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Callovian (Middle Jurassic) Radiolaria and Sponge Spicules from Southwest Germany

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With 4 plates and 3 figures

Abstract

A highly diverse Callovian radiolarian and sponge spicule assemblage enclosed in phosphoritic nodules and diagenetically replaced by pyrite, later by barite, occurs in the central part of the Jurassic basin of Southwest Germany. These faunas are not preserved in the parent rock (claystones and shales) called "Ornatenton". Furthermore these nodules contain mostly sponge-inhabitant benthonic and two species of planktonic foraminifera. This Callovian assemblage is deposited in a shallow shelf sea without any stronger water movement although suggesting "pelagic" and "Oxfordian" character. 42 radiolarian species in 27 genera include some important index species. The sponge spicules (monaxones, triaxones, tetraxones, and polyaxils) show a surprising diversity pointing to monactinal, tetractinal, and hexactinal silica sponges which were not known from this environment until now.

Zusammenfassung

In Phosphoritknollen des südwestdeutschen Calloviums kommt an einigen Fundorten des zentralen Beckenteils eine relativ hochdiverse Radiolarien- und Schwammnadelvergesellschaftung vor. Der frühe Einschluß in Phosphoritknollen und der Ersatz der Kieselsäure durch Pyrit, später durch Baryt, ermöglichten die Erhaltung dieser Faunen. Im Muttergestein (dunkelgraue Tonsteine), dem „Ornatenton", sind sie nicht überliefert. Zudem enthalten die Phosphorite Foraminiferen, und zwar benthonische, die teilweise bisher nur aus Schwämmen des Oxfordiums bekannt waren, sowie zwei planktonische Arten. Die aus 42 Arten und 27 Gattungen bestehende Radiolarienfauna enthält wichtige Leitarten. Die überraschend diversen Kieselschwamm-Nadeln (Monaxone, Triaxone, Tetraxone und Polyaxile) gehören zu monactinelliden, tetractinelliden und hexactinelliden Kieselschwämmen, die man aus dem süddeutschen Callovium bisher nicht kannte.

Contents

1. Introduction

Most of the agglutinated foraminifera in the Callovian claystones and shales of Southern Germany are crushed. Inspired by the work of Rüst (1885) who treated "coprolithes", and by excellent palynological results, for example in Wille & Gocht (1985, pp. 122–125), the present author tried to get a better preserved material by dissolving phosphoritic nodules in hydrochloric acid. Planktonic foraminifera (Riegraf, in press), the radiolaria and sponge spicules described below, and many species and genera of well-preserved agglutinated foraminifera were discovered. Most of the agglutinated species were known to have lived in sponges of the Oxfordian sponge reef facies of Southern Germany and Northern Switzerland.

In the epicontinental Jurassic deposits of Central, Western, and Northern Europe the preservation of the original silica gel of the radiolaria and sponge spicules is nearly impossible. A pyritization casting microstructures and allowing species determination is rarely observed and restricted to the Callovian discoveries described below.

Käss (1954, pl. 2, fig. 9) was the first who figured radiolaria from the Southwest German Callovian. Middle Jurassic radiolaria were already recorded by Terquem (1876, pl. 1, fig. 1; 1883, pl. 38, fig. 2; 1886, pl. 1, figs. 2—3) who described some pyritized specimens from Lorraine, eastern France und from the Bathonian of Poland. From the Bajocian of Alsace, eastern France, Klähn (1924, p. 454, pl. 22, fig. 5) regarded a radiolarian as a planktonic foraminifer. These early discoveries have not been proven until now. More workers have investigated the Alpine-Mediterranean area, for example Rüst (1885, 1898), Parona (1890, northern Italy), Hojnos (1916, Hungary), and Heitzer (1930, northern Austria). After a long time of desinterest Barbieri (1964) figured radiolaria from Sicily, Dumitrica (1970) radiolaria from the Romanian Carpathians. Kopik (1980) published short remarks without figures on Middle Jurassic radiolaria from Poland. Similar remarks are contributed in Tippit & Pessagno (1979) who discovered Jurassic radiolarians in the Oman Mountains, especially in the Callovian. Recently more authors contribute to our knowledge of Middle Jurassic radiolarians in the Japanese Islands (e. g. Aita, 1982; Isozaki et al., 1981; Matsuoka, 1982; 1983; Mitzutani & Koike, 1982; Nakaseko et al., 1981; Nakatani, 1983; Nakatani & Yao, 1980; Shashida et al., 1982; Yao, 1983; Yao et al., 1980), and of Canada (Cameron & Tipper, 1981), Alaska, Oregon, and California (Blome, 1984; Murchey et al.; 1983; Pessagno & Blome, 1982; Pessagno & Whalen, 1982). New results were obtained from the Deep Sea Drilling Project Site 534A, Blake-Bahama Basin (Baumgartner, 1983; 1984) and Site 547B, Mazagan Plateau, northwest of Morocco (Riegraf, Luterbacher & Leckie, 1984), and from Hungary (Kozur, 1985). The former "Middle Jurassic" radiolarians in Heitzer (1930) are now assigned to the Oxfordian (Wendt, 1969, p. 225).

Most of these occurences mentioned above are situated in geosynclinal areas folded during the Alpine orogeny or in DSDP sites in the Atlantic or Pacific Ocean. Only a few ones belong to epicontinental shelf deposits (e. g. Terquem, see above; Kopik, 1980). Therefore our knowledge on epicontinental Middle Jurassic radiolarians is very low although in Middle to Upper Jurassic times they have been abundant mainly in epicontinental shallow-marine areas of Europe (de Wever & Thiébault, 1981, p. 599, textfig. 4).

Acknowledgments

Grateful thanks for discussion and further help are due to H. Luterbacher and H. Gocht (Tübingen), G. Bloos (Stuttgart), and P. Möller (Berlin); for stereoscan micrographs H. Hüt-

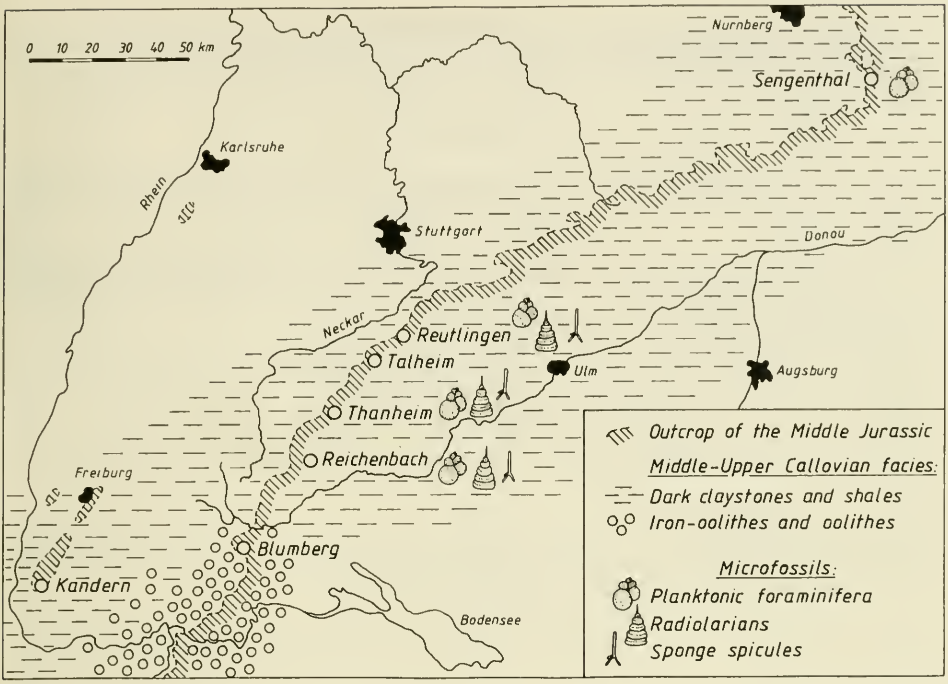

Fig. 1. Callovian outroup and facies differentiation in Southern Germany. The locations investigated in the present paper are indicated.

temann (Tübingen); for providing phosphoritic nodules to R. Jordan and the Niedersächsisches Landesamt für Bodenforschung (Hannover), and to W. Brenner and P. Zügel (Tübingen); to J. Thurow (Tübingen) for literature hints.

2. Material, Exposures, and Samples

All radiolarians and sponge spicules are deposited in the collections of the "Staatliches Museum für Naturkunde" in Stuttgart (SMNS), Southwest Germany, catalogue nos. SMNS 29304-29376. The accompanying benthonic and planktonic foraminifera have the nos. SMNS 29255-29301 and are subjects of other papers.

Callovian phosphoritic nodules from the late *jason* to *athleta* Zones are sampled and investigated along the outcrop of the South German Jurassic. Nodules from the *lamberti* Zone, partly reworked and deposited at the Oxfordian basis, contained no or rarely a few radiolarians and sponge spicules. Only three locations situated in the central part of the Jurassic basin (Fig. 1) yielded radiolarians (coordinates referred to the Topographic Map of Southern Germany, scale 1 :25,000):

1. Forest north of Reichenbach near Meßstetten, western Swabian Alb; sheet no. 7819 Meßstetten, r 34 88 100, h 53 33 030 (sample Reim. 86A).
2. Forest "Buchholder", creek southeast of Thanheim near Bisingen, western Swabian Alb; sheet no 7719 Balingen, r 34 96 170, h 53 49 790 (samples Bis. 86A; claystone: Bis. 3, Bis. 4, Bis. 5).

3. Achalm hill, several exposures, near Reutlingen, middle Swabian Alb; sheet no. 7521 Reutlingen, r 35 17 720—18 100, h 53 73 180—73 300 (samples Rt. 86A, Rt. 88A; claystone: Rt. 85, Rt. 85A, Rt. 86, Rt. 86B, Rt. 86C, Rt. 87) (GEYER & KARAPANTELAKIS, 1980, p. 273; LIPPOLD, 1983).

