors. A calcareous skeleton of irregular internal and external surface encompasses various parts of the densely disposed phloiophorous to slightly vesiculiferous branches. The basal part of branches next to the main axis were probably not calcified and the extreme distal part has been preserved in only some specimens. Distal branch tapering, as well as the honey-comb shaped cortex, which BARATTOLO et al. (1993) mention in their diagnosis,

Dimensions in mm	GRGASOVIĆ (1997)	FLÜGEL (1975)	BARATTOLO et al. (1993)
Outer thallus diameter (D)	2.05-2.11	1.4-2.7	0.73-3.12 (1.98); n = 480
Inner thallus diameter (d)	1.49-1.62	1.1-2.1	0.42-2.6 (1.55); n = 480
Thickness of the calcareous skeleton (D-d/2)	0.25-0.28		0.1-0.36 (0.22); n = 480
Distance between whorls (h)			0.075-0.15 (0.10); n = 27
Diameter of pores (p)	cca 0.1	0.04-0.12	0.051-0.24 (0.11); n = 160
Number of branches per whorl (w)	cca 30		12-31 (19.5); n = 13

Table 2 Dimensions of *Griphoporella curvata* (GÜMBEL 1872) BARATTOLO et al. 1993. The mean value is given in parentheses and "n" refers to the number of measurements.

are discernible only in places (Pl. II, Fig. 8, bottom left top right).

Stratigraphic range: Norian - Rhaetian (BARATTOLO et al., 1993), confirmed also by finds from Žumberak (*Triasina hantkeni* Taxon-range Zone).

Geographical distribution: Austria, Croatia, Germany, Italy, Romania, Spain, Switzerland (BARATTOLO et al., 1993).

Subtribe Oligoporellinae BASSOULLET et al. 1979
Genus *Physoporella* (STEINMANN 1903) PIA 1912
Physoporella jomdaensis FLÜGEL & MU 1982

Pl. II, Figs. 10, 14-15

1982 *Physoporella jomdaensis* n.sp. - FLÜGEL & MU, p. 61-62, Pl. 8, fig. 5 pars; Pl. 9, figs. 3-4

Original diagnosis (FLÜGEL & MU, 1982, p. 61): "Thin weakly calcified thallus with horn-like terminations of the pyriform branches, arranged in verticils."

Discussion: In their morphological characteristics the Žumberak specimens fully agree with those from the original description of this species. There are some differences in dimensions (Table 3), however they are consistent with the limits of variations known in the other species of this genus. The thallus of *Physoporella jomdaensis* is cylindrical, straight (Pl. II, Fig. 15), very slightly bent (Pl. II, Fig. 14) or slightly clavate (FLÜGEL & MU, 1982, Pl. 9, fig. 3). Branches are of the typical pear like - piriferous type and disposed in whorls, which are the principal characteristics of the genus *Physoporella*. Internal branch parts, as well as the surface of the main axis were most likely not calcified. Calcification affects separately the external side of each branch and is complete, so that the external thallus surface is undulated. The calcareous envelope is about 0.06 mm thick. The proximal parts of branch envelopes are fused (Pl. II, Fig. 15, top; FLÜGEL & MU, 1982, Pl. 9, fig. 3, middle part). Branches in individual and neighbouring whorls are densely disposed as far as their calcareous envelopes allow it. The original thallus structure was most probably aragonitic, like in recent Dasycladales, but, in the early diagenetic phases it was replaced by tiny mosaic dolomite crystals, as other skeletal particles in this dolomite. The phenomenon described by FLÜGEL & MU (1982) that "...the distal part of the thallus is covered by a thin calcareous sheet (0.035-0.070 mm thick)..." has not been recorded in present material. This might be due to the diagenetic origin of this envelope in type specimens, possibly in the form of early diagenetic acicular calcite.

Stratigraphic range and geographic distribution: The species was originally attributed to the Carnian of eastern Tibet (FLÜGEL & MU 1982), and can now be extended to the Norian of Žumberak (*Aulotortus sinuosus* Interval Zone).

Order Dasycladales PASCHER 1931
Morpho tribe Aciculelleae BASSOULLET et al. 1979
Genus *Aciculella* PIA 1930
Aciculella sp.

