PALAEONTOLOGIA POLONICA

EDITOR

ADAM URBANEK

No. 57, 1997

UPPER JURASSIC SILICEOUS SPONGES FROM THE SWABIAN ALB: TAXONOMY AND PALEOECOLOGY

(GÓRNOJURAJSKIE GĄBKI KRZEMIONKOWE Z ALBU SZWABII:
TAKSONOMIA I PALEOEKOLOGIA)

by

ANDRZEJ PISERA

(WITH 35 TEXT-FIGURES AND 54 PLATES)

WARSZAWA 1997

INSTYTUT PALEOBIOLOGII PAN im. ROMANA KOZŁOWSKIEGO

PALAEONTOLOGIA POLONICA

Tome I, 1929 — Roman Kozłowski. Les Brachiopodes Gotlhandiens de la Podolie Polonaise. I–XIII. 254 pp., 1 carte, 95 fig. dans le texte, 12 planches.

Tome II, No. 1, 1932 (le seul paru) — Maria Wiśniewska. Les Rhynchonellidés du Jurassique sup. de Pologne. I–VIII. 71 pp., 20 fig. dans le texte, 6 planches.

Tome III, 1948 — Roman Kozłowski. Les Graptolithes et Quelques Nouveaux Groupes d'Animaux du Tremadoc de la Pologne. I–XII. 235 pp., 66 fig. dans le texte, 32 planches.

No. 4, 1952 — Henryk Makowski. La Faune Callovienne de Łuków en Pologne. I–X. 64 pp., 12 fig. dans le texte, 9 planches.

No. 5, 1952 — Maria Różkowska. Pachyphyllinae et Phillipsastraea du Frasnien de Pologne. I–V. 89 pp., 41 fig. dans le texte, 8 planches.

No. 6, 1954 — Zofia Kielan. Les Trilobites Mésodévoniens des Monts de Saine-Croix. I–V. 50 pp., 35 fig. dans le texte, 7 planches.

No. 7, 1955 — Julian Kulczycki. Les Ossements des Mammouth. I–IV. 65 pp., 28 fig. dans le texte, 10 planches.

No. 8, 1957 — Krystyna Pożaryska. Lagenidae de Crétacé Supérieur de Pologne. I–X. 190 pp., 45 fig. dans le texte, 27 planches et 6 text-planches.

No. 9, 1958 — Adam Urbanek. Monograptidae from Erratic Boulders of Poland. I–IV. 105 pp., 68 text-figs, 5 plates, 7 text-plates.

No. 10, 1959 — Gertruda Biernat. Middle Devonian Orthoidea of the Holy Cross Mountains and their Ontogeny. I–IV. 80 pp., 23 text-figs, 12 plates, 8 text-plates.

No. 11, 1959 — Zofia Kielan. Upper Ordovician Trilobites from Poland and Some Related Forms from Bohemia and Scandinavia. I–VI. 198 pp., 50 text-figs, 36 plates.

No. 12, 1962 — Henryk Makowski. Problem of Sexual Dimorphism in Ammonites. I–VIII. 92 pp., 14 text-figs, 20 plates, 12 text-plates.

No. 13, 1964 — L. Beverly Halstead Tarlo. Pasmmosteriformes (Agnatha) — a Review with Descriptions of New Material from the Lower Devonian of Poland. I. General Part. I–VII. 135 pp., 32 text-figs, 14 plates.

No. 14, 1965 — Krystyna Pożaryska. Formainifera and Biostratigraphy of the Danian and Montian in Poland. I–IX. 156 pp., 28 paltes, 9 text-plates, 6 tables.

No. 15, 1965 — L. Beverly Halstead Tarlo. Pasmmosteriformes (Agnatha) — a Review with Descriptions of New Material from the Lower Devonian of Poland. II. Systematic Part. I–IX. 168 pp., 48 text-figs, 19 plates.

No. 16, 1966 — Zofia Kielan-Jaworowska. *Polychaete Jaw Apparatuses from the Ordovician and Silurian of Poland and a Comparison with Modern Forms.* 152 pp., 12 text-figs, 6 tables 36 plates.

No. 17, 1966 — Gertruda Biernat. Middle Devonian Brachiopodes of the Bodzentyn Syncline (Holy Cross Mountains, Poland). 162 pp., 51 text-figs, 32 plates.

No. 18, 1967 — Anna Stasińska. Tabulata from Norway, Sweden and from the Erratic Boulders of Poland. 112 pp., 14 text-figs, 6 tables, 38 plates.