Barren in radiolarians and sponge spicules are:

4. Brickworks at Kandern, Southern Baden; sheet no. 8211 Kandern, r 33 99 800, h 52 87 400 (sample Kandern 86A; claystone; Kandern 84, Kandern 85, Kandern 86) (GASSMANN et al., 1984, pp. 75—81).
5. Former iron ore open-cast of the Dogger Erz AG, northwest of Blumberg on the Wutach river, Southern Baden; sheet no. 8115 Blumberg, r 34 67 380, h 53 00 900 (sample Bl. 1B; claystone; Bl. 1A) (ZEISS, 1955, p. 250; 1957).
6. Pipeline trench at Talheim near Mössingen, middle Swabian Alb; sheet no. 7620 Jungingen, r 35 06 790, h 53 59 410 (claystone; sample Talh. 1) (DIETL, 1977, p. 21, textfig. 14; ETZOLD et al., 1975, p. 136, textfig. 10; HAHN & KOERNER, 1971, p. 137).
7. Larger quarry of the Behringer Cement Factory at Sengenthal, Franconia; sheet no 6734 Neumarkt, without coordinates (sample Se. 1/86A; claystone: Se. 1/86) (v. FREYBERG, 1966, p. 14, textfig. 4; KOLB, 1965; MUNK & ZEISS, 1985, p. 425, textfig. 5).

Bathonian phosporitic nodules:

8. Brickworks of Lechstedt, 2 km north of Heinde, Lower Saxony; sheet no. 3826 Dingelbe, r 35 72 000, h 57 77 000 (sample Lechstedt 81A).

Samples, exposures, and faunulas are discussed intensively in RIEGRAF (in press), too.

3. Stratigraphy and Microfossil Preservation

In South Germany Callovian phosphoritic nodules occur frequently to very abundant in dark, pyrite-rich claystones or shales which contain finest shell debris of *Bositra buchi* (ROEMER), many crushed or pyritized ammonites, belemnites, crustaceans, single corals, bivalves, gastropodes, etc. They occur from the Upper Rhine Valley (Kandern, Southern Baden) to eastern Franconia (western margin of the Bohemian Massive) from the *jason* to *lamberti* Zones (Fig. 1). A horizon of abundant condensed or reworked phosphoritic nodules marks the boundary Callovian/Oxfordian. There a hiatus separates the dark claystones of the lower "Ornatenton" from the sandy, glauconite-rich marly claystones to marlstones of the upper "Ornatenton" or "Glaukonitsandmergel". For stratigraphy and faunal contents see in DIETL (1977), v. FREYBERG (1966, p. 14, textfig. 4), GASSMANN et al. (1984, pp. 75—81), GEYER & KARAPANTELAKIS (1980), HAHN & KOERNER (1971, pp. 137—143), KOLB (1965), LIPPOLD (1983), MODEL (1935), MODEL & KUHN (1935), R. & E. MODEL (1938), MUNK & ZEISS (1985), QUENSTEDT (1856—1857; 1883—1888), REUTER (1908), and ZEISS (1955). DIETL (1977), GASSMANN et al. (1984), and MUNK & ZEISS (1985) presented the most recent results on the Callovian biostratigraphy of Southern Germany.

The Callovian phosphoritic nodules are figured, for example, in REUTER (1908, p. 82, figs. 1—2, 4). Former detailed geochemical investigations of these nodules are reported by KÄSS (1954) who stated a concretionary origin. From this paper it is concluded by the high F and PO_4^{3-} amounts that the nodules consist mainly of Francolithe, $Ca_5[F|(PO_4,CO_3OH)_3]$. They have been soluble in hydrochloric acid; specimens with higher amounts of organic carbon were soluble only in hot hydrochlorid acid. The main differences between nodules and claystones are:

	phosphoritic nodules	parent rock (dark-grey claystones and shales)
radiolarians	common, highly diverse, locally abundant	not preserved
silica sponge spicules	from monactinal, hexactinal, and tetractinal silica sponges	not preserved
agglutinated foraminifera	highly diverse, often with agglutinated sponge spicules; many species are known to inhabit exclusively sponges of the Oxfordian reef facies	less diverse, without agglutinated sponge spicules, only typical Callovian claystone species
calcareous foraminifera	rarely preserved	dominant
planktonic foraminifera	frequent *Globuligerina*	not preserved
geochemistry	40% PO_4^{3-}, 2% F, 1—3% organic carbon; fossils pyritized or baritized, rarely calcareous	less than 1% PO_4^{3-}, F, and organic carbon; fossils mostly calcareous

There is a faunal difference between phosphoritic nodules and claystones which is difficult to explain: only in nodules agglutinated foraminifera contain sponge spicules (Fig. 2). Therefore these foraminifera seem to have lived under conditions different from those in the claystone. They also show some differences in outlines compared with the "normal" individuals from claystones. Foraminiferal tests with secondarily replaced calcareous silica sponge spicules could not have disappeared by diagenetic dissolution because the tests consist in major parts of quartz detritus and only in minor parts of sponge spicules. The nodules investigated here show no signs of any transportation over some distances, e.g. from the marginal to the central basin. They are diagenetically precipitated in a soft bottom ooze of a marine basin without stronger water movement. As mentioned above their concretionary origin is undoubtful.

The reason for the selective preservation is: The silica gel of the radiolaria and sponge spicules is dissolved on the sediment surface or somewhat below it (Flügel & Meixner, 1972, p. 192). If not replaced by pyrite or calcite, no remains of these fossils would be found.

In some microenvironments where enough organic matter putrefied the chemical and physical (less acidic and reducing) conditions were favourable to precipitate pyrite and to replace the original silica gel of the microfossils quickly enough by pyrite to enable the preservation. Subsequently phosphoritic concretions enclosed the pyritized microfossils and protected them against sedimentary compaction after they had been diagenetically hardened. Faupl & Beran (1983) described other possibilities of radiolarian and sponge spicula diagenesis in a Jurassic Alpine environment of siliceus claystones deposited under Tethyan deeper water conditions.

Other environmental conditions allowed a preservation even in marly claystones to marlstones. In the *tenuicostatum* Zone, Lower Toarcian, of Southwest Germany radiola-

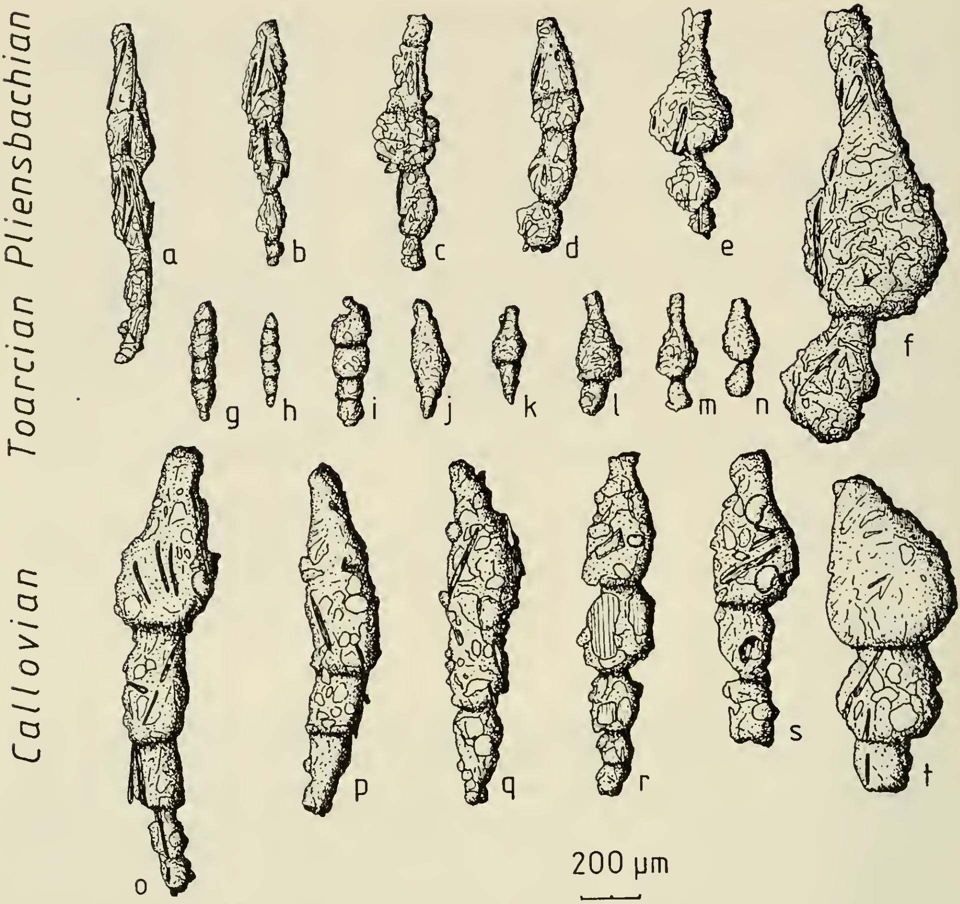

Fig. 2. *Reophax*-species in their natural proportions to each other and with agglutinated sponge spicules show how different environments change the test composition within agglutinated foraminifers (sponge spicules, mica or quartz grains). The amphistyles and rhaxes agglutinated by some of the individuals demonstrate a more common occurence in foraminiferal tests than in hydrochlorid acid residues of the phosphoritic nodules. Fig. a—f show other occurrences of sponge spicules in foraminifers from Jurassic claystones comparable to the Middle Callovian deposits.

a—f *Reophax metensis* Franke. Upper Pliensbachian, *apyrenum* Subzone, from phosphoritic nodules. — a Aalen-Reichenbach, Southwest Germany. SMNS no. 29396/3 (5704/11/4926). — b Schlewecke near Bad Harzburg, northern Germany. SMNS no. 29396/1 (5704/09/4924). — c Thionville, Alsace-Lorraine, France. SMNS no. 29404/3 (5704/23/4937). — d—e Unterstürmig, Franconia. SMNS no. 29395, 29378 (5704/7—8/4922—4923). — f Thionville, Alsace-Lorraine. SMNS no. 29404/2 (5704/22/4936). —

g—i *Reophax agglutinans* (Terquem). Lower Toarcian, *tenuicostatum* Zone, from Southwest German pyritic marly claystones. — g Aselfingen. SMNS no. 27170 (5707/15/5036). — h Dotternhausen. SMNS no. 27171 (5704/16/5037). — i Mössingen. SMNS no. 27173 (5707/20/5041). — j—n *Reophax metensis* Franke. — j, l, m—n Lower Toarcian, *tenuicostatum* Zone, from Southwest German pyritic claystones. — j, l Zell u. Aichelberg. SMNS no. 27172/1—2 (5707/17—18/5038—5039). — k Lower Toarcian, falciferum Zone, *elegans* Subzone, bituminous shales. Aselfingen, Southwest Germany. SMNS no. 27215 (5708/20/6613). — m—n Gomaringen. SMNS Nr.