Pl. II, Fig. 9

The genus *Aciculella* was first established by PIA (1927), however without illustration, and later validated by PIA (1930) on the basis of species *Aciculella bacillum*. The genus is characterized by cylindrical calcareous bodies with numerous spherical cavities, which are usually discernible in the sample as circular or elliptical sections. These calcareous cylinders are assumed to represent the calcified main axis which contained reproductive organs - the gametangia (PIA, 1927; ELLIOTT, 1971). Certain sections are very similar to the *Acicularia* genus (family Acetabulariaceae), in which the reproductive "umbrella" chambers are calcified. BYSTRICKÝ (1975) made an extensive revision of the Type Species and established several new ones, mainly on the basis of dimensions and the number of gametangia in cross section.

Since only one specimen was discovered from Žumberak, and is therefore insufficient to establish a species, it was defined as *Aciculella* sp.

Dimensions in mm	GRGASOVIĆ (1997)	FLÜGEL & MU (1982)
Outer thallus diameter (D)	0.85-1.06 (0.96); n = 3	1.5-1.75
Inner thallus diameter (d)	0.47-0.68 (0.55); n = 3	0.8-1.3
The d/D relation in %	49-64 (57); n = 3	63-77
Distance between whorls (h)	0.23-0.25; n = 2	0.12-0.25
Diameter of pores (p)	0.11; n = 3	0.15-0.22
Number of branches per whorl (w)	14; n = 1	15 ?
Maximal length of thallus (L)	4.9	11.7

Table 3 Dimensions of *Physoporella jomdaensis* FLÜGEL & MU 1982. The mean value is given in parentheses and "n" refers to the number of measurements.

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PLATE I

Microfossils from Upper Triassic dolomites from Žumberak (Croatia)

1	*Triasina hantkeni* MAJZON; black round cavity at the top is caused by bioerosion; slide SL 30-16/2; x 57
2	*Triasina hantkeni* MAJZON; slide SL 30-8/18; x 57
3	*Triasina hantkeni* MAJZON with micritic envelope, probably of cyanobacterial origin; slide SL 30-3/3; x 36
4-5, 7	*Aulotortus friedli* (KRISTAN-TOLLMANN); slides SL 30-8/15, SL 30-8/2 and SL 30-27/1; x 57
6	*Aulotortus tenuis* (KRISTAN); slide SL 30-24/1; x 57
8	*Aulotortus sinuosus* WEYNSCHENK, equatorial section; slide SL 30-8/17; x 45
9	*Aulotortus sinuosus* WEYNSCHENK, axial section; slide SL 2-12/13; x 57
10	*Aulotortus* cf. *sinuosus* WEYNSCHENK, axial section; slide SL 30-20/2; x 57
11	*Trochammina* sp. and *Aulotortus sinuosus* WEYNSCHENK; slide SL 30-30/1; x 57
12, 18	*Auloconus permodiscoides* (OBERHAUSER); slide SL 30-21/2 and SL 30-14/1; x 57
13	*Aulotortus* cf. *tumidus* (KRISTAN-TOLLMANN); slide SL 30-8/1; x 57
14	*Aulotortus tumidus* (KRISTAN-TOLLMANN); slide SL 30-8/1; x 57
15-16	*Lamelliconus multispirus* (OBERHAUSER); slide SL 3-5/X and SL 3-5/VI; x 31
17	*Lamelliconus procerus* (LIEBUS); slide SL 3-5/XVII; x 31
19	?*Parafavreina thoronetensis* BRÖNNIMANN et al.; slide SL 25-9; x 22

