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Triassic Radiolarites from Mts. Kalnik and Medvednica (Northwestern Croatia)

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Key words: Triassic, Radiolarites, Meliata Basin, Vardar Basin, Mt. Kalnik, Mt. Medvednica, Croatia.

Ključne riječi: trijas, radiolariti, Meliata bazen, Vardarski bazen, Kalnik, Medvednica, Hrvatska.

Abstract

Bedded radiolarites of Mt. Kalnik are of Carnian-Norian age, while similar rocks of Mt. Medvednica are of Late Ladinian - Carnian age, as determined on the basis of radiolarian assemblages. Radiolarites from Mt. Kalnik concordantly rest upon the pillow-lavas, or are interbedded with them. Their footwall at Mt. Medvednica is not known, due to tectonic reduction. The sedimentary rocks described were deposited from low-density turbidity currents, therefore representing fine-grained turbidites. They were deposited closely below, and partially above the CCD. Results of petrological, sedimentological and geochemical investigations indicate sedimentation under terrigenous influence with contemporaneous hydrothermal activity. The studied sections are correlated with the nearest outcrops of Triassic radiolarites associated with basic effusive rocks, i.e. with the Vardar Zone and the Meliata Unit.

Sažetak

Opisani su prugasti radiolariti Kalnika i Medvednice. Analizom radiolarija za kalničke silicijske stijene dobivena je karničko-norička starost, a za one na Medvednici od gornjeg ladinika do karnika. Radiolariti Kalnika leže na pillow-lavama ili se s njima proslojavaju, dok im je podloga na Medvednici uslijed tektonske redukcije nepoznata. Proučavani sedimenti taloženi su iz mutnih tokova male gustoće i predstavljaju sitnozrnate turbidite. Dubina sedimentacije bila je neposredno ispod, a dijelom i iznad CCD. Petrološki, sedimentološki i geokemijski rezultati istraživanja ukazuju na sedimentaciju pod utjecajem kopna uz istovremeni hidrotermalni utjecaj. Proučavani stupovi korelirani su s najbližim izdancima trijaskih radiolarita asociranih s bazičnim efuzivima, tj. s vardarskom zonom i Meliata jedinicom.

1. INTRODUCTION

Radiolarites (ribbon bedded radiolarites - JENKYNS & WINTERER, 1982, or rhythmically bedded cherts in alternation with mm-cm thick layers of siltstone or shale - DE WEVER, 1989) represent a very important palaeobathymetric indicator for palaeogeographic reconstructions. Furthermore, if they are interbedded with basic effusive rocks, radiolarians may be used to precisely determine the age of volcanic activity. Up to now radiolarites in Croatian literature have been mentioned only incidentally, as a part of magmatic-sedimentary complex (GORJANOVIĆ-KRAMBERGER, 1908; ŠIKIĆ et al., 1979; ŠIMUNIĆ & ŠIMUNIĆ, 1979; BABIĆ, 1974b; BASCH, 1983), and have never been thoroughly investigated. However, these rocks are very important for palaeogeographical reconstruction, especially concerning the fact that radiolarites and cherts of Triassic age were found in Hungary and Slovakia (KOZUR & MOCK, 1973, DUMITRICĂ & MELLO, 1982; DE WEVER 1984, 1989; KOZUR & RÉTI, 1986; KOZUR, 1991; DOSZTÁLY & JÓZSA, 1992), Romania (DUMITRICĂ, 1982), as well as in the region of Dinarides (PAMIĆ, 1981, 1982; PAMIĆ et al., 1981; OBRADOVIĆ & GORIČAN, 1989), Albanides (KELLICI & DE WEVER, 1994) and Hellenides (DE WEVER, 1982, 1989). Especially interesting are Triassic radiolarites which are interbedded with pillow-lavas, or concordantly rest upon them (KOZUR & MOCK, 1973; DE WEVER, 1982, 1984, 1989; DUMITRICĂ, 1982; KOZUR & RÉTI, 1986; OBRADOVIĆ & GORIČAN, 1989; KOZUR, 1991; DOSZTÁLY & JÓZSA, 1992).

Chert Formation and magmatic rocks of Mts. Kalnik and Medvednica have previously been determined as Early Cretaceous in age, on the basis of their common association with Lower Cretaceous sedimentary rocks (ŠIKIĆ et al., 1979; ŠIMUNIĆ & ŠIMUNIĆ, 1979; BASCH, 1983). According to CRNKOVIĆ (1963) they are of Late Cretaceous age. During investigation for the new geological map of the Republic of Croatia (scale 1:50,000) it has been determined that the magmatic-sedimentary complex is partially of Middle to Late Triassic age (as in the present study) and partially of Jurassic age (which will be discussed later). Petrological, sedimentological, palaeontological and geochemical studies from selected sections are presented and used for correlation with neighbouring areas, enabling the reconstruc-

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tion of their palaeogeographical position. Therefore, this investigation represents a new contribution to the knowledge of the arrangement of ocean and land areas in this part of Europe during the Triassic period.

2. BASIC GEOLOGICAL DATA

The Kalnik and Medvednica Mts. are situated in the SW part of the Pannonian basin. According to HAAS et al. (1990, 1995), they represent the SW extension of the Mid - Transdanubian terrain. This terrain is separated towards the SE from the Tisza Megaunit, by the Zagreb-Zemplin lineament (KOVÁCS et al., 1989). According to HERAK (1986), this area represents part of the Supradinaric geodynamic unit, or Inner Dinarides (HERAK et al., 1990).

In the region of the Kalnik and Medvednica Mts. ophiolitic rocks are found in the form of a tectonic melange, either interbedded with radiolarites or as isolated bodies of basalts, gabbros and ultramafic rocks. Ophiolitic rocks, i.e. rocks of the magmatic-sedimentary complex of Kalnik Mt. (Fig. 1b), represented by the Kestenik (1 on Fig. 1b) and Jazvina (2 on Fig. 1b) sections, are surrounded by Tertiary sediments. The contact is predominantly tectonic, characterised towards the N by reverse faults. This complex, comprising the greatest part of Kalnik Mt., is represented by dark-gray and gray-green siltstones and calcitic siltstones, brown-red siltstones, shales and cherts, sandstones, metabasalts and diabases. Gabbros are subordinate (ŠIMUNIĆ et al., 1993; VRKLJAN, 1994).

On Medvednica Mt. (Fig. 1c) ophiolitic rocks, i.e. magmatic-sedimentary complex, are situated in the NW part. They are in reverse contact with low-grade metamorphosed rocks towards the SE and NE. Towards the SW and NW part of the Medvednica Mt., this complex is bounded by Upper Cretaceous and Tertiary rocks; the contact is partially tectonic, and partially transgressive. The southwestern part also consists of a clastic-carbonate overthrust unit, composed of Lower Triassic sandstones and Middle to Upper Triassic limestones and dolomites. The magmatic-sedimentary complex is composed of basalts and metabasalts, altered diabases and gabbros, dark gray siltstones, calcitic siltstones, matrix-supported conglomerates and conglomeratic shales, violet-red and green-gray radiolarites and silicified shales and siltstones.

The siliceous sediments and effusive rocks are probably allochthonous in both localities.

3. PETROLOGY AND SEDIMENTARY STRUCTURES

The Kestenik outcrop (1 on Fig. 1b) is situated in the road-cut in the eastern part of the Kalnik Mt., and the studied section is approximately 60 m thick, including a 6.3 m thick covered interval (Fig. 2). It is composed of three parts: pillow-lavas (1), shales and radiolarites (2) and metabasalts (3).

(1) The lower part is composed of a 29 m thick sequence of weathered pillow-lavas with pillows of 0.5 to 0.8 m in diameter. Structurally these rocks are homogeneous, but very fractured, ophitic metabasalts composed of albite and augite. Albite is predominantly weathered with enclosed chlorite grains; augite is partially fresh, and partially blurred and epidotised. Opaque mineral grains are found as accessory constituents.

In the uppermost part of the pillow-lava sequence, 2 m below the boundary with the overlying sedimentary rocks, an approximately 0.5 m thick irregular body of dark red, calcitic shale occurs between pillows. This rock is composed of micro- to macrocrystalline, mostly idiomorphic calcite. The interstices are filled with almost completely haematised clay-quartz matrix. Silt-sized grains are represented by subrounded quartz grains and muscovite. Mostly idiomorphic calcite crystals indicate postdiagenetic calcitisation. This rock body is interpreted as being part of the ocean floor composed of silty shale, which was incorporated during the pillow-lava effusion, and subsequently calcitised, probably during the period of spilitisation of the basalts due to hydrothermal alteration.

At the boundary between the pillow-lavas and the radiolarite sequence the rocks are tectonised and foliated due to the differential competence of the materials; therefore, their primary contact is not clearly visible.

(2) The shales and radiolarites are 20.5 m thick. The lowest, 1 m thick interval is composed of green-gray silty siliceous shale, composed of 5 to 10 cm thick beds of homogeneous structure. The matrix is composed of clay minerals and crypto- to microcrystalline quartz. Silt-sized components are irregularly distributed, consisting of quartz grains, phyllosilicates and feldspars, while rounded zircons, apatite and opaque ferruginous grains are subordinate. Rare completely recrystallized radiolarians, up to 0.25 mm in diameter, are represented by ovals filled with cryptocrystalline quartz.

The overlying, 19.5 m thick interval of violet-red and brown-red radiolarites, comprises the main portion of silliceous deposits. It is composed of alternating 1 to 10 cm thick beds of radiolarian cherts with millimetre to centimetre thick interbeds of dark red, very thinly laminated silty shales. The proportion of shales increases in the upper part of this interval, leading to their predominance over the 5 to 10 cm thick chert beds. Therefore, this succesion indicates an increasing input of terrigenous material, and the succession in the upper part could be interpreted as dilution cycles (DECKER, 1991). Bedding surfaces are sharp and irregular. Radiolarian tests, up to 0.35 mm in diameter, are filled with microcrystalline quartz; very rarely relics of incompletely recrystallized radial chalcedony may be found. Some chert layers have very thin (<1 mm) ribbons filled with ferruginous-clayey material, which do not