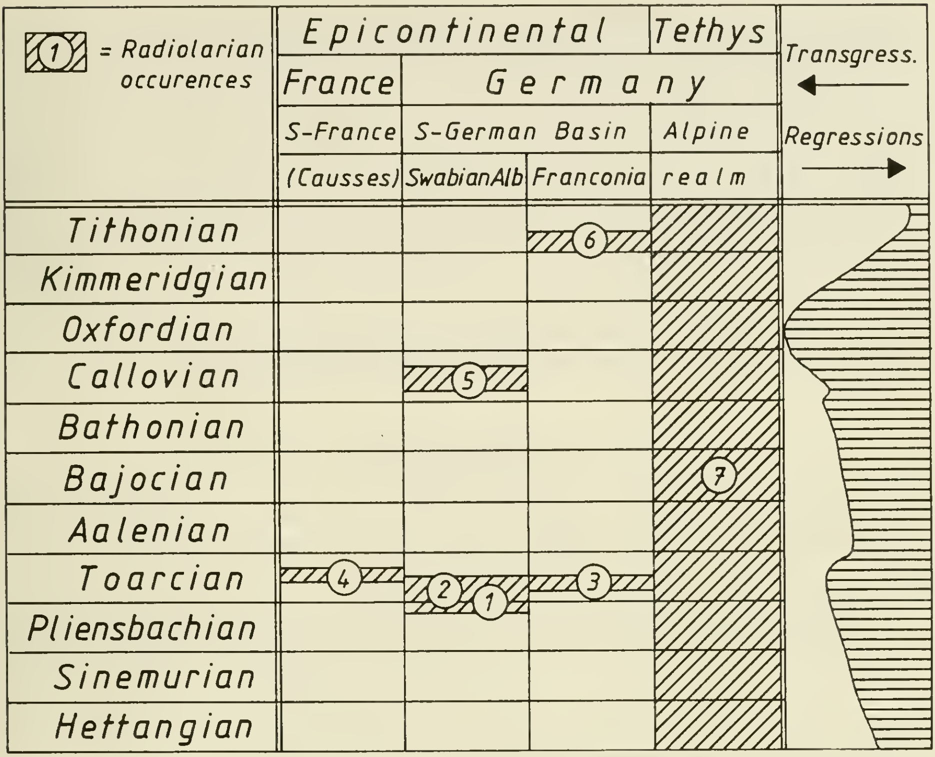

Fig. 3. Occurrences of radiolarians in Central Europe referred to eustatic rises of the world-wide sea level ("transgressions") and upwelling from the Tethys. The numbers mean (for authors see in the text):
1 = *spinatum* Zone limestones, Reutlingen
2 = *tenuicostatum* and *falciferum* Zone, marly claystones and bituminous shales
3 = *falciferum* Zone, *bituminous* shales
4 = *bifrons* Zone, dark marlstones, Truc de Balduc, Dep. Lozère
5 = middle Callovian phosporitic nodules, this paper
6 = *hybonotum* Zone limestones and cherty limestones
7 = Tethyan marlstones, limestones, and cherts throughout the Jurassic (from literature and own observations)

rians and sponge spicules are diagenetically replaced by pyrite or markasite and preserved uncrushed. From this level phosphoritic nodules are unknown. In bituminous shales of the overlaying *falciferum* Zone of the same area radiolarians are badly preserved as calcitic internal moulds (RIEGRAF, 1985, pp. 90—91, pl. 5, figs. 1—9; RIEGRAF, WERNER & LÖRCHER, 1984, pp. 49—50, textfigs. 11n—o). In the latter environment a pyritized preservation had been impossible.

27168/1—2 (5707/12—13/5033—5034). — o—t *Reophax sterkii* HAEUSLER. Callovian, *jason-* to *athleta* Zone, from phosphoritic nodules. — o Reutlingen. SMNS no. 29273 (6168/36/13998). — p—q Reichenbach. SMNS no. 29275/1—2 (6168/40—41/13999). — r—t Thanheim. SMNS no. 29274/1—3 (6168/37—39/13998—13999).

Further occurrences of pyritized or calcified radiolarians (Fig. 3) have been found in the samples Rt. 110A—110D, *spinatum* Zone, of Upper Pliensbachian limestones at Reutlingen, Southwest Germany (RIEGRAF, 1985, p. 17, textfig. 6). Three doubtful, small, pyritized *Cenosphaera*-like radiolarians have been found in dark, pyritic marlstones of the upper *transversarium* Zone, Lower Oxfordian, of the famous Lochen area near Balingen, Southwest Germany (Samples Lochen 1 and 1A). In Lower Toarcian marls of the *bifrons* Zone, Truc de Balduc, Dep. Lozère, Southern France, they are abundant (RIEGRAF, 1985, p. 91, textfig. 11). GÜMBEL (1891, p. 78) and REINSCH (1877, p. 178) reported on radiolaria discoveries from the Lower Toarcian in Franconia, BARTHEL (1964, p. 41), SCHAIRER (1971, figs. 17, 24, 25), and STÜRMER (1963) on such from the Lower Tithonian of Southern Germany. Their bad preservation and their small number need further investigations in these beds to proove undoubtfully these radiolarian occurrences.

4. Sponge Spicules

Isolated sponge spicules had been unknown in the Lower and Middle Jurassic of Southern Germany except of a few observations in the Hettangian (SCHLOZ, 1972, pp. 139, 164, pl. 27, figs. 3—4; USBECK, 1952, p. 407), Upper Pliensbachian and Lower Toarcian (RIEGRAF, 1985, p. 91), and in the Callovian (this paper) — in spite of the complete sponge bodies described from the Southwest German Bajocian by QUENSTEDT (1877—78). Complete Middle Jurassic sponge bodies are reported, too, from the Bajocian and Bathonian of England (HINDE, 1894), Bathonian and Callovian of Poland (SIEMIRADZKI, 1913), Bathonian of Hungary (POČTA, 1886), and the Callovian of Southern France (MORET, 1928). Nevertheless the main development of the European Jurassic sponge reefs was restricted to the Upper Jurassic (Oxfordian to Tithonian).

Pyritized sponge spicules were figured by TERQUEM & BERTHELIN (1875, pl. 10, figs. 19—39) from the Lower Jurassic of Lorraine, eastern France, and by FLÜGEL & MEIXNER (1972, pls. 1—2) from the Tithonian of Northern Austria. More common are silicified isolated sponge spicules in the Alpine Lower Jurassic of northern Austria (DUNIKOWSKI, 1882; SADDEDIN, 1976), in the Lower to Upper Jurassic of Northern Germany and Switzerland (RÜST, 1885, pl. 26, figs. 1—2; pl. 45, figs. 1—4, from the Oxfordian of Northern Germany (GRAMANN, 1963), from the Upper Jurassic of Southern Germany (GEYER, 1955; 1958; REIF, 1972; SCHAIRER, 1971), and from the Tithonian of Southern Poland (WIŚNIOWSKI, 1889, pl. 12).

In the Southwest German Callovian sponge spicules have been found as follows:

Monaxones: Bundled, pyritized amphistyles (pl. 4, figs. 17—19) may belong to silica sponges of the order Monactinellida; they were found only at the locality near Thanheim.

Triaxones: Rare, pyritized oxyhexactins seem to prove the order Hexactinellida (pl. 4, figs. 13, 21).

Tetraxones: Pyritized oxycalthrops, orthodichotriaenes, and asymmetrical orthodichotriaenes (pl. 4, figs. 10—12) point to the order Hexactinellida of the silica sponges.

Polyaxile spicules: Pyritized sphaerasters are very rare. Common, especially in foraminiferal tests of the agglutinated genus *Reophax* MONTFORT, are rhaxes (textfig. 3; pl. 4, fig. 14). Both spicule types cannot be assigned to a certain silica sponge order (POKORNÝ, 1958).

5. Radiolarians: Systematic Descriptions

The present author does not intend to revise suprageneric and generic systematics and follows the outlines given by the recent papers of BAUMGARTNER, FOREMAN, and PESSA-

GNO. Due to average or bad preservation, mainly of the diagnostically important microstructures, a lot of species have to be described in open nomenclature or are undetermined. If additional, better preserved material were available possibly some of the species determinations would need revision. This preliminary report should encourage other workers to continue the radiolarian research started here. Therefore long descriptions or systematic discussions are avoided. In main respect the synonymy lists should demonstrate the stratigraphic and the geographic distribution of the species described here which indicate the zone A1, 2—4 of BAUMGARTNER (1984). Index species of this paper are marked with a cross (⁺).

Genus *Pseudocrucella* PESSAGNO, 1971

Type species: *Crucella messinae* PESSAGNO, 1971.

Pseudocrucella cf. *prava* BLOME, 1984
(pl. 1, fig. 1)

cf. 1984 *Pseudocrucella prava*, n. sp. — BLOME, p. 352, pl. 3, figs. 1—4, 6, 8—17; pl. 4, figs. 1—4, 6—10, 12, 14—16; pl. 15, figs. 16—17 (Callovian, Oregon, Alaska).

Remarks: The difference between BLOME's (1984) specimens and those described here is the more slender rays of the latter, probably caused by their bad preservation.

Range: Middle Callovian.

Genus *Tritrabs* BAUMGARTNER, 1980

Type species: *Paronaella*(?) *casmaliensis* PESSAGNO, 1977).

Tritrabs ewingi (PESSAGNO, 1971)⁺
(pl. 1, fig. 4)

1885 *Rhopalastrum Crevolense* PANTANELLI. — RÜST, p. 298, pl. 33, fig. 7 (Neocomian, Bavarian Alps, Germany).

*1971 *Paronaella ewingi* PESSAGNO, n. sp. — PESSAGNO, p. 47, pl. 19, figs. 2—5 (Tithonian, DSDP Site 5A, northern Atlantic Ocean).