No. 19, 1968 — Zofia Kielan-Jaworowska. (Editor). Results of the Polish-Mongolian Paleontological Expeditions. Part I. 192 pp., 51 text-figs, 21 plates.

No. 20, 1968 — Krystyna Pożaryska and Janina Szczechura. Formaninifera from the Paleocene of Poland, their Ecological and Biostratigraphic Meaning. 107 pp., 22 text-figs, 3 tables, 18 plates.

No. 21, 1969 — Zofia Kielan-Jaworowska. (Editor). Results of the Polish-Mongolian Paleontological Expeditions. Part II. 229 pp., 60 text-figs, 42 plates.

No. 22, 1969 — Hanna Górka. Microorganismes de l'Ordovicien de Pologne. 102 pp., 44 text-figs, 31 planches.

No. 23, 1970 — Halszka Osmólska. Revision of Non-cyrtosymbolinid Trilobites from the Tournaisian-Namurian of Eurasia. 166 pp., 9 text-figs, 2 tables, 22 plates.

No. 24, 1970 — Jerzy Fedorowski. Aulophyllidae (Tetracoralla) from the Upper Visean of Sudetes and Holy Cross Mountains. 137 pp., 52 text-figs, 23 plates.

No. 25, 1971 — Zofia Kielan-Jaworowska. (Editor). Results of the Polish-Mongolian Paleontological Expeditions. Part III. 158 pp., 50 text-figs, 28 plates.

No. 26, 1971 — Józef Kaźmierczak. Morphogenesis and Systematics of the Devonian Stromatoporoidea from the Holy Cross Mountains, Poland. 150 pp., 20 text-figs, 41 plates.

No. 27, 1972 — Zofia Kielan-Jaworowska. (Editor). Results of the Polish-Mongolian Paleontological Expeditions. Part IV. 143 pp., 50 text-figs, 53 plates.

No. 28, 1973 — Gertruda Biernat. Ordovician Inarticulate Brachiopods from Poland and Estonia. 120 pp., 40 text-figs, 40 plates.

No. 29, 1973 — Magdalena Borsuk-Białynicka. Studies on the Pleistocene Rhinoceros *Coelodonta antiquitatis* (Blumenbach). 96 pp., 13 text-figs, 50 tables, 32 plates.

No. 30, 1974 — Zofia Kielan-Jaworowska. (Editor). Results of the Polish-Mongolian Paleontological Expeditions, Part V. 178 pp., 41 text-figs, 51 plates.

No. 31, 1974 — Janina Szczechura and Krystyna Pożaryska. Foraminiferida from the Paleocene of Polish Carpathians (Babice Clays). 142 pp., 4 text-figs, 38 plates.

PALAEONTOLOGIA POLONICA — No. 57, 1997

UPPER JURASSIC SILICEOUS SPONGES FROM THE SWABIAN ALB: TAXONOMY AND PALEOECOLOGY

(GÓRNOJURAJSKIE GĄBKI KRZEMIONKOWE Z ALBU SZWABII:
TAKSONOMIA I PALEOEKOLOGIA)

by

ANDRZEJ PISERA

(WITH 35 TEXT-FIGURES AND 54 PLATES)

WARSZAWA 1997
INSTYTUT PALEOBIOLOGII PAN im. ROMANA KOZŁOWSKIEGO

EDITOR

ADAM URBANEK

ASSISTANT EDITOR

MAGDALENA BORSUK-BIAŁYNICKA

Address of the Editorial Office
Instytut Paleobiologii
Polska Akademia Nauk
ul. Twarda 51/55
00-818 Warszawa, Poland

Copyright ©
by Instytut Paleobiologii PAN im. Romana Kozłowskiego
Warszawa 1997

ISBN 83-01-09860-0
ISSN 0078-8562

Published
by the Publishing Department of the Institute of Paleobiology

Production Manager — Andrzej Baliński
Typesetting & Layout — Aleksandra Szmielew

Printed in Poland

UPPER JURASSIC SILICEOUS SPONGES FROM THE SWABIAN ALB: TAXONOMY AND PALEOECOLOGY

ANDRZEJ PISERA

Pisera, A. 1997. Upper Jurassic Siliceous Sponges from the Swabian Alb: Taxonomy and Paleoecology. — *Palaeontologia Polonica* **57**, 3–216.