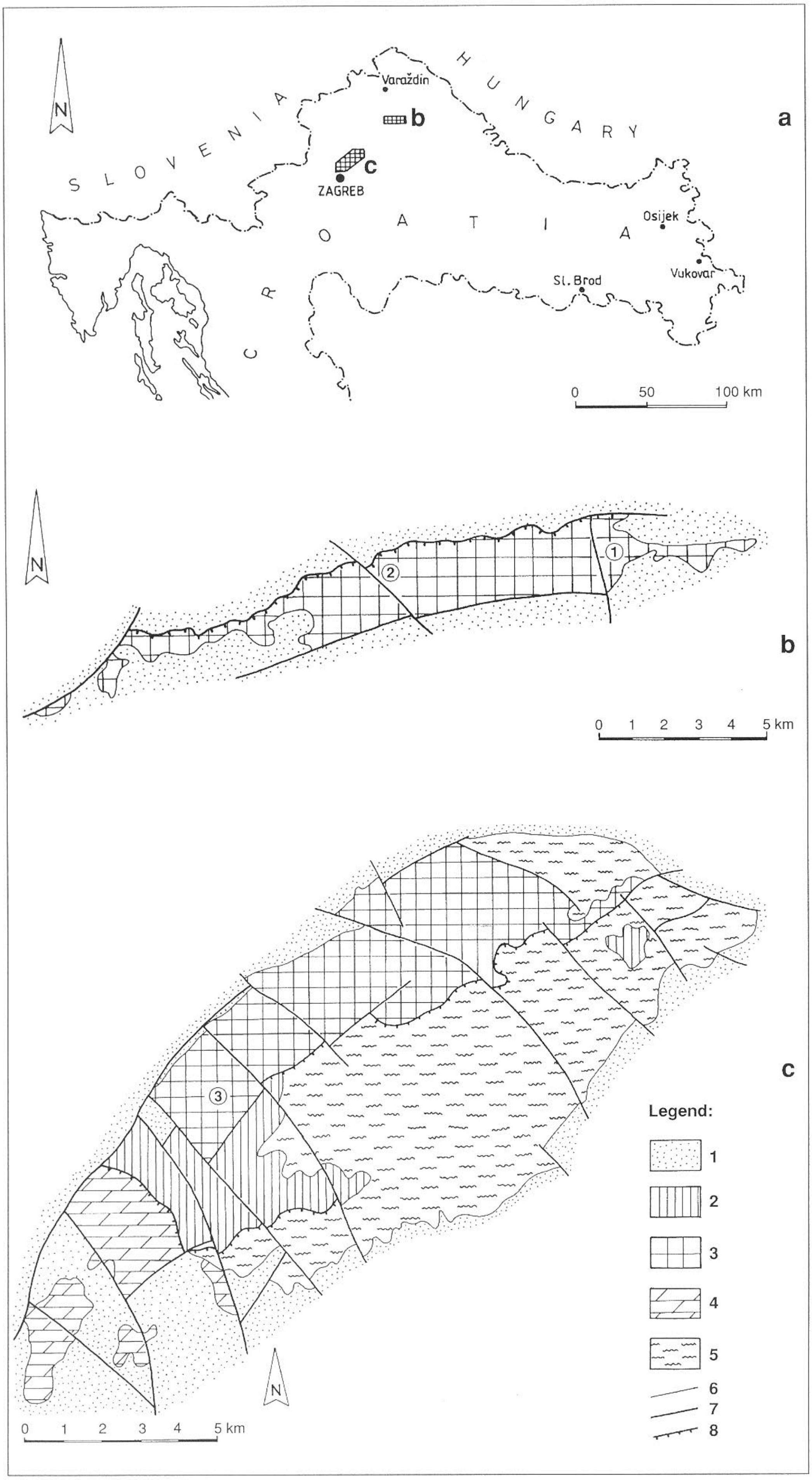

Fig. 1. Location map (a) and schematic geological maps of Mt. Kalnik (b, after ŠIMUNIĆ et al., 1982) and Mt. Medvednica (c, after ŠIKIĆ et al., 1977 and BASCH et al., 1981, both simplified). Studied localities: 1) Kestenik; 2) Jazvina; 3) Poljanica. Legend: 1 - Tertiary sedimentary rocks; 2 - Upper Cretaceous-Palaeogene sedimentary rocks; 3 - magmatic and sedimentary rocks of uncertain Lower Cretaceous age (PAMIĆ, pers. comm.); 4 - Triassic clastic and carbonate rocks of Zakičnica nappe; 5 - metamorphic rocks; 6 - boundary; 7 - fault; 8 - thrust fault.

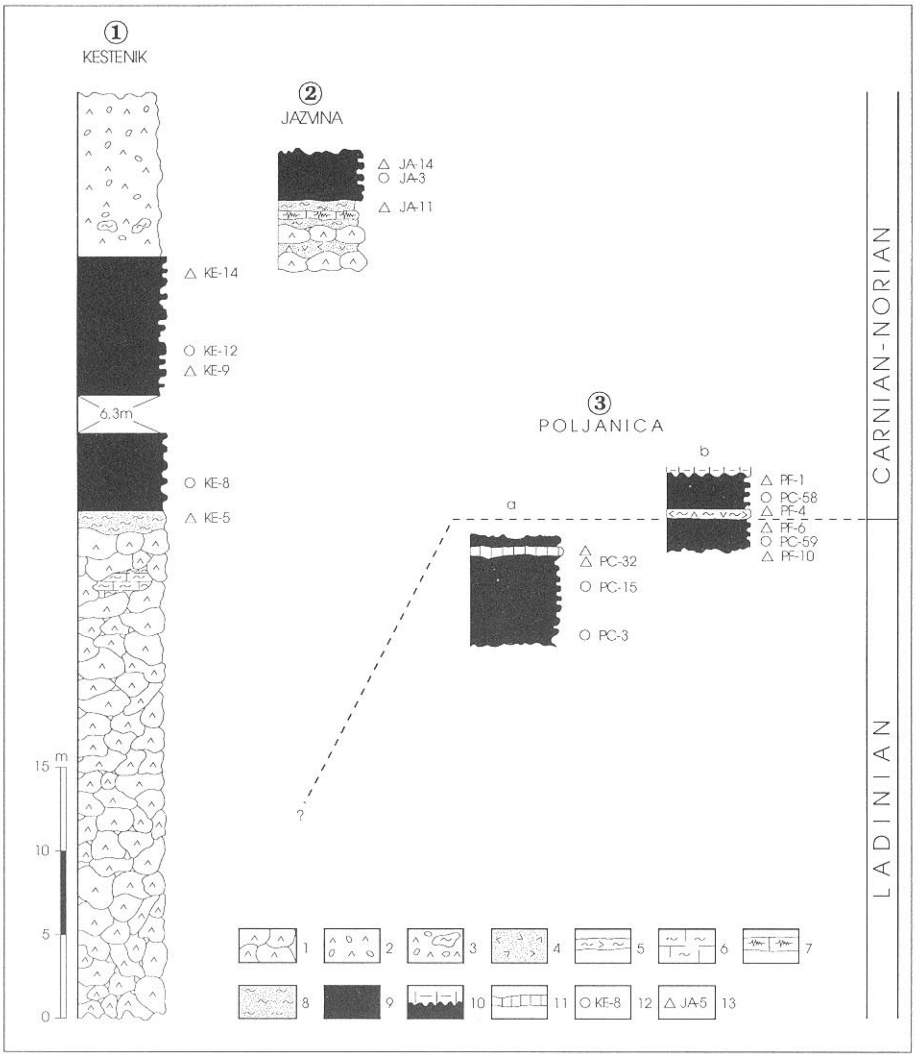

Fig. 2 Studied geological sections. Legend: 1 - pillow lavas; 2 - metabasalt with amygdaloidal structure; 3 - shale xenoliths in metabasalt with amygdaloidal structure; 4 - pyroclastic rocks; 5 - tuffitic shale; 6 - calcitized shale; 7 - silicified radiolarian limestone; 8 - silty shale; 9 - radiolarite; 10 - Cretaceous-Palaeogene marl; 11 - Mn-enriched beds; 12 - palaeontological samples; 13 - chemical analyses.

cut radiolarian tests. They probably represent small-scale anastomosing stylolites (NISBET & PRICE, 1974). The matrix is composed of microcrystalline quartz; accessory muscovite minerals are oriented parallely with radiolarian laminae. The radiolarites are characterized by poor visible gradation, depending upon the number of individual tests in the rock. Parallel lamination is expressed by the alternation of millimetre-scale lighter laminae enriched in radiolarians, and darker laminae enriched in a clay component. In some specimens weak convolute lamination has been observed (Fig. 4c). These structures indicate probable deposition from turbidity currents; therefore the rocks could be interpreted as fine-grained turbidites (PIPER & STOW, 1991).

Silty shale beds have the same colour as the radiolarian cherts, and are from a few millimetres to several tens of centimetres thick. The rock is intensely impregnated by a ferruginous substance. X-ray analyses of fine-grained material have shown that approximately 50% of the rock is composed of quartz, and the muscovite and/or illite proportion is also important; plagioclase, haematite and chlorite are subordinate. The silt-sized grains are composed of quartz grains and muscovite; feldspars, chlorite and opaque ferruginous minerals are subordinate. The rock is characterised by millimetre lamination.

(3) The upper part of the section is composed of intensely weathered calcitised vesicular metabasalt with cm-scale enclaves of dark red shale (Fig. 3a). Albites and pyroxenes in the metabasalt are very blurred, fractured and calcitised. Vesicles, which are usually 0.1 to 2, rarely up to 10 mm in diameter, have a monomineralic composition, usually of coarse-crystalline calcite, rarely chlorite. Calcite vesicles with a thin chlorite rim and chalcedony vesicles are very infrequent. Vesicles are infrequently coalesced into clusters up to 15 cm in diameter.

A continuation of the section is not visible, due overburden cover, but secondary boulders indicate the presence of another unit composed of shales and cherts above the vesicular metabasalts.

The Jazvina outcrop (2 on Fig. 1b) is situated in the central part of the Kalnik Mt. in a small, abandoned quarry. The rocks are heavily tectonised, except in the second level in the southern part of the quarry, where a relatively undisturbed succession outcrops.

The lower part of the section is composed of calcitised, weakly porphyritic ophitic metabasalt. Albite