1973 *Paronaella*(?) *ewingi*(?) PESSAGNO. — FOREMAN, p. 262, pl. 8, fig. 1 (Valanginian-Hauterivian, DSDP Site 196, northern Pacific Ocean).

1977 *Paronaella*(?) *ewingi* PESSAGNO. — PESSAGNO, p. 70, pl. 1, figs. 14—15 (Kimmeridgian-Tithonian, California Coast Range) (1977b).

1977 *Paronaella*(?) *ewingi* PESSAGNO. — PESSAGNO, pl. 11, fig. 6 (Tithonian, California) 1977c).

1980 *Tritrabs ewingi* (PESSAGNO). — BAUMGARTNER, p. 293, pl. 4, figs. 5, 7, 17, 18 (Upper Jurassic, Argolis Peninsula, Greece).

1980 *Paronaella*(?) *ewingi* PESSAGNO. — HOLZER, p. 159, pl. 1, figs. 15—17 (Tithonian-Neocomian, Salzburg Alps, Austria).

1984 *Tritrabs ewingi* (PESSAGNO). — BAUMGARTNER, p. 791, pl. 10, fig. 10, data 54, range 70, pob 113, rk 34 (Callovian-Hauterivian, Sicily).

1984 *Tritrabs ewingi* (PESSAGNO). — OŽVOLDOVA & SYKORA, p. 273, pl. 15, fig. 5 (Berriasian, Western Carpathians, Czechoslovakia).

Remarks: This is a wide-spread, now long-ranging index species.

Range: Callovian-Hauterivian.

Genus *Tetratrabs* BAUMGARTNER, 1980

Type species: *Tetratrabs gratiosa* BAUMGARTNER in BAUMGARTNER, DE WEVER & KOCHER, 1980.

Tetratrabs zealis (OŽVOLDOVA, 1979)+
(pl. 1, fig. 2)

*1979 *Crucella zealis* n. sp. — OŽVOLDOVA, p. 254, pl. 2, fig. 1 (Callovian-Oxfordian, Western Carpathians, Czechoslovakia).
1980 *Tetratrabs gratiosa* BAUMGARTNER new species. — BAUMGARTNER, DE WEVER & KOCHER, p. 63, pl. 2, fig. 6 (Upper Jurassic-Lower Cretaceous, Lombardia, Italy); nomen nudum: without description and diagnosis.
1980 *Tetratrabs gratiosa* BAUMGARTNER, n. sp. — BAUMGARTNER, p. 295, pl. 1, fig. 11; pl. 5, figs. 2—7; pl. 6, figs. 4—7, 9—14; pl. 11, figs. 7—9 (Upper Jurassic, Argolis Peninsula, Greece).
1984 *Tetratrabs zealis* (OŽVOLDOVA). — BAUMGARTNER, p. 788, pl. 9, fig. 10, data 36, range 24, pob 121, rk 61 (Bathonian-Tithonian, Argolis Peninsula, Greece).

Remarks: BAUMGARTNER (1984, p. 788) recognized the synonymy of his species with that of Ožvoldova.
Range: Bathonian-Tithonian (?Berriasian).

Genus *Patulibracchium* PESSAGNO, 1971

Type species: *Patulibracchium sexangulum* PESSAGNO, 1971.

Patulibracchium bronnimanni (PESSAGNO, 1977)+
(pl. 1, fig. 5)

?1885 *Rhopalastrum contractum m.* — RÜST, p. 297, pl. 32, fig. 10 (Neocomian, Bavarian Alps, Germany).
*1977 *Paronaella bronnimanni* PESSAGNO, n. sp. — PESSAGNO, p. 69, pl. 1, figs. 4—5 (Kimmeridgian-Tithonian, California Coast Range) (1977b).
1980 *Paronaella bronnimanni* PESSAGNO. — HOLZER, p. 159, pl. 1, fig. 14; pl. 2, fig. 12 (Berriasian-Valanginian, northern Austria).

Remarks: The 3—4 spines of each ray are not preserved.
Range: Kimmeridgian-Valanginian.

Patulibracchium sp.
(pl. 1, fig. 8)

?1885 *Dictyastrum singulare* m. — RÜST, p. 299, pl. 33, fig. 9 (Neocomian, Bavarian Alps, Germany).

Remarks: In spite of its quite good preservation the figured specimen cannot be assigned to any known species.
Range: Middle Callovian.

Genus *Crucella* PESSAGNO, 1971

Type species: *Crucella messinae* PESSAGNO, 1971.

Crucella sp.
(pl. 1, fig. 6)

e. p. ?1885 *Hagiastrum astrictum* m. — RÜST, p. 299, pl. 34, fig. 3 (Tithonian, Western Switzerland).

Range: Middle Callovian.

Genus *Angulobracchia* BAUMGARTNER, 1980

Type species: *Paronaella*(?) *purismaensis* PESSAGNO, 1977.

Angulobracchia purismaensis (PESSAGNO, 1977)+
(pl. 1, fig. 12—13)

*1977 *Paronaella*(?) *purismaensis* PESSAGNO, n. sp. — PESSAGNO, p. 71, pl. 2, figs. 4—6 (Kimmeridgian-Tithonian, California Coast Range) (1977b).
1980 *Angulobracchia purismaensis* (PESSAGNO). — BAUMGARTNER, p. 312, pl. 10, figs. 9—10; pl. 12, figs. 9—10 (Upper Jurassic, Argolis Peninsula, Greece).
1984 *Angulobracchia purismaensis* (PESSAGNO). — BAUMGARTNER, p. 757, pl. 2, fig. 4, data 67, range 57, pob 144, rk 42 (Callovian-Kimmeridgian, Argolis Peninsula, Greece).
1985 *Halesium* sp. — DE WEVER, DUÉE & KADIRI, pl. 1, fig. 21 (Middle Jurassic, Morocco).

Range: Callovian-Tithonian.

Genus *Halesium* PESSAGNO, 1971

Type species: *Halesium sexangulum* PESSAGNO, 1971.

Halesium sp.
(pl. 1, fig. 11)

aff. 1971 *Halesium quadratum* PESSAGNO, n. sp. — PESSAGNO, p. 23, pl. 3, figs. 1—6, pl. 4, fig. 1 (Cenomanian, California Coast Range).

Remarks: Lacking bracchiopyles do not allow to assign the German material to PESSAGNO's species.
Range: Middle Callovian.

Genus *Bernoullius* BAUMGARTNER, 1984

Type species: *Bernoullius cristatus* BAUMGARTNER, 1984.

Bernoullius cristatus BAUMGARTNER, 1984+
(pl. 2, fig. 1)

*1984 *Bernoullius cristatus* BAUMGARTNER n. gen. n. sp. — BAUMGARTNER, p. 760, pl. 2, figs. 14—15, data 39, range 39, pob 221, rk 109 (Callovian, DSDP Site 534A, northern Atlantic Ocean).

Range: Callovian.

Bernoullius dicera (BAUMGARTNER, 1980)+
(pl. 2, fig. 2)

1979 *Lophophaena* sp. — OŽVOLDOVA, p. 259, pl. 4, figs. 4—5 (Callovian-Oxfordian, Western Carpathians, Czechoslovakia).

*1980 *Eucyrtis*(?) *dicera* BAUMGARTNER, new species. — BAUMGARTNER, DE WEVER & KOCHER, p. 54, pl. 3, fig. 16; pl. 6, figs. 6, 10 (Upper Jurassic-Lower Cretaceous, Lombardia, Italy).

1981 *Eucyrtis*(?) *dicera* BAUMGARTNER. — KOCHER, pl. 13, figs. 17—18 (Upper Jurassic, Southern Alps, Italy).

1984 *Bernoullius dicera* (BAUMGARTNER). — BAUMGARTNER, p. 760, pl. 2, fig. 16, data 35, range 56, pob 223, rk 69 (Callovian-Kimmeridgian, DSDP Site 534A, northern Atlantic Ocean).

Range: Callovian-Kimmeridgian (?Berriasian/Valanginian).

Genus *Orbiculaforma* PESSAGNO, 1973

Type species: *Orbiculaforma quadrata* PESSAGNO, 1973.

Orbiculaforma sp.
(pl. 2, figs. 5—7)

1971 *Spongodiscus* sp. — KOZLOVA, p. 1175, pl. 1, fig. 7 (Lower Kimmeridgian, Timan-Ural area, USSR).

Range: Callovian-Kimmeridgian.

?*Orbiculaforma* sp.
(pl. 2, fig. 8)

aff. 1977 *Orbiculaforma lowreyensis* PESSAGNO, n. sp. — PESSAGNO, p. 74, pl. 3, fig. 15—16; pl. 4, figs. 1—3 (Kimmeridgian-Tithonian, California Coast Ranges) (1977b).

Remarks: A very similar, also indeterminable species is figured in RIEGRAF (1985, pl. 5, fig. 6) from the Lower Toarcian bituminous shales of Southwest Germany.

Range: Middle Callovian.

Genus *Andromeda* BAUMGARTNER, 1980

Type species: *Andromeda crassa* BAUMGARTNER in BAUMGARTNER, DE WEVER & KOCHER, 1980.

Andromeda praepodbielensis BAUMGARTNER, 1984+
(pl. 2, figs. 3—4)

*1984 *Andromeda praepodbielensis* BAUMGARTNER n. sp. — BAUMGARTNER, p. 756, pl. 1, figs. 13—15, data 3, range 2, pob 6 (Bathonian, Lombardia, Italy).

Range: Bathonian-Callovian.

Genus *Emiluvia* FOREMAN, 1973

Type species: *Emiluvia chica* FOREMAN, 1973.

Emiluvia tympanica (OŽVOLDOVA, 1979)
(pl. 2, figs. 18–19)

?1885 *Staurosphaera gracilis* m. — RÜST, p. 288, pl. 27, fig. 18 (Neocomian, Bavarian Alps, Germany).
cf. 1977 *Staurolonche* sp. aff. *robusta* RÜST. — PESSAGNO, p. 75, pl. 4, fig. 8 (Kimmeridgian, California Coast Range) (1977b).
*1979 *Staurosphaera tympanica* n. sp. — OŽVOLDOVA, p. 251, pl. 1, fig. 1 (Callovian-Oxfordian, Western Carpathians, Czechoslovakia).