The fauna of siliceous sponges (hexactinellids and demosponges) from the Upper Jurassic of the Swabian Alb is described and revised. It consists of 124 species representing 67 genera. Only 15 species show frequency higher than 1% of the whole assemblage. Nearly all sponges represent groups with solid skeletons: Hexactinosa and Lychniscosa, and lithistid Demospongea. Loose spicules occurring are also described and illustrated. Two new species are proposed: lithistid *Amphibleptula jurassica* sp. n. and hexactinosan *Sphenaulax irregularis* sp. n. Several other new species are described in an open taxonomy. The presence or absence of dermal and/or gastral layers of pentactines or stauractines in Hexactinosa and Lychniscosa is of no taxonomic value, because it is mostly a taphonomical phenomenon, and both types of spicules can be present in the same species. Lithification of sponges leading to origin of the so called "sponge mummies" preserves (except in one lyssacinosan sponge) only parts of the sponges delimited by solid skeletal structures. The Oxfordian assemblage is dominated by hexactinosan and lychniscosan sponges, while beginning with the Kimmeridgian lithistid demosponges are very common. The proportion of lithistid sponges in the assemblage increases steadily and the uppermost Kimmeridgian assemblage consists mostly of lithistids. This trend is interpreted here in terms of superimposed bathymetric changes and type of food dominant in the environment: particulate (domination of lithistid demosponges) and colloidal (hexctinellids domination). Ecological analysis of the sponge fauna and sedimentological analysis of sponge-bearing sequences point to a relatively deep-water setting of the Upper Jurassic siliceous sponge biofacies: the most shallow mixed sponge-coral Upper Kimmeridgian assemblages dominated by lithistid demosponges could be from 60–100 meters, while Oxfordian hexactinellid dominated assemblages may be from as deep as 200–600 m. The apperance of rich siliceous sponge assemblages in the Upper Jurassic is mostly ecological phenomenon since the numerous genera contributing to this assemblage are rooted in the Lower Jurassic at least. Generally high sea level during the Upper Jurassic produced large, relatively deep water areas, remote from the shore and thus with slow sedimentation. Such new habitats suitable for sponges have been colonized by immigrants from refugia existing on continental and island slopes. Large sponge populations were supported by high nutrient availability characteristic for the Upper Jurassic.

Key words: Siliceous sponges, Hexactinosa, Lychniscosa, Lithistida, taxonomy, paleoecology.

Andrzej Pisera [apis@twarda.pan.pl], Instytut Paleobiologii PAN, Twarda 51/55, PL-00 818 Warszawa, Poland.

Received July 1996, accepted December 1996

CONTENTS

INTRODUCTION

The sponges of the Swabian Alb have been the subject of several studies beginning with classical monographs of GOLDFUSS (1833) and QUENSTEDT (1878); modern type of taxonomy was applied to them as early as in 1877 by ZITTEL, and the first revision of older works was prepared by KOLB (1910). This author produced enormous taxonomic problems, however, synonymizing various earlier erected species (concerning mostly hexactinellids) on rather vague morphological criteria, without going into details; unfortunately in later and quite recent works this is repeated by non-critical acceptation of his synonymies. In effect often I had to reject such conclusions and repeat synonymizing taxa of old papers anew. The most thorough research on the sponges from the Swabian Alb was done by SCHRAMMEN (1924, 1936, 1937), who based his study to a large extent, however, on the especially well preserved (original spicules preserved) fauna from Streitberg in the Franconian Alb. Recently, several excellent papers dealing with particular genera or special aspects of siliceous sponges from the Swabian Alb have been presented by MÜLLER (1972, 1974, 1987, 1988, 1990, 1991, 1994) based on many years of collecting. Most of these papers, however, lack statistical data concerning frequency of taxa and their distribution in space and lithology, data which are necessary in evaluation of paleoecological aspects of sponge assemblages, as well. Loose siliceous sponge spicules were described by SCHRAMMEN (1937) and more recently by REIF (1967). The present study is an attempt to revise, whenever allowed by the material, the siliceous sponge fauna of the Swabian Alb including classical collections housed in Tübingen (QUENSTEDT, SCHRAMMEN), Bonn (GOLDFUSS), München (GOLDFUSS and SCHRAMMEN) and Stuttgart (MÜLLER and some KOLB specimens), as well as to consider its distributions (in a quantitative manner) in time and lithology, to reveal existing patterns allowing for interpretation of the sponge biofacies environmental setting and genesis.