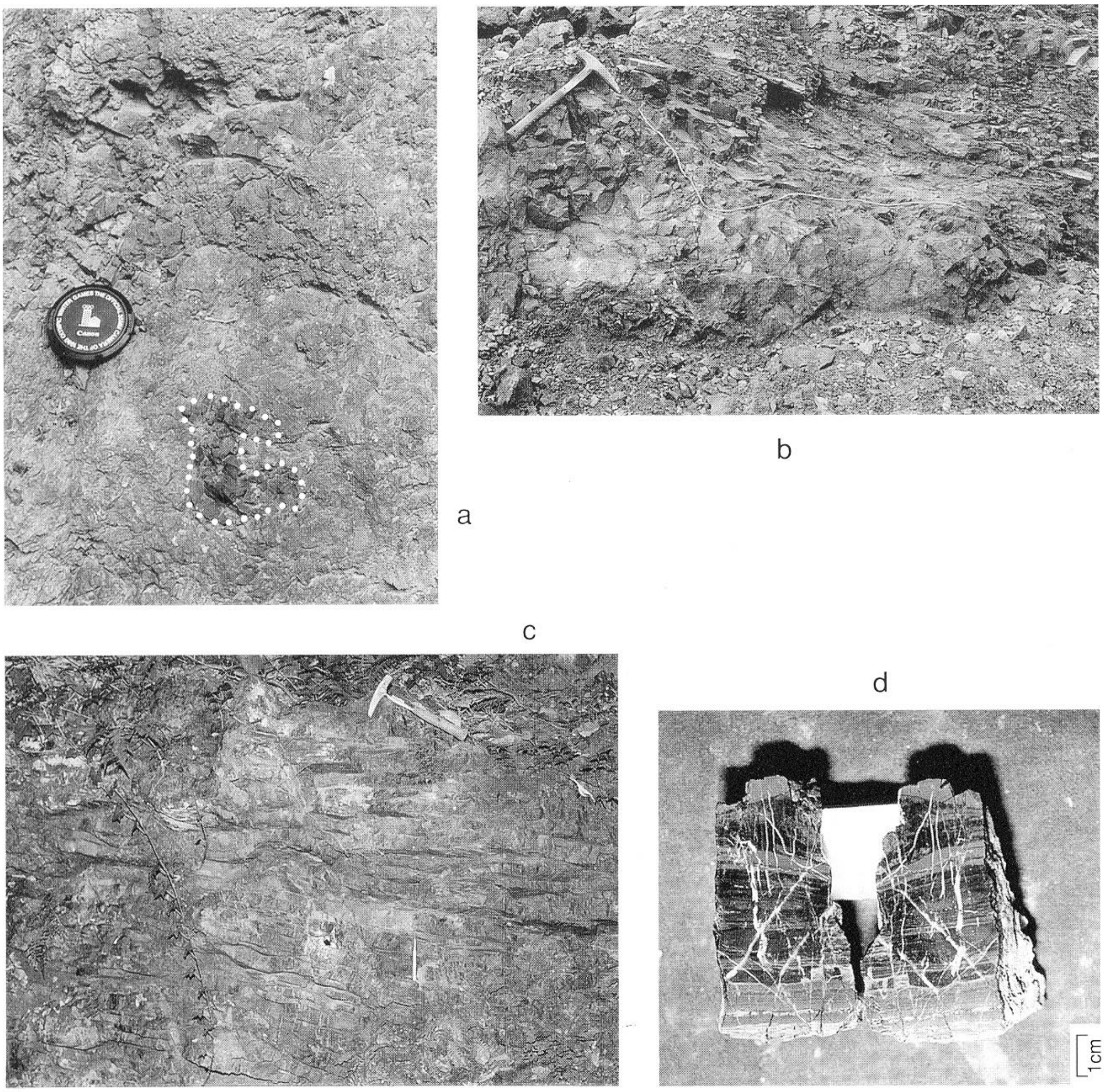

Fig. 3 a) Enclave of dark red siliceous shale (dotted) in metabasalt with amygdaloidal structure (Kestenik outcrop, Kalnik Mt., upper part of the section); b) irregular boundary between pillow lavas and radiolarite. Metabasalt is in the lower part of the picture, below light coloured measuring band (Jazvina outcrop, Kalnik Mt.); c) ribbon radiolarite exhibiting pinch and swell structure (Poljanica outcrop, Mt. Medvednica); d) cm-thick Mn-enriched beds (Poljanica outcrop, Mt. Medvednica).

crystals are elongated, 0.1 to 0.3 mm long; augite crystals are blurred, and partially epidotised. Interstices are filled with chlorite. Sparse albite phenocrysts occur (0.3 to 0.7 mm long, rarely up to 2 mm). Samples are tectonised, and fractures are filled with calcite; joints are occasionally manganised. The pillow structure is visible despite tectonic disintegration. Within the metabasalts there is a layer of light-green basic tuff, which in the lower part is crystalloclastic, and in the upper part crystallovitroclastic. Lithoclasts are fragments of metabasalts, and crystalloclasts are fragments of albite and fresh to altered augite. Tuffs have homogenuous structure, but are, like the metabasalts, intensely tectonically disintegrated.

The boundary between the pillow-lava and sediments is irregular (Fig. 3b). Weakly silty clayey shale, which overlies the effusive rocks in the succession, is intensely limonised along the fractures. The silt-sized component is composed of quartz grains, mica, and subordinate chlorite. Rounded zircon grains are accessory minerals. Horizontal lamination is a consequence of parallely oriented muscovite and/or illite.

The next interval is characterised by 30 cm thick bed of silicified radiolarian microsparite. In the calcite matrix there are up to 0.35 mm large radiolarian tests. They are filled with radial chalcedony, the marginal parts of which are calcitised. The interstices between some calcite crystals are filled with microcrystalline quartz. Haematite is an accessory.

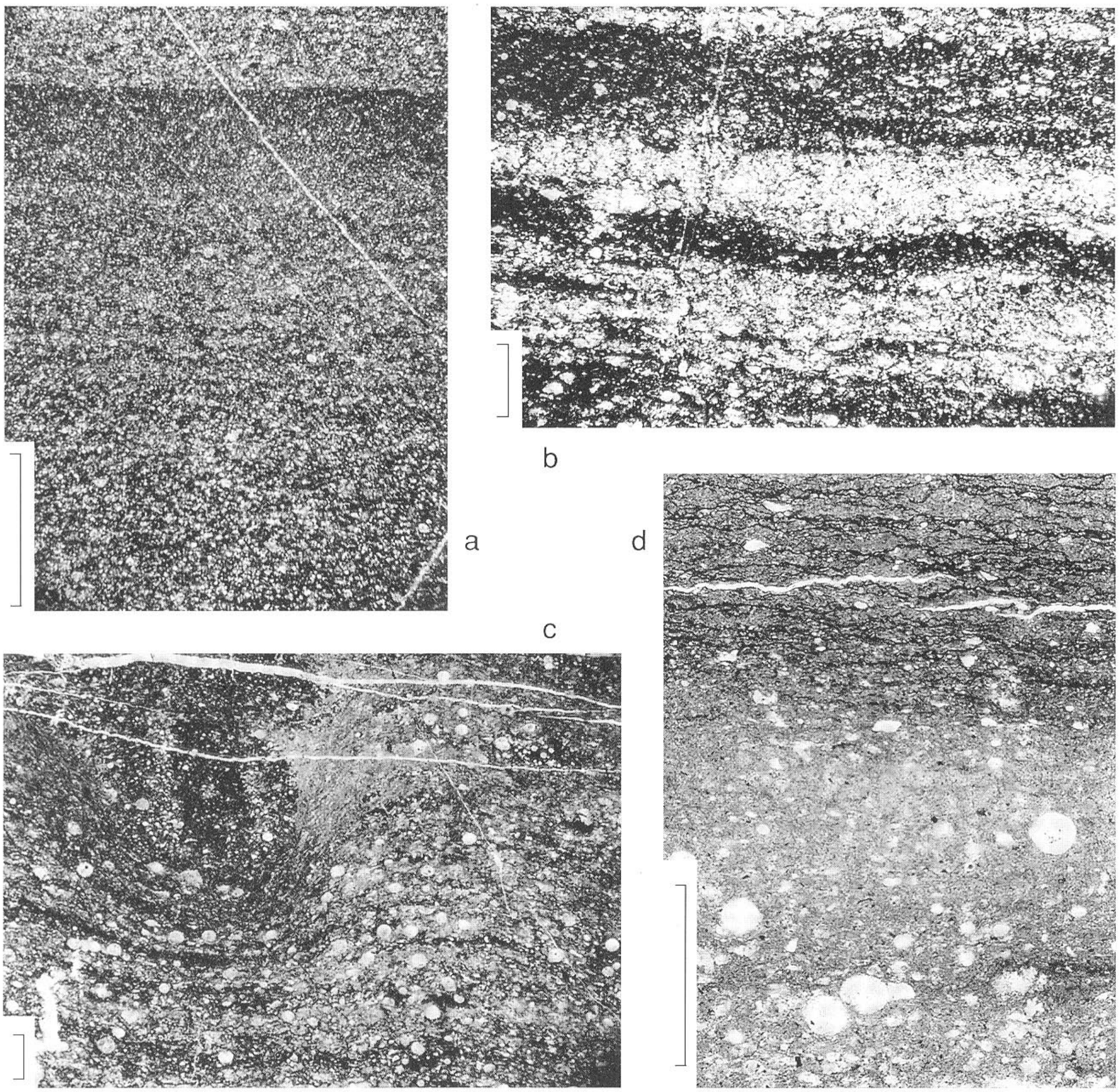

Fig. 4 a) A photomicrograph of normal gradational structure (Poljanica outcrop, Mt. Medvednica); b) a photomicrograph of parallel lamination (Poljanica outcrop, Mt. Medvednica); c) a photomicrograph of convolute lamination (Kestenik outcrop, Mt. Kalnik); d) a photomicrograph of weakly expressed normal gradation with microstylolites in the upper part of the interval (Kestenik outcrop, Mt. Kalnik). Scale bar = 1 mm.

The following 1.3 m of the section is composed of haematitised silty clayey shale, characterised by a laminated structure. Silt-sized components are represented by quartz grains and illite. X-ray analyses have determined that muscovite and/or illite comprise a significant proportion of the sediment, while quartz represents approximately 35%. Chlorite, plagioclase, haematite and vermiculite are subordinate.

For the next 2.75 m the colour of the rock is green-gray, probably as a consequence of lower haematite contents. This interval is composed of poor silty radiolarian cherts of an homogeneous structure. Radiolarian tests (0.1 to 0.15 mm in diameter) are irregularly distributed, and mostly completely recrystallized into microcrystalline quartz.

The upper part of the section is once again composed of reddish haematised radiolarian shale with infrequent, irregularly distributed radiolarian tests. The remainder of the section is covered, and probably cut by a fault towards the south.

Besides the horizontal lamination in the shales the succession has no other structural characteristics. Therefore, we suppose that it was deposited from suspension in a very quiet environment, with possible redeposition by weak bottom currents.

The Poljanica outcrops (3 on Fig. 1c) are situated on the NW slopes of the SW part of Medvednica Mt., in the valley of Poljanica creek, about 1.2 km eastern from Poljanica village. Sections of siliceous sediments totalling 12.5 m have been studied. The section "3b"

(Fig. 2) is strongly condensed (see section 4). The outcrops are represented by typical dark red, bedded radiolarites (Fig. 3c) with pinch and swell structures (JENKYNS & WINTERER, 1982), characterised by the alternation of centimetre- to decimetre-thick beds of radiolarian cherts with millimetre- to centimetre-thick beds of silty shales. Bedding surfaces are sharp, but irregular. The sediments are intensely folded, partially even overturned (section 3b), as indicated by inverse grading and micropalaeontological evidence (in the hipsometrically higher level an older autochthonous microfossil assemblage has been found compared to that in the lower part). The foot-wall of the radiolarite sequence is not known, due to intense tectonics, while the hanging-wall is represented by discordant Palaeocene calcitic siltstones. However, on the basis of current geological mapping of this region (HALAMIĆ, in prep.) it is possible to conclude that the examined Triassic radiolarites are partially overlain by similar silty siliceous sediments (radiolarian cherts, siliceous shales, siltstones, matrix-supported conglomerates and basic effusive rocks) of uncertain Jurassic age.

In the Poljanica section, 2-12 cm thick beds consist of haematised radiolarian cherts. The matrix is composed of microcrystalline quartz with mm radiolarian-enriched laminae (Fig. 4b). Radiolarian tests are filled predominantly with microcrystalline quartz; relics of radial chalcedony are infrequent. Sponge spicules and radiolarian debris of coarse silt to fine sand size also contribute to the sediment, as well as silt-sized clastic material composed of scarce quartz grains and muscovite/illite. Apatite and zircon are accessory minerals, and calcite represents secondary mineral filling in very small fractures. Macroscopically visible lamination is a consequence of different levels of haematisation. Under the microscope most samples exhibit graded intervals (Fig. 4a), characterised by an erosional lower surface and gradual transition into haematised silty shale. In these radiolarian cherts, as in the Kestenik section, anastomosed stylolites enriched in ferruginous matter occur (Fig. 4d).

Millimetre- to centimetre-thick beds of dark red silty shales are also intensely haematised. Rare radiolarian tests are irregularly distributed, but mostly well preserved, as a consequence of a clayey component which prevented silica dissolution and circulation during diagenesis. The main components of silty shales are muscovite and illite. Quartz comprises approximately 20%, plagioclase 15%, and haematite 5%, while chlorite is subordinate.

Within some beds of radiolarian chert, Mn-enriched laminae occur from a few-millimetre to 2 cm thick (Fig. 3d). Chemical analysis of one lamina has shown that it is composed of 47.96% MnO, 1.28% Fe_2O_3 and 1.19% TiO_2. Manganese is probably genetically related to volcanism, as a consequence of hydrothermal activity during, or immediately after, basic effusion on the sea-bed.