Range: Callovian-Kimmeridgian.

Genus *Archaeohagiastrum* BAUMGARTNER, 1984

Type species: *Archaeohagiastrum munitum* BAUMGARTNER, 1984

Archaeohagiastrum munitum BAUMGARTNER, 1984^{+}
(pl. 2, figs. 9—10)

1981 *Emiluvia* sp. A, B. — KOCHER, pl. 13, figs. 11—12 (Upper Jurassic, Southern Alps).
*1984 *Archaeohagiastrum munitum* BAUMGARTNER n. gen. n. sp. – BAUMGARTNER, p. 759, pl. 2, figs. 9—13, data 92, range 40, pob 271 (Callovian, DSDP Site 534 A, northern Atlantic Ocean).

Range: Callovian-?Tithonian.

Archaeohagiastrum sp.
(pl. 2, fig S. 11—15)

Range: Middle Callovian.

Genus *Acaeniotyle* FOREMAN, 1973

Type species: *Xiphosphaera umbilicata* RÜST, 1898.

Acaeniotyle(?) sp.
(pl. 2, fig. 16)

Range: Middle Callovian.

Genus *Triactoma* RÜST, 1885

Type species: *Triactoma tithonianum* (RÜST, 1885) in CAMPBELL, 1954, p. D181 by subsequent designation.

Triactoma sp. aff. *T. cornuta* BAUMGARTNER
(pl. 2, fig. 17)

aff. 1980 *Triactoma cornuta* BAUMGARTNER, n. sp. – BAUMGARTNER, DE WEVER & KOCHER, p. 63, pl. 2, figs. 2—3 (Oxfordian-Kimmeridgian, Argolis Peninsula, Greece).

Remarks: The holotype has finer pores, shorter and thicker spines.
Range: Middle Callovian.

Genus *Cenosphaera* EHRENBERG, 1854

Type species: *Cenosphaera plutonis* EHRENBERG, 1854.

Cenosphaera hirta PARONA, 1890
(pl. 3, fig. 16)

1890 *Cenosphaera hirta* n. f. — PARONA, p. 19, pl. 1, fig. 7 (Upper Jurassic, northern Italy).
1977 *Cenosphaera hirta* PARONA. — MUZAVOR, p. 42, pl. 2, fig. 4 (Upper Jurassic, Bavarian Alps).

Range: Callovian-?Kimmeridgian.

Cenosphaera euganea SQUINABOL, 1903
(pl. 3, fig. 18)

*1903 *Cenosphaera euganea* n. sp. – SQUINABOL, p. 109, pl. 8, fig. 1 (Upper Cretaceous, Italy).
?1971 *Carposphaera dupla* KOZLOVA sp. n. — KOZLOVA, p. 1175, pl. 1, fig. 1 (Kimmeridgian, Timan-Ural area, USSR) (nomen nudum, lacking type description and diagnosis).
1977 *Cenosphaera euganea* SQUINABOL. — MUZAVOR, p. 41, pl. 2, fig. 4 (Upper Jurassic, Bavarian Alps, Germany).
1980 *Cenosphaera* aff. *porosissima* VINASSA. — DIERSCHE, pl. 1, figs. 1a—b (Oxfordian, Bavarian Alps, Germany).

Remarks: It is doubtful whether SQUINABOL's species is conspecific with the Jurassic finds.
Range: Callovian-?Upper Cretaceous.

Cenosphaera micropora RÜST, 1898
(pl. 3, fig. 17)

*1898 *Cenosphaera micropora* n. sp. — RÜST, p. 5, pl. 1, fig. 1 (Neocomian, Gardenazza, northern Italy).
1977 *Cenosphaera micropora* RÜST. — MUZAVOR, p. 43, pl. 2, fig. 2 (Upper Jurassic, Bavarian Alps, Germany).
1981 *Cenosphaera micropora* RÜST. — STEIGER, pl. 14, fig. 1 (Tithonian, northern Austria).

Range: Callovian-Neocomian.

Genus *Hsuum* PESSAGNO, 1977

Type species: *Hsuum cuestaense* PESSAGNO, 1977

Hsuum(?) *inexploratum* BLOME, 1984
(pl. 3, fig. 1—2)

1982 *Hsuum* sp. aff. *mirabundum* PESSAGNO. — PESSAGNO & WHALEN, p. 133, pl. 7, fig. 10 (Bajocian, Oregon).
*1984 *Hsuum* (?) *inexploratum* BLOME, n. sp. — BLOME, p. 356, pl. 8, figs. 6, 11, 14; pl. 10, figs. 1, 6, 15, 19 (Callovian, Alaska).

Range: Bajocian-Callovian.

Genus *Archaeodictyomitra* PESSAGNO, 1976

Type species: *Archaeodictyomitra squinaboli* PESSAGNO, 1976

Archaeodictyomitra brevicostatus (OŽVOLDOVA)
(pl. 3, fig. 4—5)

1976 *Dictyomitra* sp. D. — BAUMGARTNER & BERNOULLI, p. 617, fig. 12j (Tithonian?, Berriasian-Valanginian, eastern Greece).
*1979 *Lithostrobus brevicostatus* OŽVOLDOVA, p. 259, pl. 5, fig. 2 (Callovian-Oxfordian, Western Carpathians, Czechoslovakia).
1980 *Dictyomitra* sp. — DIERSCHE, pl. 2, figs. g, j (Oxfordian, Bavarian Alps, Germany).

Range: Callovian-Berriasian/Valanginian.

Archaeodictyomitra(?) sp.
(pl. 3, fig. 3)

1930 *Stichoformis* aff. *radiata*, RÜST. — HEITZER, p. 398, pl. 29, fig. 59 (Oxfordian, northern Austria).

Range: Middle Callovian-Oxfordian.

Archaeodictyomitra(?) sp.
(pl. 3, fig. 6)

Range: Middle Callovian.

Genus *Parvicincula* PESSAGNO, 1977b

Type species: *Parvicingula santabarbarensis* PESSAGNO, 1977b.

Parvicingula cf. *media* PESSAGNO & WHALEN, 1982
(pl. 3, fig. 7)

1971 *Siphocampe*(?) *alexandre* CHABAKOV. — KOZLOVA, p. 1175, pl. 1, fig. 15 (Kimmeridgian, Timan-Ural area, USSR).
cf. 1982 *Parvicingula media* PESSAGNO and WHALEN, n. sp. — PESSAGNO & WHALEN, p. 139, pl. 9, figs. 3, 4, 17, 21; pl. 13, fig. 6 (Bajocian, Oregon).

Remarks: The bad preservation do not allow a sure determination.
Range: Bajocian-Kimmeridgian.

Genus *Spongocapsula* PESSAGNO, 1977

Type species: *Spongocapsula palmerae* PESSAGNO, 1977.

Spongocapsula palmerae PESSAGNO, 1977+
(pl. 3, figs. 8—9)

?1930 *Lithocampe elegans* HINDE. — HEITZER, p. 399, pl. 29, figs. 64a, b (Oxfordian, Salzburg Alps, Austria).
*1977 *Spongocapsula palmerae* PESSAGNO, n. sp. — PESSAGNO, p. 88, pl. 11, figs. 12—14, 16 (Kimmeridgian-Tithonian, California Coast Range) (1977b).
1977 *Lithocampe pervulgata* RÜST. — OŽVOLDOVA, p. 259, pl. 5, fig. 5 (Callovian-Oxfordian, Western Carpathians, Czechoslovakia).
1984 *Spongocapsula palmerae* PESSAGNO. — BAUMGARTNER, p. 785, pl. 8, fig. 16, data 50, range 38, pob 99, rk 76 (Bathonian-Berriasian, DSDP Site 534A, northern Atlantic Ocean).

Range: Bathonian-Berriasian.

Spongocapsula sp.
(pl. 3, fig. 10)

Range: Middle Callovian.

Genus *Podobursa* WIŚNIOWSKI, 1889, emend. FOREMAN, 1973

Type species: *Podobursa dunikowskii* WIŚNIOWSKI, 1899.

Podobursa helvetica (RÜST, 1885)+
(pl. 3, fig. 11)

*1885 *Theosyringium Helveticum* m. — RÜST, p. 309, pl. 27, fig. 14 (Tithonian, eastern Switzerland).
1980 *Podobursa helvetica* (RÜST). — BAUMGARTNER, DE WEVER & KOCHER, p. 60, pl. 3, figs. 11; pl. 6, fig. 5 (Upper Jurassic-Lower Cretaceous, Argolis Peninsula, Greece).
1981 *Podobursa helvetica* (RÜST). — KOCHER, pl. 15, fig. 17 (Upper Jurassic, Southern Alps, Italy).
1984 *Podobursa* sp. aff. *triacantha* (FISCHLI). — OŽVOLDOVA & SYKORA, p. 269, pl. 12, figs. 1—3 (Berriasian, Western Carpathians, Czechoslovakia).
1984 *Podobursa helvetica* (RÜST). — BAUMGARTNER, p. 779, pl. 7, fig. 7, data 18, range 13, pob 169, rk 98 (Bathonian-lower Kimmeridgian, Greece).

Range: Bathonian-Berriasian.

Podobursa triacantha (FISCHLI, 1916)
(pl. 3, figs. 12—13)

?1885 *Theriosyringium proboscideum* m. — RÜST, p. 309, pl. 37, fig. 12 (Tithonian, Western Switzerland).
*1916 *Theosyringium acanthophorum* RÜST var. *triacanthus*. — FISCHLI, p. 47, fig. 38 (Lower Cretaceous, Switzerland).
1916 *Theosyringium acanthophorum* RÜST var. *tetracanthus*. — FISCHLI, p. 47, fig. 39 (Lower Cretaceous, Switzerland).