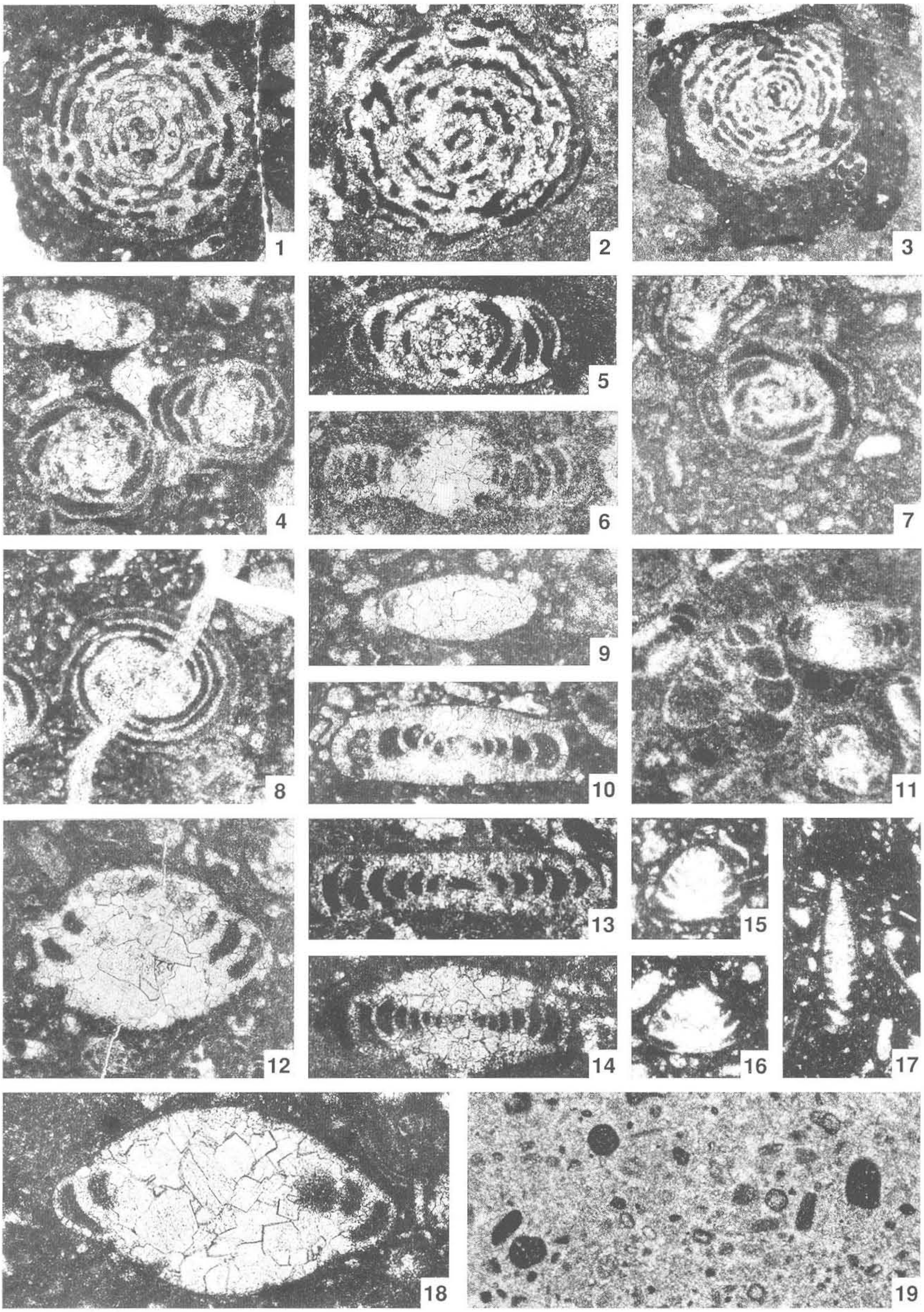

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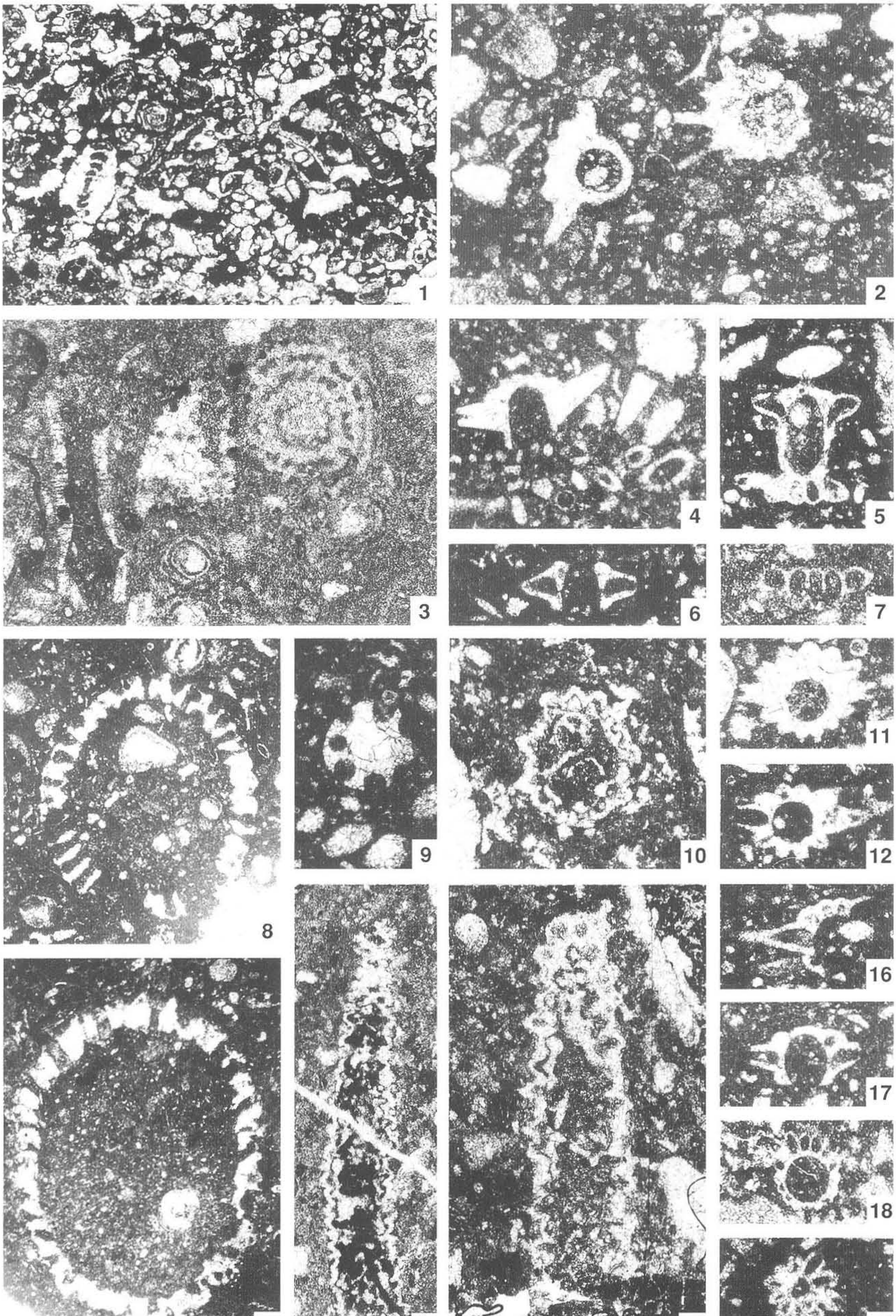
PLATE II

Microfossils from Upper Triassic dolomites from Žumberak (Croatia)

1	Microfacies of Interval-zone *Aulotortus sinuosus*: *Aulotortus sinuosus* WEYNSCHENK (left and right) and *Aulotortus friedli* (KRISTAN-TOLLMANN) (middle); slide SL 12-34A; x 22
2	Microfacies of Taxon-range zone *Clypeina besici*: *Clypeina besici* PANTIĆ, transversal, slightly oblique sections; slide SL 2-12C/II; x 60
3	Microfacies of Taxon-range zone *Triasina hantkeni*: *Triasina hantkeni* MAJZON (right), *Aulotortus friedli* (KRISTAN-TOLLMANN) (down) and Gymnocodiacea indet. (left); slide SL 30-8/2; x 36
4	*Clypeina besici* PANTIĆ, fragment of oblique section (left) and Dasycladacea indet., oblique section with visible phloiophorous branches (down right); slide SL 3-5/VI; x 31
5	*Clypeina besici* PANTIĆ, oblique section (down) and *Aulotortus sinuosus* WEYNSCHENK (up); slide SL 3-5/IV; x 28
6	*Clypeina besici* PANTIĆ, longitudinal section through a whorl; slide SL 3-5/V; x 31