In the middle part of this section a 20 cm thick bed of green-gray, homogeneous tuffitic radiolarian silty shale has been observed. It is composed of clay minerals and cryptocrystalline quartz. Completely recrystallized radiolarian tests, up to 0.15 mm in diameter, are also filled with cryptocrystalline quartz. Accessory components include apatite, zircon and haematite, while calcite and chlorite are probably of a secondary origin. Apatite and zircon could also be related to the volcanic activity, as already described in the Mn-enriched sediments.

On the basis of sedimentary structures (especially gradation and lamination), and grain size it may be concluded that these rocks were (as well as the rocks from the Kalnik Mt.) deposited from low-density turbidite currents and reworked by bottom currents. The small grain size probably indicates distal turbidites. Contemporaneous volcanic activity is directly expressed at Kestenik and Jazvina outcrops by effusive rocks in the lower parts of sections, while at the Poljanica outcrop there are only indirect volcanic indicators (represented by a tuffitic component and Mn-enriched beds). However, it is possible that in the footwall of the investigated radiolarites from the Medvednica Mt. there were also effusive rocks, which were reduced by thrust-tectonics.

4. RADIOLARIAN BIOSTRATIGRAPHY

Eight radiolarian-bearing samples have been studied. The position of samples is shown in Fig. 2. Radiolarians were extracted using standard HF methods.

Locality Kestenik (1):

Sample KE 8: red chert, 2 m above the contact with pillow lavas. Radiolarian content:

Betraccium (?) sp., Pl. II, Figs. 1-2.
Capnuchosphaera cf. *crassa* YEH 1990
Capnuchosphaera triassica DE WEVER, in DE WEVER et al. 1979, Pl. II, Fig. 9.
Nakasekoellus sp.
Spongostylus carnicus KOZUR & MOSTLER 1979

Sample KE 12: red laminated chert, 16.5 m above the contact with pillow lavas. Radiolarian content:

Capnodoce sp., Pl. II, Figs. 3, 5.
Capnuchosphaera cf. *lea* DE WEVER, in DE WEVER et al. 1979
Nakasekoellus sp., Pl. I, Fig. 19.
Spongostylus carnicus KOZUR & MOSTLER 1979, Pl. II, Fig. 19.
Xiphotheca sp., Pl. I, Fig. 23.

Age: Both samples are dominated by *Capnuchosphaera* and detached twisted curved spines, which we assigned to *Spongostylus carnicus* KOZUR & MOSTLER. Numerous multicyrtid nassellarians generally resembling *Triassocampe* or *Annulotriassocampe* are present but cannot be determined due to poor preservation.

Spongostylus carnicus KOZUR & MOSTLER first appears in the Middle Carnian (Julian) (KOZUR & MOSTLER, 1994). The latest occurrence of S. *carnicus* documented so far is Late Carnian (CARTER et al., 1989). The earliest occurrence of *Nakasekoellus* is reported from probably the Late Carnian or late Middle Carnian *Nakasekoellus inkensis* Zone (KOZUR & MOSTLER, 1994). This genus (determined as *Xipha*) ranges to the late Middle Norian *Latium paucum* Subzone (BLOME, 1984).

In sample KE 12 rare and relatively small specimens of *Capnodoce* occur. The earliest well dated appearance of *Capnodoce* is Late Carnian based on associated ammonoids and conodonts (CARTER et al., 1989; CARTER, 1991). The concluded age for sample KE 12 is thus Late Carnian, and for sample Ke 8 lacking *Capnodoce* Middle to Late Carnian.

Locality Jazvina (2):

Sample JA 3: dark red chert, 3 m above the contact with pillow lavas. Radiolarian content:

Capnodoce anapetes DE WEVER, in DE WEVER et al. 1979, Pl. II, Fig. 7.
Capnodoce sp., Pl. II, Fig. 8.
Capnuchosphaera cf. *constricta* (KOZUR & MOCK), in KOZUR & MOSTLER 1981, Pl. II, Fig. 11.
Capnuchosphaera theloides DE WEVER, in DE WEVER et al. 1979, Pl. II, Fig. 13.
Capnuchosphaera (?) sp., Pl. II, Fig. 10.
Nassellaria gen. et sp. indet., Pl. I, Fig. 18.
Sarla sp., Pl. II, Figs. 17, 20.
Xiphotheca karpenissionensis DE WEVER, in DE WEVER et al. 1979, Pl. I, Fig. 25.
Xiphotheca sp., Pl. I, Fig. 24.
Whalenella cf. *regia* (BLOME) 1984, Pl. I, Figs. 21-22.
Whalenella sp., Pl. I, Fig. 20.

Age: *Capnuchosphaera* and *Capnodoce* are the most frequent genera in this sample. *Capnodoce* ranges from the Late Carnian (CARTER et al., 1989; CARTER, 1991) to the late Middle Norian (BLOME, 1984), *Capnuchosphaera* has a longer stratigraphic range. *Whalenella* (determined as *Corum*) is restricted to the *Capnodoce Zone* (Late Carnian?/Early to late Middle Norian) (BLOME, 1984). The age of this sample is thus Late Carnian to Middle Norian.

This assemblage differs from the assemblage found in sample KE 12 at Kestenik by containing more abundant and larger specimens of *Capnodoce*, and by lacking *Spongostylus carnicus* KOZUR & MOSTLER. This difference probably indicates that the assemblage from sample JA 3 is younger, i. e. latest Carnian to Middle Norian.

Sample JA 5: red vitreous chert. The section with sample JA 5 is separated from the section with sample JA 3 by a fault. The contact with pillow lavas has not been observed. Radiolarian content:

Capnodoce anapetes DE WEVER, in DE WEVER et al. 1979, Pl. II, Fig. 6.
Capnuchosphaera theloides DE WEVER, in DE WEVER et al. 1979
Capnuchosphaera triassica DE WEVER, in DE WEVER et al. 1979
Xiphotheca sp.
Whalenella sp., Pl. I, Fig. 17.

Age: This assemblage is a correlative of the assemblage from sample JA 3, which is assigned to the Late (probably latest) Carnian to Middle Norian.

Locality Poljanica (3):

Sample PC 58: dark red chert. Radiolarian content:

Capnodoce sp., Pl. II, Fig. 4.
Capnuchosphaera crassa YEH 1990, Pl. II, Fig. 12.
Capnuchosphaera cf. *lea* DE WEVER, in DE WEVER et al. 1979, Pl. II, Figs. 14-15.
Capnuchosphaera triassica DE WEVER, in DE WEVER et al. 1979
Capnuchosphaera tricornis DE WEVER, in DE WEVER et al. 1979, Pl. II, Fig. 16.
Spongostylus carnicus KOZUR & MOSTLER 1979, Pl. II, Fig. 18.

Age: This sample is characterized by abundant specimens of *Capnuchosphaera,* spines of *Spongostylus carnicus* KOZUR & MOSTLER, and rare small *Capnodoce.* The species composition is similar to that found in sample KE 12 from Kestenik. It is assignable to Late Carnian.

Sample PC 3: dark red chert. Species content:

Gomberellus bispinosus (KOZUR & MOSTLER) 1981
Muelleritortis cochleata (NAKASEKO & NISHIMURA) 1979, Pl. I, Figs. 13-14.
Pseudostylosphaera goestlingensis (KOZUR & MOSTLER) 1979
Spongoserrula rarauana DUMITRICĂ 1982, Pl. I, Fig. 2.
Triassocampe sp.

Sample PC 15: dark red chert. Species content:

Muelleritortis cf. *cochleata* (NAKASEKO & NISHIMURA) 1979
Muelleritortis (?) sp., Pl. I, Fig. 12.
Pseudostylosphaera goestlingensis (KOZUR & MOSTLER) 1979, Pl. I, Fig. 9.
Triassocampe sp.

Sample PC 59: dark red chert. Species content:

Gomberellus bispinosus (KOZUR & MOSTLER) 1981, Pl. I, Fig. 6.
Hungarosaturnalis sp., Pl. I, Fig. 7.
Muelleritortis cochleata (NAKASEKO & NISHIMURA) 1979
Muelleritortis firma (GORIČAN), in GORIČAN & BUSER 1990, Pl. I, Fig. 15.
Oertlispongus inaequispinosus DUMITRICĂ, KOZUR & MOSTLER 1980, Pl. I, Fig. 1

Pseudostylosphaera goestlingensis (KOZUR & MOSTLER) 1979, Pl. I, Figs. 8, 10-11.
Spongoserrula cristagalli DUMITRICĂ 1982, Pl. I, Figs. 3-5.
Triassocampe sp.
Wuranella cf. *carnica* KOZUR & MOSTLER 1981, Pl. I, Fig. 16.
Zhamojdasphaera sp.

Age: Samples PC 3, PC 15 and PC 59 contain *Muelleritortis cochleata* (NAKASEKO & NISHIMURA). According to KOZUR & MOSTLER (1994), this species defines the *Muelleritortis cochleata* Zone (Langobardian) and disappears within the lower *Tritortis kretaensis* Zone (highest Langobardian or basal Cordevolian). *Hungarosaturnalis*, *Pseudostylosphaera* with twisted spines, and advanced Oertlispongidae are commonly associated with *M. cochleata*. The occurrence of *Oertlispongus inaequispinosus* DUMITRICĂ, KOZUR & MOSTLER in this assemblage is rare, but it has been recorded (DUMITRICĂ,1982; DOZSTALY, 1991).

Summary: On Mt. Kalnik the radiolarites directly overlying basaltic volcanics are of Late Triassic age (Middle Carnian to Late Carnian at Kestenik, Late (probably latest) Carnian to Middle Norian at Jazvina). The radiolarites on Mt. Medvednica are in part contemporaneous (Late Carnian) but range down to the Late Ladinian or base of Carnian.

5. GEOCHEMISTRY

Macroelements were measured using standard chemical analyses. Ca, Fe_2O_3, Mg and Al were analysed complexometrically by EDTA with corresponding indicators; Ti, Mn and P were analysed spectrophotometrically from the same solution. K and Na contents were measured by flame photometry, while Fe^{2+} and Si contents were determined gravimetrically. Volatiles were measured by loss of ignition at 1150°C (analysed by Vlasta JURIŠIĆ-MITROVIĆ, Institute of Geology, Zagreb).

Five samples of radiolarian cherts and five samples of siliceous silty shales were analysed. They were choosen as representatives of both the sediment types, and also of the vertical succession. Results are shown in Table 1.

SiO_2 contents in cherts range from 87 to 93%, and are slightly higher in samples from Kalnik Mt. than from Medvednica Mt. The SiO_2 content of shales is lower, ranging from 67 to 83%, and is less in samples from Kalnik Mt. TiO_2 contents represent a measure of the input of clastic material (SUGISAKI, 1984), which explains why it is much lower in analysed radiolarites than in shales. However, it is obvious that determined contents in the radiolarian cherts (average 0.176%) are much higher than 0.045%, which is the average value for cherts of hydrothermal origin, i.e. cherts with low terrigenous contamination (ADACHI et al., 1986).