1916 *Theosyringium acanthophorum* RÜST var. polyacanthus. — FISCHLI, p. 47, fig. 41 (Lower Cretaceous, Switzerland).
1975 *Podobursa triacantha* (FISCHLI). — FOREMAN, p. 617, pl. 2L, figs. 4—6; textfig. 4 (Berriasian-Barremian, DSDP Sites 305—306, northern Pacific Ocean).
1977 *Podobursa triacantha* (FISCHLI). — MUZAVOR, p. 110, pl. 7, figs. 1—3 (Upper Jurassic, Bavarian Alps, Germany).
1977 *Podobursa triacantha* (FISCHLI). — PESSAGNO, p. 57, pl. 11, fig. 6 (Valanginian, California Coast Ranges) (= 1977a).
1977 *Podobursa triacantha* (FISCHLI). — PESSAGNO, p. 92, pl. 12, fig. 6 (Kimmeridgian-Tithonian, California Coast Ranges) (= 1977b).
1977 *Podobursa triacantha* (FISCHLI). — OŽVOLDOVA, p. 256, pl. 2, fig. 2 (Callovian-Oxfordian, Western Carpathian, Czechoslovakia).
1981 *Podobursa triacantha* (FISCHLI). — KOCHER, pl. 15, fig. 19 (Upper Jurassic, Southern Alps, Italy).
1981 *Podobursa triacantha* (FISCHLI). — STEIGER, pl. 14, fig. 10 (Tithonian, northern Austria).
1984 *Podobursa triacantha* (FISCHLI). — OŽVOLDOVA & SYKORA, p. 269, pl. 3, fig. 8 (Berriasian, Western Carpathians, Czechoslovakia).

Range: Callovian-Valanginian (?Barremian).

Podobursa pantanelli (PARONA, 1890)
(pl. 3, figs. 14—15)

*1890 *Podobursa Pantanellii* n. f. — PARONA, p. 35, pl. 5, fig. 8 (Upper Jurassic, northern Italy).
1974 *Podobursa pantanellii* (PARONA). — RIEDEL & SANFILIPPO, p. 36, pl. 8, fig. 5; pl. 13, fig. 6 (Tithonian-Valanginian, DSDP Site 251, southern Indian Ocean).
1977 *Podobursa pantanelli* (PARONA). — MUZAVOR, p. 108, pl. 7, fig. 5 (Upper Jurassic, Bavarian Alps, Germany).

Range: Callovian-?Kimmeridgian.

Genus *Stichocapsa* HAECKEL, 1881

Type species: *Stichocapsa jaspidea* RÜST, 1885.

Stichocapsa rotunda HINDE, 1900+
(pl. 4, fig. 1)

?1885 *Tetracapsa pinguis* m. — RÜST. p. 313, pl. 39, fig. 1 (Tithonian, Western Switzerland).
*1900 *Stichocapsa rotunda* sp. nov. — HINDE, p. 41, pl. 3, fig. 24 (?Jurassic or ?Lower Cretaceous, Borneo, Indonesia).
1973 *Stichocapsa rotunda* HINDE. — FOREMAN, p. 265, pl. 11, fig. 1 (Valanginian-Hauterivian, DSDP Site 196, northern Pacific Ocean).
1975 *Stichocapsa*(?) *rotunda* HINDE. — FOREMAN, p. 616, pl. 2 J, fig. 6; pl. 7, fig. 5; textfig. 4 (Berriasian-Hauterivian, DSDP Site 306, Northern Pacific Ocean).
1977 *Stichocapsa rotunda* HINDE. — MUZAVOR, p. 122, pl. 5, fig. 11—12 (Upper Jurassic, Bavarian Alps, Germany).
1977 *Obesocapsula* sp. aff. *O. morroensis* PESSAGNO. — PESSAGNO, p. 53, pl. 11, fig. 7 (Valanginian, California) (1977c).
1979 *Stichocapsa rotunda* HINDE. — OŽVOLDOVA, p. 257, pl. 5, figs. 5—6 (Callovian-Oxfordian, Western Carpathians, Czechoslovakia).
1980 *Syringocapsa rotunda* (HINDE). — BAUMGARTNER, DE WEVER & KOCHER, p. 62, pl. 3, fig. 12 (Lower Cretaceous, DSDP Site 5A, northern Atlantic Ocean).

1984 *Syringocapsa rotunda* (HINDE). — OŽVOLDOVA & SYKORA, p. 271, pl. 14, figs. 4, 6 (Berriasian, Western Carpathians, Czechoslovakia).

1984 *Obesocapsula rotunda* (HINDE). — BAUMGARTNER, p. 775, pl. 6, fig. 13, data 83, range 95, pob 202, rk 16 (late Tithonian-Valanginian, DSDP Site 5A, northern Atlantic Ocean).

Range: Callovian-Hauterivian.

Genus *Stylosphaera* EHRENBERG, 1847

Type species: *Stylosphaera hispida* EHRENBERG, 1854.

Stylosphaera sp.
(pl. 3, fig. 19)

1980 *Stylosphaera* sp. — DIERSCHE, pl. 2, fig. 1 (Oxfordian, Bavarian Alps)

Range: Callovian-Oxfordian.

Gen et sp. indet. I
(pl. 3, fig. 20)

Gen. et sp. indet II
(pl. 4, fig. 2)

Gen. et sp. indet. III
(pl. 4, figs. 3—4)

Gen. et sp. indet. IV
(pl. 4, figs. 5—6)

Gen. et sp. indet. V
(pl. 4, fig. 7)

cf. 1977 *Podobursa amphitreptera* (FOREMAN). — MUZAVOR, p. 112, pl. 7, fig. 4 (Upper Jurassic, Bavarian Alps, Germany).

Gen. et sp. indet. VI
(pl. 4, figs. 8—9)

?1898 *Spongotripus trigonus*, n. sp. — RÜST, p. 34, pl. 11, fig. 13 (Neocomian, Lombardia, Italy).

Gen. et sp. indet VII
(pl. 1, fig. 3)

Remarks: Possible a bad preserved *Tetratrabs* sp.
Range of gen. et sp. indet. I—VII: Middle Callovian.

6. Results

1. Middle Callovian phosporitic nodules of three localities in the centre of the Jurassic basin of Southern Germany yielded 42 radiolarian species of 27 genera and spicules of monactinellid, tetractinellid, and hexactinellid silica sponges. These fossils were obtained by dissolution with hydrochloric acid.
2. Especially in microenvironments with reducing, less acidid conditions and higher contents of organic matter, these microfossils were pyritized, later sometimes barytized, after dissolution of the silica gel. The inclusion in phosphoritic nodules protected them against further diagenetic solution and sediment compaction.
3. For these reasons such microfossils are only found in phosphoritic nodules but not in the surrounding claystones and shales.
4. The sponge spicules of the nodules prove the presence of more or less autochthonous monactinal, tetractinal, and hexactinal silica sponges in the soft bottom environment during the deposition of the fine-clastic "Ornatenton" of the Middle Callovian in Southwest Germany. There, until now, such sponges had been discovered in the Hettangian, Pliensbachian, Toarcian, Bajocian, Oxfordian, Kimmeridgian, and Tithonian.
5. The relatively diverse radiolarian assemblage (A1 zone of Baumgartner 1984) yields some index species known, for instance, from the DSDP Sites in the northern Atlantic Ocean or from geosynclinal deposits in Greece, Italy or California.
6. Radiolarian and sponge spicules are accompanied by frequent planktonic foraminifera (*Globuligerina*) and many benthonic foraminiferal species most of which usually lived in sponges as known from the Oxfordian.
7. These "pseudopelagic" assemblages are deposited in a shallow shelf sea under the influence of possible upwelling from the nearby Tethys in the south which opened at that time during a rise of the sea level (so-called "Callovian transgression").
8. Radiolarian blooms in the central European epicontinental Jurassic are observed in the Upper Pliensbachian and Lower Toarcian of Southwest Germany, Franconia, and Southern France, in the Callovian of Southwest Germany, and in the Lower Tithonian of Franconia. Uncertain records in the Lower Oxfordian of Southwest Germany need further research. Probably these "episodical" occurrences are the result of changing preservational conditions during the Jurassic in Southern Germany.

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Explanation to plate 1 see p. 26

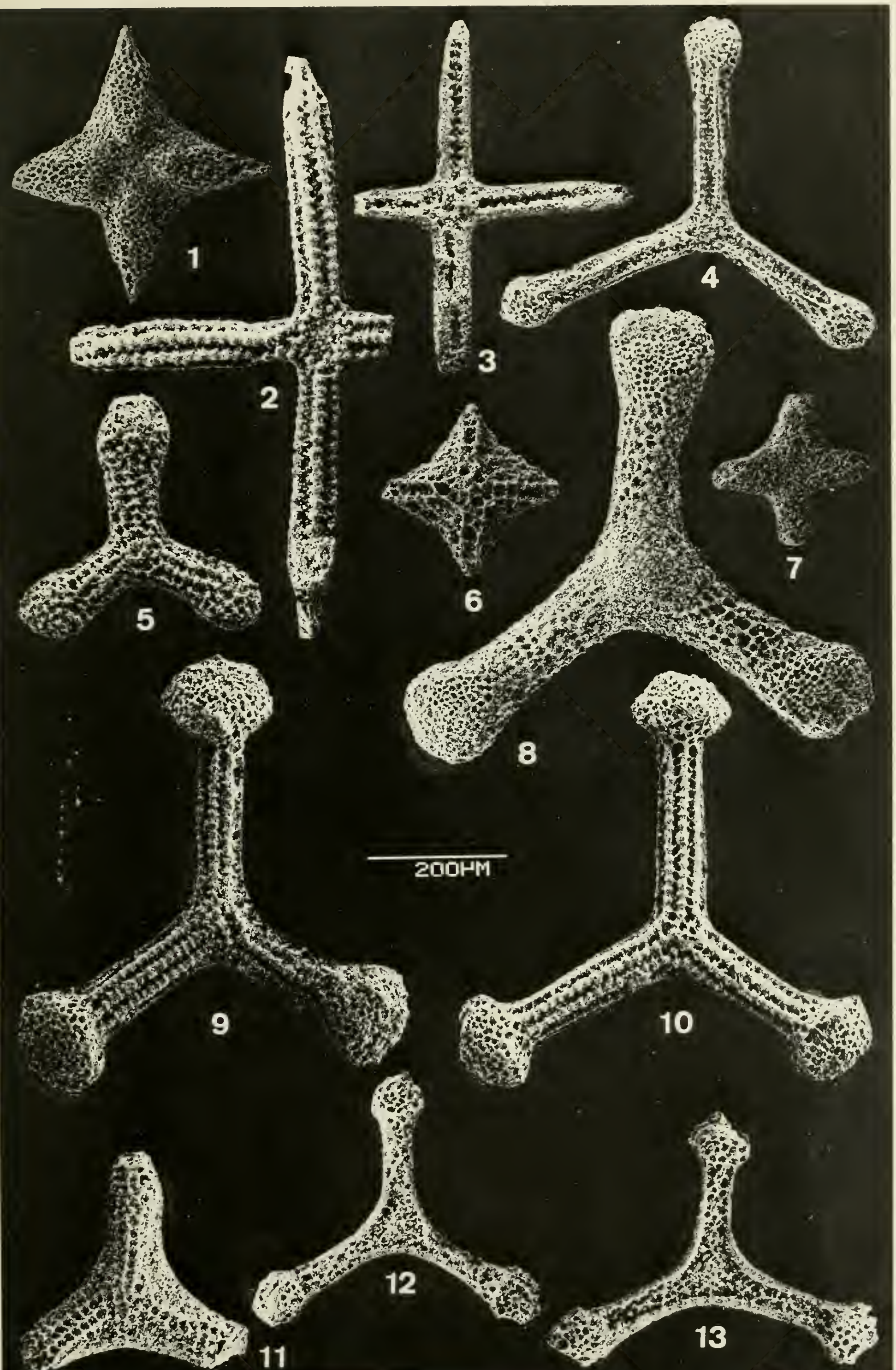
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Plate 1