7	*Clypeina besici* PANTIĆ, tangential section through a whorl; slide SL 3-6/I, x 31
8	*Griphoporella curvata* (GÜMBEL), transversal, slightly oblique section; slide SL 30-8/12; x 31
9	*Aciculella* sp., transversal section; slide SL 3-5/II; x 31
10	*Physoporella jomdaensis* FLÜGEL & MU, transversal, slightly oblique section; slide SL 19-15/IV; x 22
11-12, 18	*Clypeina besici* PANTIĆ, transversal sections; slides SL 3-5/XI, SL 3-5/XII and SL 2-12D; x 31
13	*Griphoporella curvata* (GÜMBEL), oblique section; slide SL 30-8/3; x 31
14	*Physoporella jomdaensis* FLÜGEL & MU, longitudinal section; slide SL 17-9; x 17
15	*Physoporella jomdaensis* FLÜGEL & MU, longitudinal section; slide SL 19-15/V; x 22
16	*Clypeina besici* PANTIĆ, fragment of transversal, slightly oblique, section; slide SL 3-5/XII; x 31
17	*Clypeina besici* PANTIĆ, oblique section; slide SL 3-5/IX; x 31
19	*Clypeina besici* PANTIĆ, transversal section, possibly of the top part of the thallus; slide SL 3-5/II; x 31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