Sample	RADIOLARIAN CHERTS					SILICEOUS SILTY SHALES				
	KE -9	JA - 14	PF - 1	PF - 6	PF - 10	KE - 5	KE - 14	JA - 11	PC - 32	PF - 4
SiO_2	89.24	93.88	87.88	88.05	88.29	79.83	73.78	67.03	83.17	80.06
TiO_2	0.35	0.07	0.11	0.18	0.17	0.41	0.37	0.69	0.21	0.20
Al_2O_3	3.11	1.66	3.26	2.64	3.70	4.34	8.98	10.25	3.06	5.94
Fe_2O_3	0.62	0.65	1.11	3.07	2.91	2.74	4.72	5.07	2.71	4.63
FeO	1.52	1.24	0.98	0.73	0.68	0.69	1.14	1.65	0.72	0.74
MnO	0.07	0.07	0.24	0.18	0.11	0.08	0.14	0.12	0.15	0.13
MgO	0.20	0.42	1.88	0.62	0.71	1.89	1.83	3.06	0.64	1.45
CaO	1.49	0.34	0.63	0.71	0.70	0.98	1.96	1.32	2.47	0.67
Na_2O	0.45	0.17	0.38	0.53	0.18	1.22	0.46	1.69	0.81	0.59
K_2O	1.01	0.36	0.78	1.27	0.48	3.33	2.60	4.39	2.17	2.49
P_2O_5	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01
LOI	1.25	0.58	2.42	1.45	1.54	3.64	3.75	4.33	3.10	2.81
Total %	99.31	99.44	99.67	99.43	99.47	99.15	99.73	99.60	99.21	99.71
[1]$CaCO_3$	2.49	0.52	0.95	1.12	1.05	1.51	3.01	1.80	4.23	0.86
Si/Si+Al+Fe+Ca	0.9060	0.9453	0.9170	0.8991	0.8915	0.8725	0.7692	0.7367	0.8694	0.8342
Si/Si+Al+Fe	0.9275	0.9502	0.9264	0.9092	0.9012	0.8871	0.7940	0.7534	0.9051	0.8432
Al/Al+Fe+Mn	0.4965	0.3737	0.5001	0.3287	0.4250	0.4774	0.5251	0.5243	0.3865	0.4454
Fe/Ti	7.6988	33.8544	23.3505	25.1511	25.1619	9.9788	18.8891	11.6719	19.4996	31.8065
MnO/TiO_2	0.2000	1.0000	2.1818	1.0000	0.6471	0.1951	0.3783	0.1739	0.7143	0.6500

Table 1 Chemical composition (in weight %) of radiolarian cherts and siliceous silty shales from Mt. Kalnik (samples KE - Kestenik, and JA - Jazvina) and Mt. Medvednica (samples PF and PC - Poljanica).
[1]$CaCO_3$ contents is calculated after BALTUCK (1982).

Al_2O_3 contents are generally lower in radiolarites, which is a consequence of the greater proportion of alumosilicates in the shales.

However, it is obvious that radiolarites from the Kestenik and Jazvina sections have higher values than similar rocks from Medvednica Mt. $CaCO_3$ contents calculated by Baltuck's method (BALTUCK, 1982) range from 0.9 to 4.2% in shales, and from 0.5 to 2.5% in radiolarites. However, in samples which were chemically analysed detrital calcite has not been found by macroscopic or microscopic analyses, except in sample PF-4. Therefore, such $CaCO_3$ contents is interpreted as a consequence of the secondary filling of fractures, which is obvious especially in the upper part of the Poljanica section; only a minute part could be ascribed to analytical error.

Furthermore, different macroelement ratios were calculated, to gain information on the origin of the silica in the sediment, on the terrigenous influence, as well as on depositional environment and synsedimentary hydrothermal influence (SUGISAKI et al., 1982; BALTUCK, 1982; ADACHI et al., 1986; RUIZ-ORTIZ et al., 1989).

The Si/Si+Al+Fe+Ca ratio gives information on the contents of biogenic silica vs. alumosilicates, ferruginous and calcium minerals (RUITZ-ORTIZ et al., 1989). Typical values for rocks rich in biogenic silica are 0.8-0.9. Already during microscope examination it was obvious that the silica in the samples is mostly of biogenic origin (abundant radiolarians, spicules and siliceous biogenic detritus), which is confirmed by Si/Si+Al+Fe+Ca ratio ranging from 0.89 to 0.94 (average 0.91) in radiolarian cherts, and from 0.73 to 0.87 (average 0.82) in siliceous silty shales. Moreover, the input of silica in the pore water during weathering of alumosilicates and volcanic material is very small, especially regarding the influence of organic input (CALVERT, 1974).

The Al/Al+Fe+Mn ratio represents an indicator of the terrigenous origin of detrital material, i.e. a measure of the relative input of terrigenous vs. marine material (BALTUCK, 1982; RUITZ-ORTIZ et al., 1989). Typical continental matter has a value of 0.619 (average compositional value of shale), marine biogenic material has a value of 0.39 (BALTUCK, 1982), while the value of this ratio for pelagic clay of average composition amounts to 0.56 (WEDEPOHL, 1969). Sediments deposited under more important hydrothermal influence have lower values, ranging from 0.12 to 0.32 (ADACHI et al., 1986). The analysed radiolarian cherts have an Al/Al+Fe+Mn ratio of 0.43, and siliceous silty shales of 0.47 (both values are average), which indicates their biogenic origin with some terrigenous influence (microscopically determined detrital quartz grains and muscovite and/or illite of silt-size). Therefore, it may be concluded that the depositional environment had some continental influence, i.e. it was probably a marginal sea or distal part of the continental slope. Sample PF-6 from the Medvednica Mt. has value 0.33, which could indicate a hydrothermal influence, also testified by Mn-enriched beds.

Higher MnO/TiO_2 and Fe/Ti ratios also indicate a hydrothermal influence (SUGISAKI et al., 1982; SUGISAKI, 1984; ADACHI et al., 1986). Examined radiolarian cherts and siliceous shales from the Kalnik and Medvednica Mts. have higher values (Table 1) than Triassic cherts and shales from Kamis (Central Japan) which were not influenced by hydrothermal activity (MnO/TiO_2 average ratio for radiolarian cherts 0.254, and for shales 0.168 - SUGISAKI et al., 1982; ADACHI et al., 1986). This indicates a hydrothermal influence, i.e. Mn and Fe input during sedimentation. Therefore, this ratio could represent further, although indirect evidence that the Mn-enriched beds from the Poljanica section are of hydrothermal origin.

By comparison of the MnO/TiO_2 ratio in examined samples with recent marine sediments it could be possible to indirectly infer a sedimentary environment for the siliceous deposits from Kalnik and Medvednica Mts. However, the relatively high variation of the MnO/TiO_2 ratio in examined deposits (0.2 to 2.18 in radiolarian cherts, 0.17 to 0.71 in siliceous silty shales) is probably a consequence of synsedimentary hydrothermal influence; therefore, it would not be proper to use this criterion as a reliable indicator of depositional environment, i.e. basin character. Calculated values of the MnO/TiO_2 ratio for examined samples of siliceous deposits from Kalnik and Medvednica Mts. would approximately fit into the range of pelagic sediments sampled from the Pacific Ocean floor more than 800 km from nearest land. This comparison is clearly discordant with other obtained data, especially the relatively abundant silt-sized detritus in radiolarian cherts and values of the Al/Al+Fe+Mn ratio.

6. DEPOSITIONAL ENVIRONMENT

Siliceous sediments from the Kalnik and Medvednica Mts. were rhythmically deposited: beds of biogenically enriched radiolarian cherts alternate with siliceous shales enriched with terrigenous material. Their rhythmical character was predisposed by the cyclical input of chalcedony related to the variable productivity of planktic organisms due to upwelling processes (DE WEVER, 1994), as well as by oscillations in terrigenous input (dilution cycles - DECKER, 1991). However, rhythmicity could also represent the consequence of resedimentation by turbidity currents and conturites, as shown by the double accumulation model, which suggests that radiolarian cherts were accumulated by the continuous slow sedimentation of siliceous biogenic material (radiolarians, spicules, etc.), while the shale represents phases of rapid sedimentation of terrigenous material by distal turbidites (IJIMA et al., 1985).

A major part of the structural characteristics described in the investigated sections indicate that at least part of the cherts were deposited from low-densi-

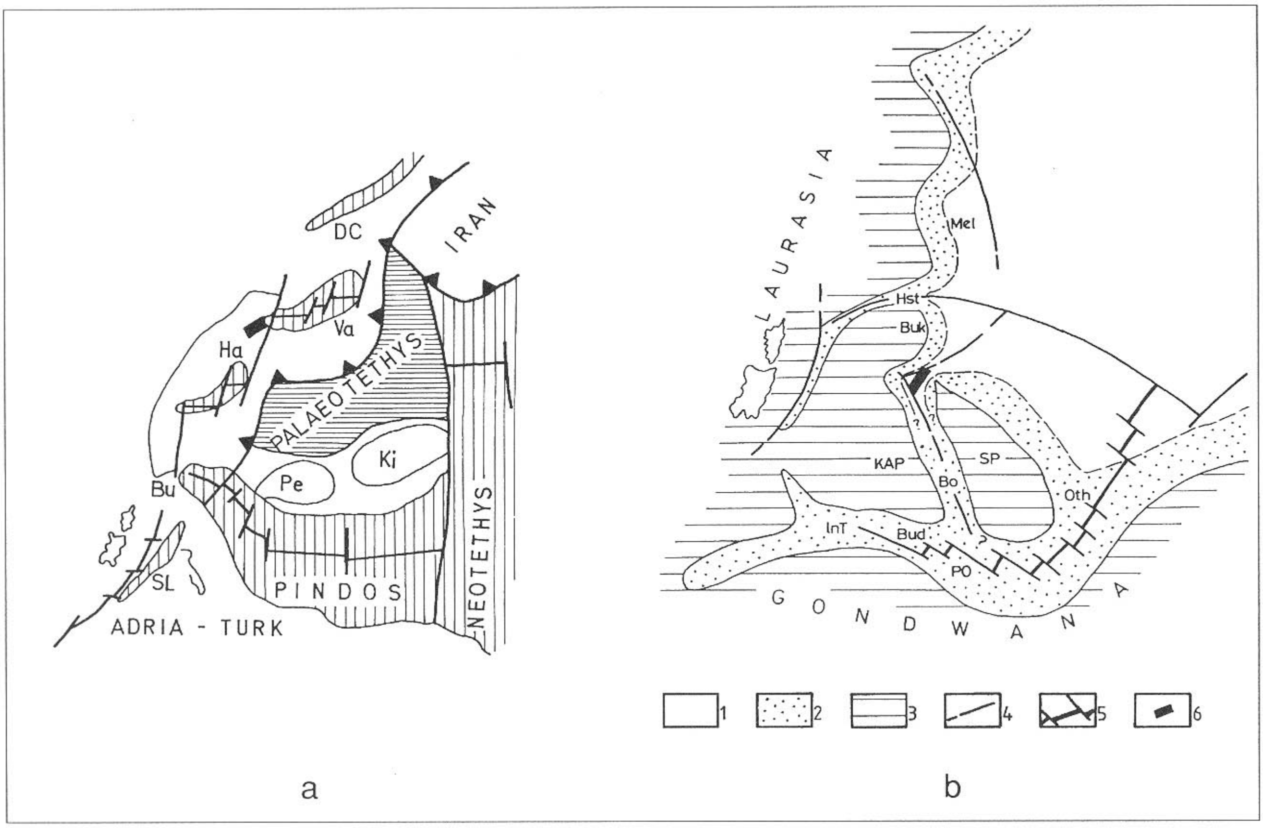

Fig. 5 a) Palaeogeographic location of studied radiolarites from Kalnik and Medvednica Mts. in the Late Triassic (map after STAMPFLI & PILLEVUIT, 1993). Legend: SL - Sosio-Lagonegro trough; Bu - Budva; Ha - Hallstatt trough; Va - Vardar; DC - Dici-Crimea trough; Pe - Pelagonian terrane; Ki - Kirshehir; ■ - position of studied radiolarites. b) Palaeogeographic location of studied radiolarites from Kalnik and Medvednica Mts. in Late Triassic (map after MARCOUX et al., 1993 - partly modified). Legend: 1 - deep basin below CCD; 2 - slope or deep basin above CCD; 3 - shallow platform; 4 - fault; 5 - active spreading ridge; 6 - position of studied radiolarites; Bo - Bosnia; PO - Pindos-Olos; Bud - Budva; InT- Lagonegro basin; Oth - Othrys; SP - Serbo-Pelagonian; KaP - Karst platform; Buk - Bükk; Hst - Hallstatt; Mel - Meliata unit.

ty, low-velocity turbidity currents (NISBET & PRICE, 1974; FOLK & McBRIDE, 1978; SUGISAKI et al., 1982) combined with redeposition by bottom currents (JENKYNS & WINTERER, 1982, VECSEI et al., 1989). During quiet periods terrigenous material was deposited from suspension, resulting in millimetre to centimetre-thick beds of siliceous silty shales (dillution cycles - DECKER, 1991). According to the grain-size of the turbidite sequences their distal character may be infered.