In plates 1—4 all figures are Cambride Stereoscan 250 scanning electron micrographs (15kV), stereoscan stub no. 6218. They came from the phosphoritic nodules, upper *jason* to *athleta* Zone, Middle Callovian, unless otherwise stated. SMNS means: deposited under this no. in the collections of the "Staatliches Museum für Naturkunde" in Stuttgart, Western Germany.

Radiolaria (× 100)

Fig. 1. *Pseudocrucella* cf. *prava* Blome. Thanheim. SMNS no. 29338 (36/14139).
Fig. 2 *Tetratrabs zealis* (Ožvoldova). Thanheim. SMNS no. 29332 (30/14136).
Fig. 3 Gen. indet. VII: Reutlingen. SMNS no. 29331 (29/14136).
Fig. 4. *Tritrabs ewingi* Pessagno. Thanheim. SMNS no. 29317 (14/14219).
Fig. 5. *Patulibracchium bronnimanni* (Pessagno). Thanheim. SMNS no. 29349 (47/14144).
Fig. 6—7. *Crucella* sp. Thanheim. SMNS no. 29339—29340 (37—38/14139—14140).
Fig. 8. *Patulibracchium* sp. Reichenbach. SMNS no. 29316 (13/14128).
Fig. 9—10. *Homoeoparonaella argolidensis* Baumgartner. Thanheim. SMNS no. 29345, 29343 (43, 42/14141—14142).
Fig. 11. *Halesium* sp. Thanheim. SMNS no. 29348 (46/14144).
Fig. 12—13. *Angulobracchia purismaensis* (Pessagno). Thanheim. SMNS no. 29347, 29346 (45, 44/14143).

Plate 2

Radiolaria (× 100)

Fig. 1. *Bernoullius cristatus* Baumgartner. Thanheim. SMNS no. 29342 (25/14140).
Fig. 2. *Bernoullius dicera* Baumgartner. Reutlingen. SMNS no. 29326 (24/14133).
Fig. 3—4. *Andromeda praepodbielensis* Baumgartner. Reutlingen. SMNS no. 29318—29319 (15—16/14130).
Fig. 5—7. *Orbiculaforma* sp. Thanheim. SMNS no. 29352, 29351, 29350 (50, 49, 48/14145—14146).
Fig. 8. ?*Orbiculaforma* sp. Reutlingen. SMNS no. 29327 (25/14134).
Fig. 9—10. *Archaeohagiastrum munitum* Baumgartner. Thanheim. Fig. 9 SMNS no. 29333 (31/14137). Fig. 10 SMNS no. 29335 (33/14137).
Fig. 11—12. *Archaeohagiastrum* sp. Fig. 11 SMNS no. 29334 (32/14137). Fig. 12 SMNS no. 29341 (39/14140).
Fig. 13. *Emiluvia* sp. Reutlingen. SMNS no. 29325 (23/14133).
Fig. 14—15. *Emiluvia* sp. Thanheim. SMNS no. 29336—29337 (34—35/14138).
Fig. 16. *Acaeniotyle*(?) sp. Reutlingen. SMNS no. 29323—1 (20/14132).
Fig. 17. *Triactoma* sp. aff. *T. cornuta* Baumgartner. Reutlingen. SMNS no. 29320 (18/14131).
Fig. 18—19. *Emiluvia tympanica* (Ožvoldova). Fig. 18 Thanheim. SMNS no. 29360 (57/14149). Fig. 19 Reutlingen. SMNS no. 29324 (22/14133).

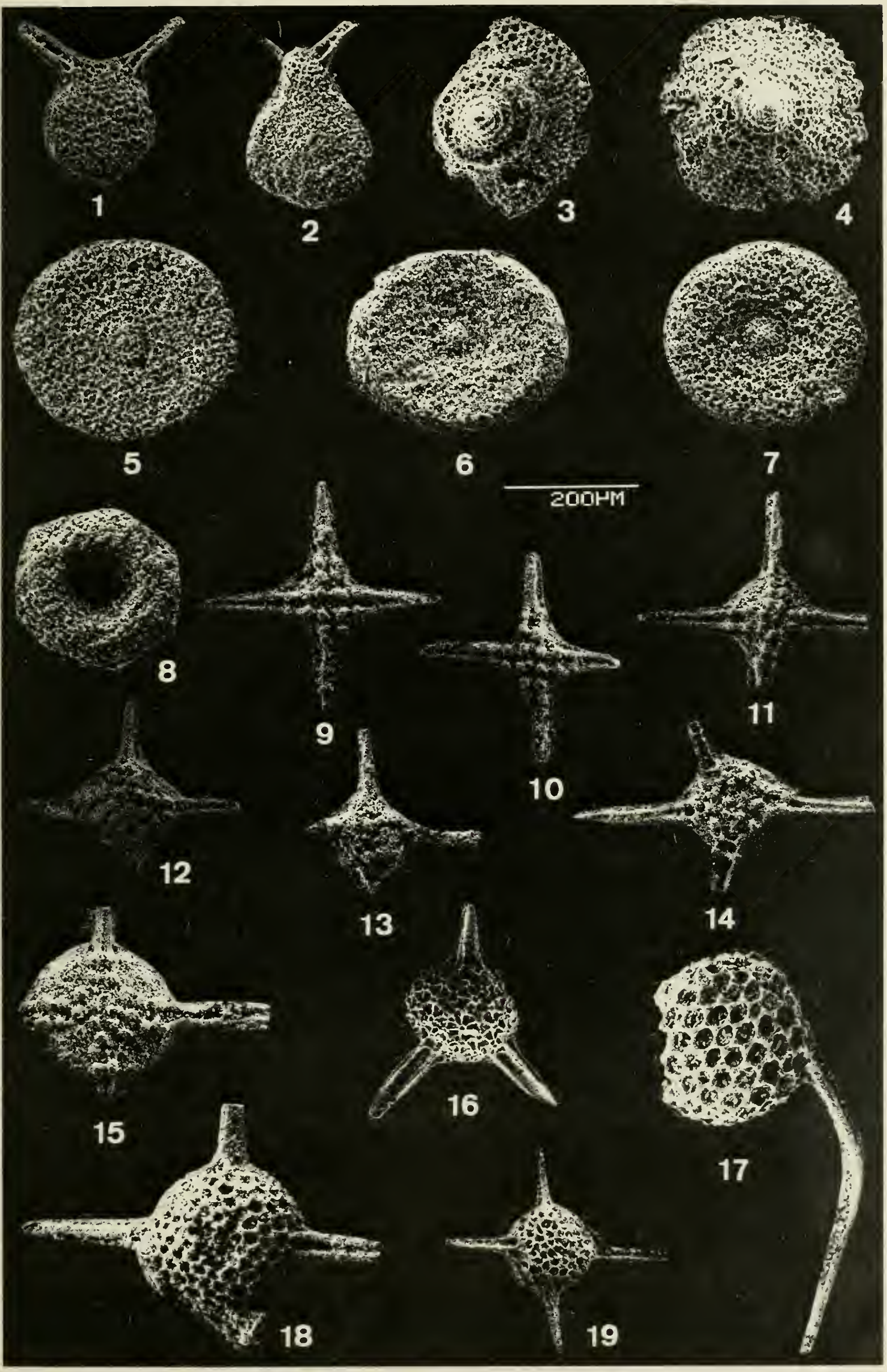
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Plate 3

Radiolaria (× 100)

Fig. 1—2. *Hsuum*(?) *inexploratum* BLOME. Thanheim. Fig. 1 SMNS no. 29370 (67/14155). Fig. 2 SMNS no. 29369 (66/14154).

Fig. 3. *Archaeodictyomitra*(?) sp. SMNS no. 29371 (68/14155).

Fig. 4—5. *Archaeodictyomitra*(?) *brevicostatus* (OŽVOLDOVA). Thanheim. Fig. 4 SMNS no. 29372 (69/14155—14156). Fig. 5 Reutlingen. SMNS no. 29328 (26/14134).

Fig. 6. *Archaeodictyomitra*(?) sp. Thanheim. SMNS no. 29376 (73/14157).

Fig. 7. *Parvicingula* cf. *media* PESSAGNO and WHALEN. Thanheim. SMNS no. 29375 (72/14157).

Fig. 8—9. *Spongocapsula palmerae* PESSAGNO. Fig. 8 Reutlingen. SMNS no. 29329 (27/14134). Fig. 9 Thanheim. SMNS no. 29373 (170/14156).

Fig. 10. *Spongocapsula* sp. Thanheim. SMNS no. 29374 (71/14156).

Fig. 11. *Podobursa helvetica* (RÜST). Reutlingen. SMNS no. 29322 (19/14132).

Fig. 12—13. *Podobursa triacantha* (FISCHLI). Thanheim. SMNS no. 29357, 29359 (55—56/14148—14149).

Fig. 14—15. *Podobursa pantanelli* (PARONA). Fig. 14 Thanheim. SMNS no. 29344 (41/14141). Fig. 15 Reutlingen. SMNS no. 29321 (18/14131).

Fig. 16. *Cenosphaera hirta* PARONA. Thanheim. SMNS no. 29366 (63/14153).

Fig. 17. *Cenosphaera micropora* RÜST. Thanheim. SMNS no. 29367 (64/14154).

Fig. 18. *Cenosphaera euganea* SQUINABOL. Thanheim. SMNS no. 29368 (65/14154).

Fig. 19 *Stylosphaera* sp. Thanheim, SMNS no. 29361 (58/14150).

Fig. 20. Gen. indet. I. Reutlingen. SMNS no. 29330 (28/14135).

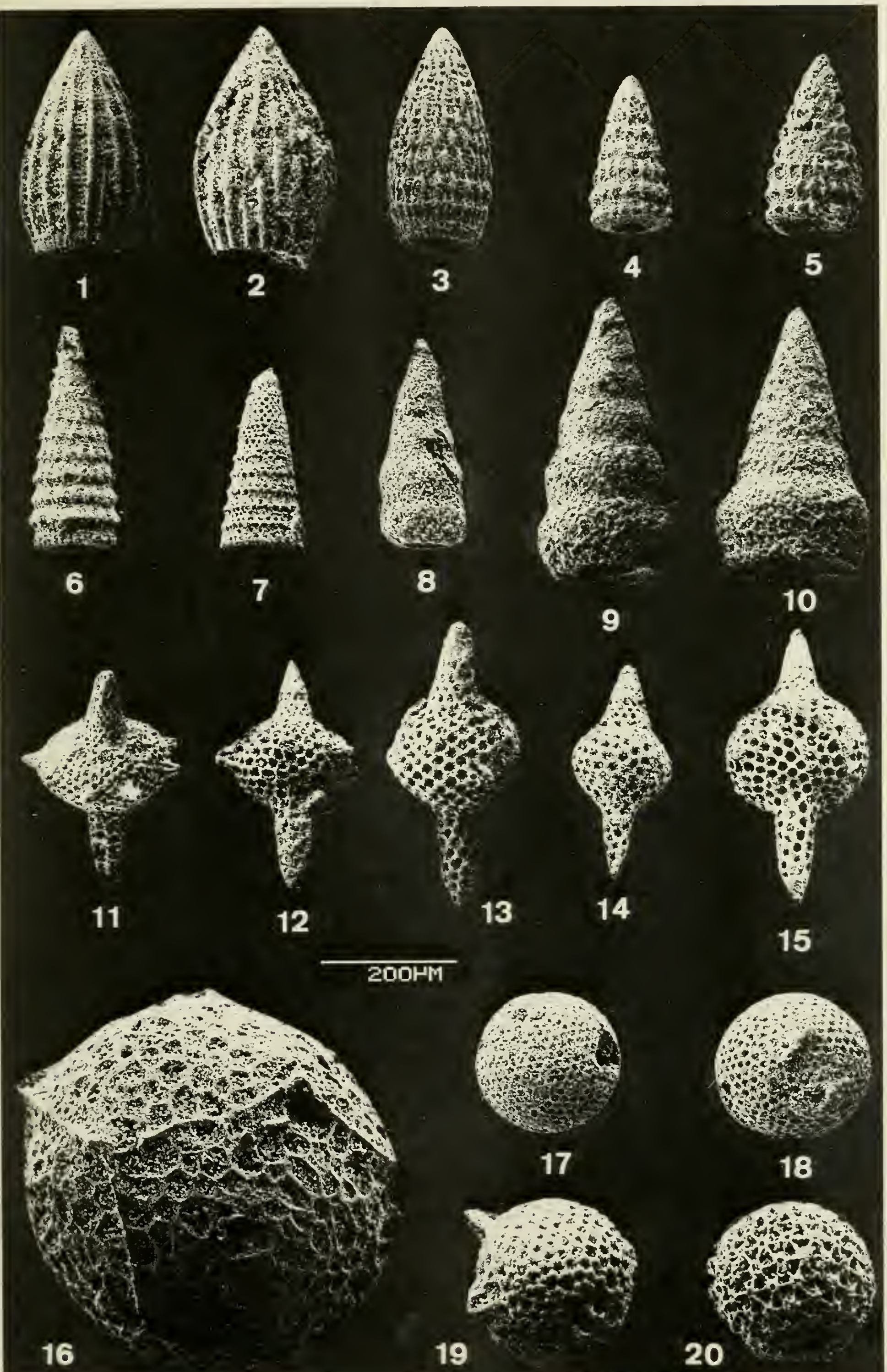
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Plate 4

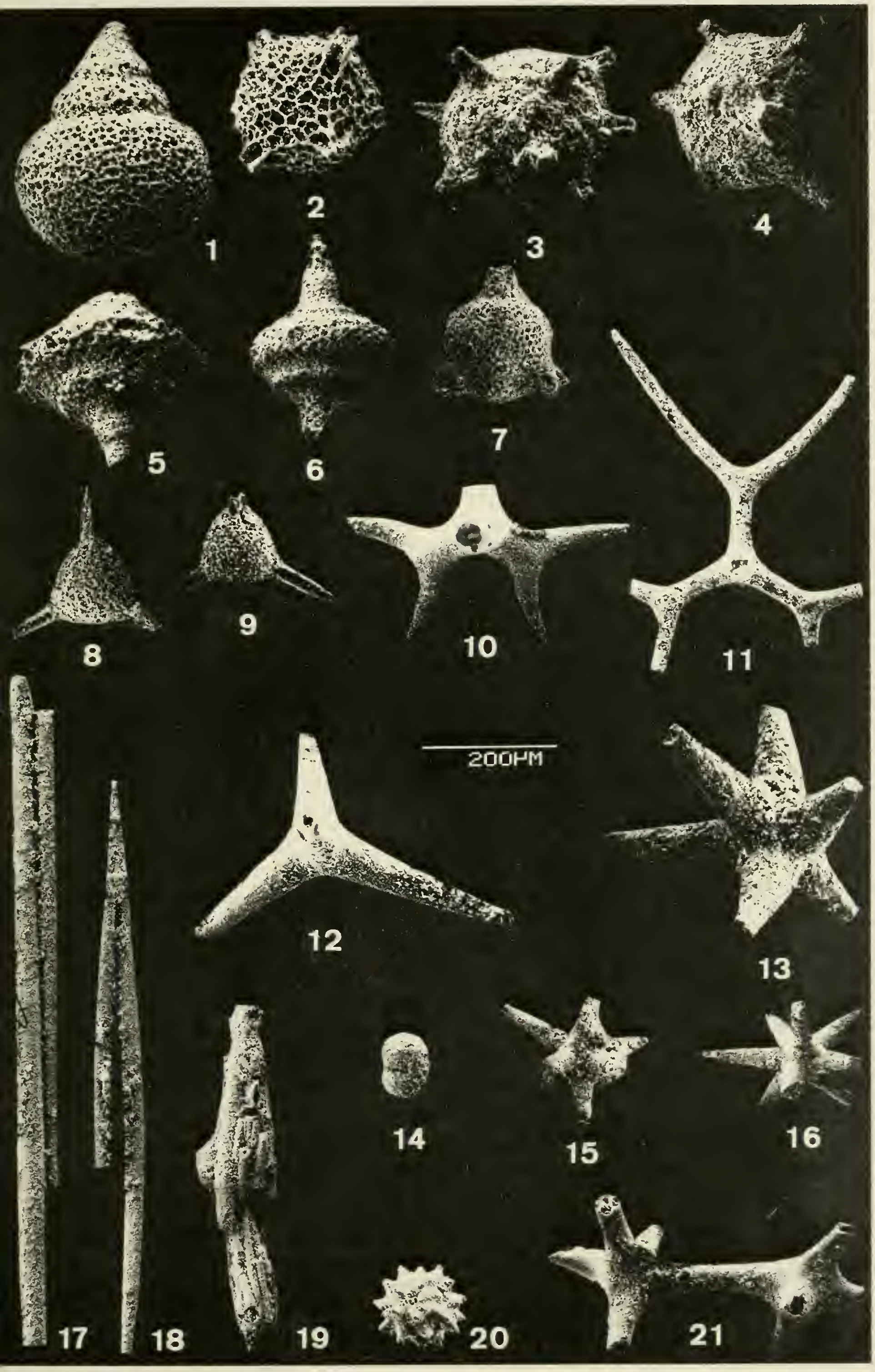
Radiolaria (× 100)

Fig. 1. *Stichocapsa rotunda* HINDE. Thanheim. SMNS no. 29355 (53/14148).

Fig. 2—9. Gen. indet. II—VI. Fig. 2 II. Thanheim. SMNS no. 29363 (60/14151). Fig. 3—4 III. SMNS no. 29353—29354 (51/14147). Fig. 5 IV. SMNS no. 29362 (59/14150). Fig. 6 IV. SMNS no. 29356 (54/14148). Fig. 7 V. SMNS no. 29365 (62/14152). Fig. 8 VI. SMNS no. 29364 (61/14151). Fig. 9 VI. Reutlingen. SMNS no. 29323—2 (21/14132).

Sponge spicules (× 100)

Fig. 10. Orthodichotriaene. Thanheim. SMNS no. 29306 (3/14122).
Fig. 11. Asymmetrical Orthodichotriaene. Reutlingen. SMNS no. 29304(1/14120).
Fig. 12. Oxycalthrop. Thanheim. SMNS no. 29305 (2/14121).
Fig. 13. Oxyhexactine. Thanheim. SMNS no. 29308 (5/14124).
Fig. 14. Rhax. Thanheim. SMNS no. 29312 (9/14126).
Fig. 15—16. ?Sphaerasters. Thanheim. SMNS no. 29309–29310 (6—7)/1425).
Fig. 17—19. Amphistyles. Thanheim. SMNS no. 29313—29315 (10—12/14127).
Fig. 20. Sphaeraster. Thanheim. SMNS no. 29311 (8/14126).
Fig. 21. Oxyhexactine. Thanheim. SMNS no. 29307 (4/14123).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