The scarcity of primary calcite in the studied sediments at the Kestenik and Poljanica localities indicate that depositional depth was below the calcite compensation depth (CCD). From the 30 cm thick bed of silicified radiolarian microsparite in the lower part of the Jazvina section it may be concluded that it was probably deposited slightly above the CCD. However, this does not mean that during deposition of the studied sediments from Kalnik and Medvednica Mts. there was a global vertical variation of the calcite compensation depth; this was probably a consequence of a local aberration (BERGER & WINTERER, 1974). As the siliceous sediments were deposited in a marine basin of relatively modest dimensions, and not very far from land, it may be presumed that the CCD was rather shallow. The CCD is generally shallow where the productivity of plankton is high. It can, furthermore, be concluded that the radiolarites from the Kalnik and Medvednica Mts. were accumulated relatively far from the highly productive carbonate platforms which could have exported carbonate mud offshore and led to the deposition of periplatform carbonate ooze in the basin (BAUMGARTNER, 1987).

7. PALAEOGEOGRAPHICAL IMPLICATIONS

It is very difficult to make a palaeogeographic reconstruction of the studied sections, as: (1) the studied sections underwent very intense radial and tangential tectonic deformation since the Triassic, resulting in the present contacts of rocks of different age and lithology, and (2) Triassic rocks are commonly overlain by a thick Tertiary-Quaternary succession. Therefore, allochthonous radiolarites of the Kalnik and Medvednica Mts. represent small relics of obducted Triassic deep-sea sediments; the largest part was consumed during the (?)Early Cretaceous subduction of former ocean crust under the Eurasian continent.

For a more complete picture of the palaeogeographical position of the radiolarites from the Kalnik and Medvednica Mts. in the Triassic they should be correlated with contemporaneous rocks from neighbouring areas deposited in similar environments. The nearest outcrops of similar rocks can be found about 150 km southeastern of Medvednica in Northwest and central Bosnia, in a 200 km long zone composed of radiolarites associated with Upper Triassic micrites and spilites (PAMIĆ et al., 1981). The major part of radiolarites from this zone are probably of Jurassic to Early Cretaceous age (PAMIĆ, 1982). Triassic (Carnian-Norian) radiolarites directly overlying pillow lavas were found in the Vardar Zone in Serbia (OBRADOVIĆ & GORIČAN, 1989).

Towards the NE, in the borehole Inke, south of Lake Balaton, ophiolitic rocks associated with Upper Carnian or upper Middle Carnian radiolarian-bearing siliceous rocks are present (KOZUR, 1994, appendix to KOZUR & MOSTLER, 1994). They can be well correlated with our Upper Triassic sequences from Mt. Kalnik.

In the Meliata Unit in northeastern Hungary and southern Slovakia, radiolarites overlying or interbedded with pillow lavas are assigned to the Early Ladinian, Late Ladinian and Early Carnian (Cordevolian) (KOZUR & MOCK, 1973; DE WEVER, 1984; KOZUR & RÉTI, 1986; KOZUR, 1991; DOSZTÁLY & JÓZSA, 1992). In Middle Carnian to Norian radiolarites of the Meliata Unit no intercalations of volcanics have been found (KOZUR, 1991). The Middle to Late Carnian (Kestenik section) and Late Carnian to Norian (Jazvina section) ages of radiolarites in contact with basic volcanics suggest that sea-floor spreading was still active in the study area while it had already ceased in the Meliata Basin.

Upper Ladinian to Upper Carnian radiolarites from Mt. Medvednica, the base of which is not known, could have been deposited either on oceanic crust or on thinned continental crust. Correlation of this isolated radiolarite sequence with any other basinal sequence is difficult. Middle and Upper Triassic radiolarites are common in the Meliata Unit (DE WEVER, 1984; KOZUR, 1991; DOSZTÁLY & JÓZSA, 1992), and some Middle Triassic radiolarites were found as megablocks in the ophiolitic melange in the Vardar Zone as well as in the South-western Diabase-Chert Formation Belt (OBRADOVIĆ & GORIČAN, 1989). Current investigation (HALAMIĆ & GORIČAN, in prep.) revealed that on Mt. Medvednica radiolarites and megabreccias of Jurassic age are present but a Jurassic age for the effusive rocks has not been confirmed. As Jurassic turbidites and olistostromes are known also from the Meliata Unit (KOZUR, 1991) this would suggest the possibility that the basin evolution of both areas was rather similiar.

According to the results of sedimentological and geochemical investigations presented in this paper it may be concluded that the basin represented by studied outcrops from Kalnik and Medvednica Mts. was located rather close to the land. We suppose that the radiolarites were deposited during the Middle to Late Triassic relatively close to the continent or continents, i.e. in the vicinity of a slope or in a marginal sea between them.

The possible position of the studied area in two alternative Late Triassic palaeogeographic maps by STAMPFLI & PILLEVUIT (1993) and by MARCOUX et al. (1993) is shown in Figs. 5a and 5b.

8. CONCLUSIONS

1. Siliceous sediments of Kalnik and Medvednica Mts. are typical ribbon bedded cherts. On Mt. Kalnik they are concordantly lying upon pillow lavas, composing one geological formation. On Mt. Medvednica their foot-wall is unknown, due to tectonic reduction.

2. On the basis of radiolarian biostratigraphy a Middle Carnian to Norian age for the radiolarites from Kalnik Mt., and a Late Ladinian to Late Carnian age for radiolarites from Medvednica Mt. has been determined. Since these rocks on Kalnik Mt. are lying directly on pillow lavas or are interbedded with them (Kestenik outcrop) the volcanics are also of Late Triassic age.

3. According to their structural characteristics (horizontal lamination, gradation and convolute lamination), we suggest deposition from low-density turbidity currents for the radiolarites. Subsequently they were probably reworked by bottom currents. Depositional depth was close to the CCD, which was probably rather shallow.

4. Petrological, sedimentological and geochemical results indicate deposition in a relatively narrow basin or relatively close to the land (important terrigenous influence) characterised by hydrothermal activity.

5. Studied sections could be correlated with the nearest outcrops of Triassic radiolarites associated with basic volcanic rocks. The studied area was probably part of the Vardar Basin.

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9. REFERENCES

ADACHI, M., YAMAMOTO, K. & SUGISAKI, R. (1986): Hydrothermal chert and associated siliceous rocks from the Northern Pacific: Their geological significances as an indication of ocean ridge activity.- Sedimentary Geol., 47, 125-148.

BABIĆ, Lj. (1974b): Jurassic-Cretaceous sequence of Mt. Ivanščica.- Bull. Sci. Cons. Acad. Yougosl., (A) 19/7-8, 180-181, Zagreb.

BALTUCK, M. (1982): Provenance and distribution of Tethyan pelagic and hemipelagic siliceous sediments, Pindos Mountains, Greece.- Sedimentary Geol., 31, 63-88.

BASCH, O. (1981): Osnovna geološka karta 1:100.000, list Ivanić-Grad L 33-81.- Institut za geol. istr. Zagreb, Sav. geol. zavod, Beograd.

BASCH, O. (1983): Tumač za Osnovnu geološku kartu, list Ivanić-Grad L 33-81.- Institut za geol. istr. Zagreb, Sav. geol. zavod, 1-66, Beograd.

BAUMGARTNER, P.O. (1987): Age and genesis of Tethyan Jurassic radiolarites.- Eclogae geologicae Helvetiae, 80/3, 831-879.

BERGER, W.H. & WINTERER, E.L. (1974): Plate stratigraphy and the fluctuating carbonate line.- In: HSÜ K.J. & JENKYNS H.C. (eds.): Pelagic sediments on land and under the sea. IAS Spec. Publ., 1, 11-48.

BLOME, C.D. (1984): Upper Triassic Radiolaria and Radiolarian Zonation from Western North America.- Bull. Amer. Paleontology, 85/318, 1-88.

CALVERT, S.E. (1974): Deposition and diagenesis of silica in marine sediments.- In: HSÜ K.J. & JENKYNS H.C. (eds.): Pelagic sediments on land and under the sea. IAS Spec. Publ., 1, 273-299.

CARTER, E.S. (1991): Late Triassic radiolarian biostratigraphy of the Kunga Group, Queen Charlotte Islands, British Columbia.- In: Evolution and Hydrocarbon Potential of the Queen Charlotte Basin, British Columbia. Geological Survey of Canada, Paper 90-10, 195-201.

CARTER, E.S., ORCHARD, M.J. & TOZER, E.T. (1989): Integrated ammonoid-conodont-radiolarian biostratigraphy, Late Triassic Kunga Group, Queen Charlotte Islands, British Columbia.- Current Research, Part H., Geological Survey of Canada, Paper 89-1H, 23-30.

CRNKOVIĆ, B. (1963): Petrografija i petrogeneza magmatita sjeverne strane Medvednice.- Geol. vjesnik, 16, 63-160.

DECKER, K. (1991): Rhythmic bedding in siliceous sediments - an overview.- In: EINSELE, G., RICKEN, W. & SEILACHER, A. (eds.): Cycles and events in stratigraphy. Springer Verlag, 464-479.

DE WEVER, P. (1982): Radiolaires du Trias et du Lias de la Tethys (Systématique, Stratigraphie).- Société Géologique du Nord, Publication no. 7, 1-599.

DE WEVER, P. (1984): Triassic radiolarians from the Darnó area (Hungary).- Acta geol. Hungarica, 27/3, 295-306.

DE WEVER, P. (1989): Radiolarians, radiolarites and Mesozoic paleogeography of the Circum-Mediterranean Alpine belts.- In: HEIN, J.R. & OBRADOVIĆ, J. (eds.): Siliceous deposits of the Tethys and Pacific Regions. Springer Verlag, 31-49.

DE WEVER, P. (1994): Radiolarians and radiolarite.- C.R. Acad. Sci., Paris, 319/II, 513-526.

DE WEVER, P., SANFILIPPO, A., RIEDEL, W.R. & GRUBER, B. (1979): Triassic radiolarians from Greece, Sicily and Turkey.- Micropaleontology, 25/1, 75-110.

DOSZTÁLY, L. (1991): Triassic radiolarians from the Balaton Upland.- Magyar Állami Földtani Intezet, Ann. Reports 1989, 333-355.

DOSZTÁLY, L. & JÓZSA, S. (1992): Geochronological evaluation of Mesozoic formations of Darnó Hill at Recsk on the basis of radiolarians and K-Ar Age data.- Acta geol. Hungarica, 35/4, 371-393.

DUMITRICĂ, P. (1982): Triassic Oertlisponginae (Radiolaria) from Eastern Carpathians and Southern Alps.- Dari de Seama, Inst. geol. geofiz., 67, 57-74.

DUMITRICĂ, P., KOZUR, H. & MOSTLER, H. (1980): Contribution to the radiolarian fauna of the Middle Triassic of the Southern Alps.- Geol. Paläont. Mitt. Innsbruck, 10/1, 1-46.

DUMITRICĂ, P. & MELLO, J. (1982): On the age of the Meliata Group and the Silica Nappe radiolarites (localities Držkovce and Bohúnovo, Slovak Karst, ČSSR).- Geol. práce, 77, 17-28.

FOLK, R.L. & McBRIDE, E.F. (1978): Radiolarites and their relation to subjacent "Oceanic Crust" in Liguria, Italy.- J.Sed.Petrol., 48, 1069-1102.

GORIČAN, Š. & BUSER, S. (1990): Middle Triassic radiolarians from Slovenia (Yugoslavia).- Geologija, 31-32, 133-197.

GORJANOVIĆ-KRAMBERGER, D. (1908): Geologijska prijegledna karta i tumač geologijskoj karti Zagreb (Zona 22, Col.XIV).- Naklada kr.zemaljske vlade, 1-75, Zagreb.

HAAS, J., CSÁSZÁR, G., KOVÁCS, S. & VÖRÖS, A. (1990): Evolution of the Western Part of the Tethys as reflected by the geological formations of Hungary.- Acta Geod. Geoph. Mont. Hung., 25/3-4, 325-344.

HAAS, J., KOVÁCS, S., KRYSTYN, L. & LEIN, R. (1995): Significance of Late Permian-Triassic facies zones in terrane reconstructions in the Alpine-North Pannonian domain.- Tectonophysics, 242, 19-40.

HERAK, M. (1986): A new concept of geotectonics of the Dinarides.- Acta geologica, 16, 1-42, Zagreb.

HERAK, M., JAMIČIĆ, D., ŠIMUNIĆ, A. & BUKOVAC, J. (1990): The northern boundary of the Dinarides.- Acta geologica, 20, 5-27, Zagreb.

IIJIMA, A., MATSUMOTO, R. & TADA, R. (1985): Mechanism of sedimentation of rhythmically bedded chert.- Sedimentary Geology, 41, 221-233.

JENKYNS, H.C. & WINTERER, E.L. (1982): Palaeoceanography of Mesozoic ribbon radiolarites.- Earth and Planetary Sci. Letters, 60, 351-375.

KELLICI, I. & DE WEVER, P. (1994): Ouverture triasique du bassin de la Mirdita (Albanie) révélée par les radiolaires.- C. R. Acad. Sci. Paris, 318/II, 1669-1676.

KOVÁCS, S., CSÁSZÁR, G., GALACZ, A., HAAS, J., NAGY, E. & VÖRÖS, A. (1989): The Tisza Superunit was originally part of the North Tethyan (European) Margin.- Mémoires de la Soc. Geol. de France, 4, 81-100, Paris.

KOZUR, H. (1991): The evolution of the Meliata-Hallstatt ocean and its significance for the early evolution of the Eastern Alps and Western Carpathians.- Palaeogeogr., Palaeoclimatol., Palaeoecol., 87, 109-135.

KOZUR, H. & MOCK, R. (1973): Die Bedeutung der Trias-Conodonten für die Stratigraphie und Tektonik der Trias in den Westkarpaten.- Geol. Paläont. Mitt. Innsbruck, 3/2, 1-14.

KOZUR, H. & MOSTLER, H. (1979): Beiträge zur Erforschung der mesozoischen Radiolarien. Teil III: Die Oberfamilien Actinommacea Haeckel 1862 emend., Artiscacea Haeckel 1882, Multiarcusellacea nov. der Spumellaria and triassische Nassellaria.- Geol. Paläont. Mitt. Innsbruck, 9/1-2, 1-132.

KOZUR, H. & MOSTLER, H. (1981): Beiträge zur Erforschung der mesozoischen Radiolarien. Teil IV: Thalassosphaeracea Haeckel, 1862, Hexastylacea Haeckel, 1882 emend. Petrushevskaja, 1979, Sponguracea Haeckel, 1862 emend. und weitere triassische Lithocycliacea, Trematodiscacea, Actinommacea und Nassellaria.- Geol. Paläont. Mitt. Innsbruck, Sonderbd., 1-208.

KOZUR, H. & MOSTLER, H. (1994): Anisian to Middle Carnian radiolarian zonation and description of some stratigraphically important radiolarians.- Geol. Paläont. Mitt. Innsbruck, Sonderbd. 3, 39-255.

KOZUR, H. & RÉTI, Z. (1986): The first paleontological evidence of Triassic ophiolites in Hungary.- N. Jb. Geol. Paläont. Mh., 1986/5, 284-292.

MARCOUX, J., BAUD, A., RICOU, L.E., BELLION, Y., BESSE, J., GAETANI, M., GALLET, Y., GUIRAUD, R., JAILLARD, E., KRYSTYN, L., MOREAU, C. & THEVENIAUT, H. (1993): Late Norian (215-212 Ma).- In: DERCOURT, J., RICOU, L.E. & VRIELYNCK, B. (eds): Atlas Tethys Palaeoenvironmental Maps, Gauthier-Villars, Paris, 307 p.

NAKASEKO, K. & NISHIMURA, A. (1979): Upper Triassic Radiolaria from Southwest Japan.- Sci. Rep., Col. Gen. Educ. Osaka Univ., 28/2, 61-109.

NISBET, E. G. & PRICE, I. (1974): Siliceous turbidites: Bedded cherts as redeposited ocean ridge-derived sediments.- In: HSÜ, K. J. & JENKYNS, H. C. (eds): Pelagic Sediments on Land and under the Sea. IAS Spec. Publ., 1, 351-366.

OBRADOVIĆ, J. & GORIČAN, Š. (1989): Siliceous Deposits in Yugoslavia: Occurences, Types and Ages.- In: HEIN, J. R. & OBRADOVIĆ, J. (eds): Siliceous deposits of the Tethys and Pacific Regions. Springer Verlag, 51-64.

PAMIĆ, J. (1981): Ofioliti i ofioliti Dinarida.- LMGK, Bilten 3, 175-184.

PAMIĆ, J. (1982): Some geological problems of the Dinaridic Ophiolites and their associations.- Earth Evolution Sci., 2/1, 30-35.

PAMIĆ, J., SUNARIĆ-PAMIĆ, O. & OLUJIĆ, J. (1981): Tumač za Osnovnu geološku kartu, list Teslić L 33-132.- Sav. geol. zavod, 1-65, Beograd.

PIPER, D.J.W. & STOW, D.A.V. (1991): Fine-grained turbidites.- In: EINSELE, G., RICKEN, W. & SEILACHER, A. (eds.): Cycles and events in stratigraphy. Springer Verlag, 360-376.

RUITZ-ORTIZ, P.A., BUSTILLO, M.A. & MOLINA, J.M. (1989): Radiolarite sequences of the Subbetic, Betic Cordillera, Southern Spain.- In: HEIN, J.R. & OBRADOVIĆ, J. (eds): Siliceous deposits of the Tethys and Pacific regions, 107-127.

STAMPFLI, G. & PILLEVUIT, A. (1993): An alternative Permo-Triassic reconstruction of the kinematics of the Tethyan realm.- In: DERCOURT, J., RICOU, L.E. & VRIELYNCK, B. (eds): Atlas Tethys Palaeoenvironmental Maps, Explanatory notes. Gauthier-Villars, Paris, 55-62.

SUGISAKI, R. (1984): Relation between chemical composition and sedimentation rate of Pacific Ocean-floor sediments deposited since the middle Cretaceous: Basic evidence for chemical constraints on depositional environments of ancient sediments.- J. Geol., 92, 235-259.

SUGISAKI, R., YAMAMOTO, K. & ADACHI, M. (1982): Triassic bedded chert in Central Japan are not pelagic.- Nature, 298, 644-647.

ŠIKIĆ, K., BASCH, O. & ŠIMUNIĆ, A. (1977): Osnovna geološka karta SFRJ 1:100.000, list Zagreb L 33-80.- Institut za geološka istraživanja Zagreb, Sav. geol. zavod, Beograd.

ŠIKIĆ, K., BASCH, O. & ŠIMUNIĆ, A. (1979): Tumač za Osnovnu geološku kartu SFRJ 1:100.000, list

Zagreb L 33-80.- Institut za geološka istraživanja Zagreb, Sav. geol. zavod, Beograd, 81p.

ŠIMUNIĆ, Al. & ŠIMUNIĆ, An. (1979): Litofacijelno rasčlanjivanje mezozojskih naslaga Kalničkog gorja.- Zbornik radova 4. god. Znan. skupa Sekcije za primjenu geol., geofiz., geokem. Znan. savjeta za naftu Jugosl. Akad. znan. i umjet., Stubičke Toplice (1978), 125-137, Zagreb.

ŠIMUNIĆ, An., PIKIJA, M. & HEĆIMOVIĆ, I. (1982): Osnovna geološka karta SFRJ 1:100.000, list Varaždin L 33-69.- Institut za geološka istraživanja Zagreb, Sav. geol. zavod, Beograd.

ŠIMUNIĆ, A., NAJDENOVSKI, J. & PAMIĆ, J. (1993): Chaotic rock complexes - possible hydrocarbon accumulations in South-Western Parts of the Pannonian Basin (Republic of Croatia).- Nafta, 44/11, 609-616, Zagreb.

VECSEI, A., FRISCH, W., PIRZER, M. & WETZEL, A. (1989): Origin and tectonic significance of radiolarian chert in the Austroalpine rifted continental margin.- In: HEIN, J.R. & OBRADOVIĆ, J. (eds.): Siliceous Deposits of the Tethys and Pacific Regions. Springer Verlag, 65-80.

VRKLJAN, M. (1994): Petrographic Characteristics of Extrusive Rocks from Hruškovec, Mt. Kalnik, NW Croatia.- Geol. Croat., 47/2, 181-191.

WEDEPOHL, K.H. (1969): Composition and abundance of common sedimentary rocks.- In: WEDEPOHL, K.H. (ed): Handbook of geochemistry, Vol. I, Springer Verlag, Berlin, Heidelberg, New York, 250-271.

YEH, K-Y. (1990): Taxonomic studies of Triassic Radiolaria from Busuanga Island, Philippines.- Bulletin of the National Museum of Natural Science, 2, 1-63.

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PLATE I

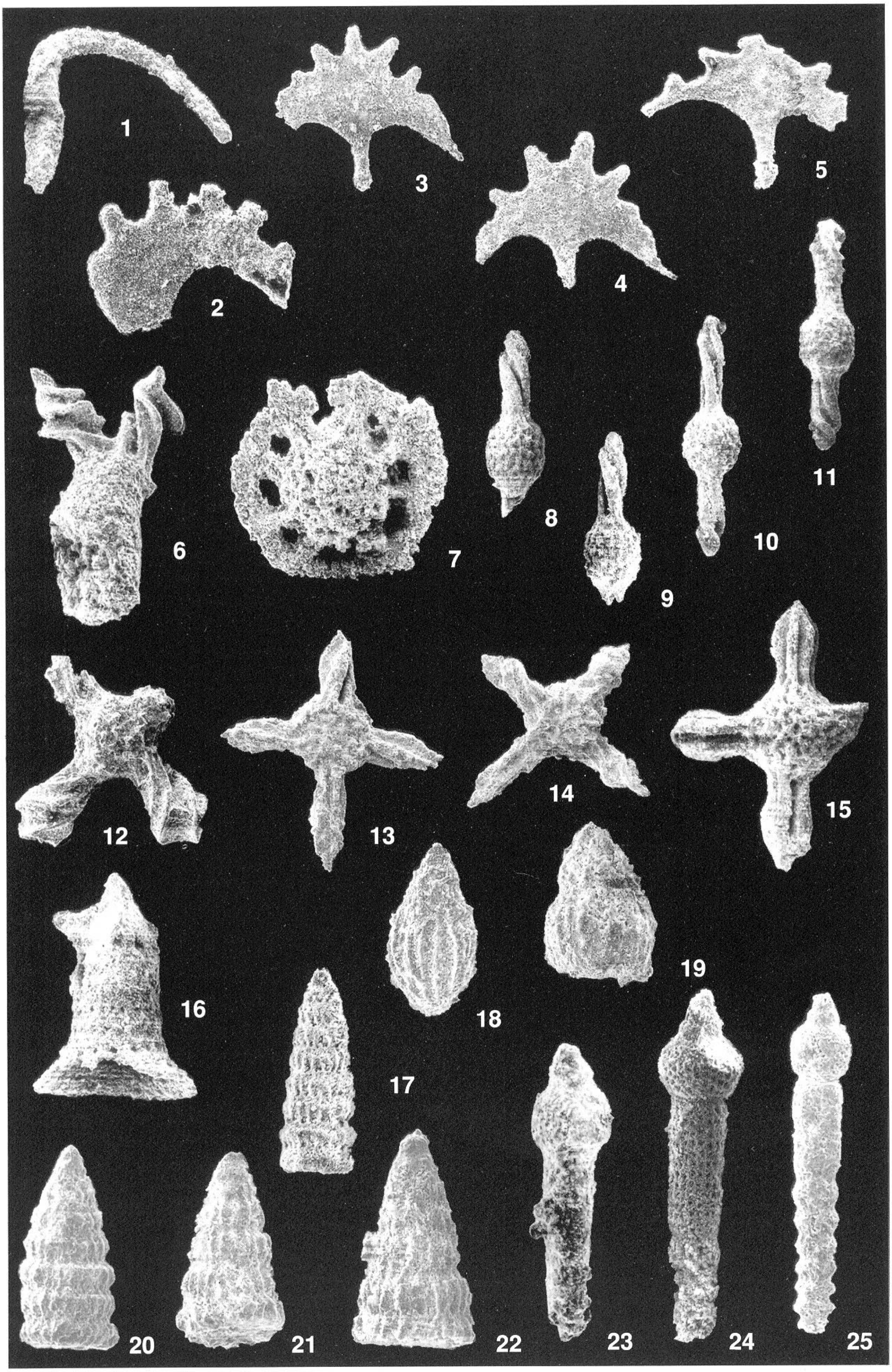
1	*Oertlispongus inaequispinosus* DUMITRICĂ, KOZUR & MOSTLER, PC 59, 940231, 150x.
2	*Spongoserrula rarauana* DUMITRICĂ, PC 3, 950124, 150x.
3-5	*Spongoserrula cristagalli* DUMITRICĂ, PC 59, 3: 940302, 4: 940303, 5: 940232, 100x. Specimens in Figs. 3-4 have a more symmetrical spine than the type material.
6	*Gomberellus bispinosus* (KOZUR & MOSTLER), PC 59, 940313, 200x.
7	*Hungarosaturnalis* sp., PC 59, 940227, 200x.
8-11	*Pseudostylosphaera goestlingensis* (KOZUR & MOSTLER), 8: PC 59, 940327; 9: PC 15, 940419; 10: PC 59, 940321; 11: PC 59, 940324; 100x.
12	*Muelleritortis* (?) sp., PC 15, 940414, 150x.
13-14	*Muelleritortis cochleata* (NAKASEKO & NISHIMURA), PC 3, 13: 950134, 14: 950131, 100x.
15	*Muelleritortis firma* (GORIČAN), PC 59, 940219, 150x.
16	*Wuranella* cf. *carnica* KOZUR & MOSTLER, PC 59, 940331, 200x.
17	*Whalenella* sp., JA 5, 940207, 200x.
18	Nassellaria gen. et sp. indet., JA 3, 940124, 200x.
19	*Nakasekoellus* sp., KE 12, 950405, 300x.
20	*Whalenella* sp., JA 3, 940132; 200x.
21-22	*Whalenella* cf. *regia* (BLOME), JA 3, 21: 940129, 22: 940125, 200x.
23-24	*Xiphotheca* sp., 23: KE 12, 950329; 24: JA 3, 940121; 200x.
25	*Xiphotheca karpenissionensis* DE WEVER, JA 3, 940123, 150x.

For each illustration the sample number, SEM-negative number, and magnification are indicated. The scanning electron micrographs were taken on a JEOL JSM-330A at the Ivan Rakovec Institute of Palaeontology, Scientific Research Centre of the Slovenian Academy of Sciences and Arts. Rock samples, residues and SEM negatives are stored in the collection of the second author.

PLATE II

1-2	*Betraccium* (?) sp., KE 8, 1: 950218, 2: 950217, 200x.
3-5	*Capnodoce* sp., 3: KE 12, 950313; 4: PC 58, 950102; 5: KE 12, 950403; 200x.
6-7	*Capnodoce anapetes* DE WEVER, 6: JA 5, 940210; 7: JA 3, 940115; 200x.
8	*Capnodoce* sp., JA 3, 940113, 200x.
9	*Capnuchosphaera triassica* DE WEVER, KE 8, 950230, 150x.
10	*Capnuchosphaera* (?) sp., JA 3, 940106, 150x.
11	*Capnuchosphaera* cf. *constricta* (KOZUR & MOCK), JA 3, 940111, 150x.
12	*Capnuchosphaera crassa* YEH, PC 58, 950108, 150x.
13	*Capnuchosphaera theloides* DE WEVER, JA 3, 940104, 150x.
14-15	*Capnuchosphaera* cf. *lea* DE WEVER, PC 58, 14: 950101, 15: 950117, 150x.
16	*Capnuchosphaera tricornis* DE WEVER, PC 58, 950105, 150x.
17	*Sarla* sp., JA 3, 940103, 150x.
18-19	*Spongostylus carnicus* KOZUR & MOSTLER, 18: PC 58, 950103; 19: KE 12, 950324, 150x.
20	*Sarla* sp., JA 3, 940102, 150x.

For each illustration the sample number, SEM-negative number, and magnification are indicated. The scanning electron micrographs were taken on a JEOL JSM-330A at the Ivan Rakovec Institute of Palaeontology, Scientific Research Centre of the Slovenian Academy of Sciences and Arts. Rock samples, residues and SEM negatives are stored in the collection of the second author.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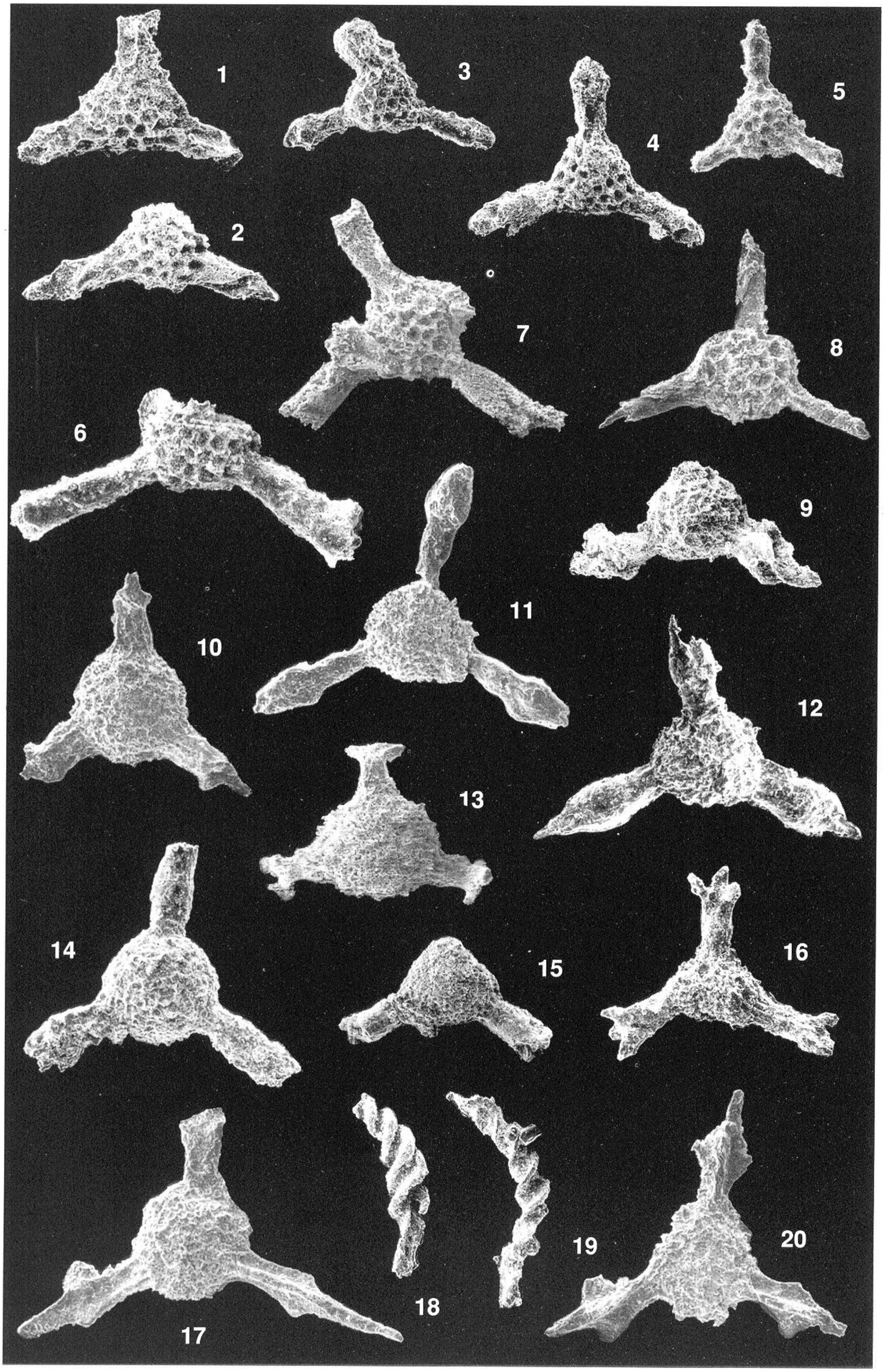
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