Perhaps much more attention has been paid, especially recently, to sedimentological aspects of the sponge biofacies of southern Germany. General facies types (especially biohermal facies) were described by ROLL (1934). Later several detailed sedimentological and paleontological analyses of particular areas or outcrops were presented by FRITZ (1958), HILLER (1964), PAULSEN (1964), WAGENPLAST (1972), and NITZOPOULOS (1974). An excellent synthesis of all aspects (stratigraphy, sedimentology, paleoecology) of the Upper Jurassic, especially sponge biofacies, was published by GWINNER (1976) and ZIEGLER (1977, 1987). More recently, several important papers dealing with sedimentological and paleoecological aspects of the sponge biofacies of southern Germany were published by KEUPP *et al.* (1990), LEINFELDER (1993), and LEINFELDER *et al.* (1994); there one can find complete references to the earlier literature concerning this subject. One has to mention at the end an excellent paleogeographical study by MEYER and SCHMIDT-KALER (1990).

Acknowledgements. — The idea of this study was proposed by my friend late Professor Antoni HOFFMAN. Professors Jerzy TRAMMER and Andrzej MATYJA (both from the University of Warsaw, Warszawa) introduced me into the problems of the Upper Jurassic sponge megafacies, especially in Poland and Germany; Andrzej MATYJA shared with me his stratigraphical knowledge of the Upper Jurassic and helped in the field during one of my stays in Spain. Most of the field work in Spain was possible thanks to the invaluable help of Dr. Guillermo MELENDEZ (University of Zaragoza, Zaragoza) and Dr. Sebastian CALZADA (Museo del Seminario de Barcelona, Barcelona) while visits to the Prebetic and Betic Jurassic outcrops were organised by Dr. Federico OLORIZ (University of Grenada, Granada). Professor Jerzy TRAMMER helped to collect sponges from Plettenberg, Hochwang and partly from Bärenthal sections in the Swabian Alb, and was always eager to discuss problems of sponge taxonomy and paleoecology. These investigations would not have been possible without help of my German colleagues: Professor Otto GEYER and Dr. Manfred KRAUTTER (Stuttgart University, Stuttgart), Professor Bernhard ZIEGLER, Dr. Gerd DIETL and Dr. Ursula LAUXMANN, and the staff of the Museum am Löwentor (Stuttgart), Mr. Walter MÜLLER (Esslingen), Professor Hans-Peter LUTTERBACHER, Dr. Alexander LIEBAU and Dr. Zdzisław BEŁKA (Tübingen University, Tübingen). Part of my field work and museum studies in Germany were made possible by a DAAD scholarship, while stays in Spain were partly supported by CSIC in Madrid. Dr. Reinhart GYGI (Naturhistorisches Museum Basel, Basel) supported my stay in Switzerland allowing collection of sponges from classical outcrops there, and he determined some ammonites thus helping biostratigraphical attribution of samples, while Dr. Felix WIEDENMAYER (also from Basel), helped in search for some OPPLIGER's specimens and supplied important literature. Professor Heinrich RISTEDT (Bonn Univeristy) made possible examination of GOLDFUSS collection in Bonn, while Drs. Winfried WERNER and Gerhard SCHAIRER (both Bayerische Statssammlung für Paläontologie und Historische Geologie, München) made possible examination of sponge collections in München. Early stages of this project were supported by a National Geographic Society grant to Dr. Joseph GHIOLD (then Louisiana State University, Baton Rouge). Professor J. Keith RIGBY critically read the manuscript and improved the language. Professor Jerzy TRAMMER read the manuscript and suggested some changes. Most macrophotographs were taken by Ms. Grażyna DZIEWIŃSKA (Institute of Paleobiology, Warszawa). SEM photographs of specimens from the Museum am Löwentor (Stuttgart) were taken in the SEM laboratory of this Museum, while the rest in the SEM laboratory of the Institute of Paleobiology (Warszawa) using a Philips XL-20 scanning microscope. I would like to extend my most sincere thanks to all these people and institutions.

GEOLOGICAL SITUATION OF THE SPONGE BIOFACIES

The Upper Jurassic sponge biofacies, *i.e.* all Upper Jurassic calcareous rocks containing numerous siliceous sponges, both bedded and biohermal in character (as defined by MATYJA and PISERA 1991) are often called "Upper Jurassic Sponge Megafacies". This term (later referred to as UJSM) was coined by MATYJA (1976), who also presented the first paleogeographical map of this facies in Europe; the meaning of UJSM is similar to the Malm Reef Belt of WILSON (1975), which concerns, however, mostly biohermal

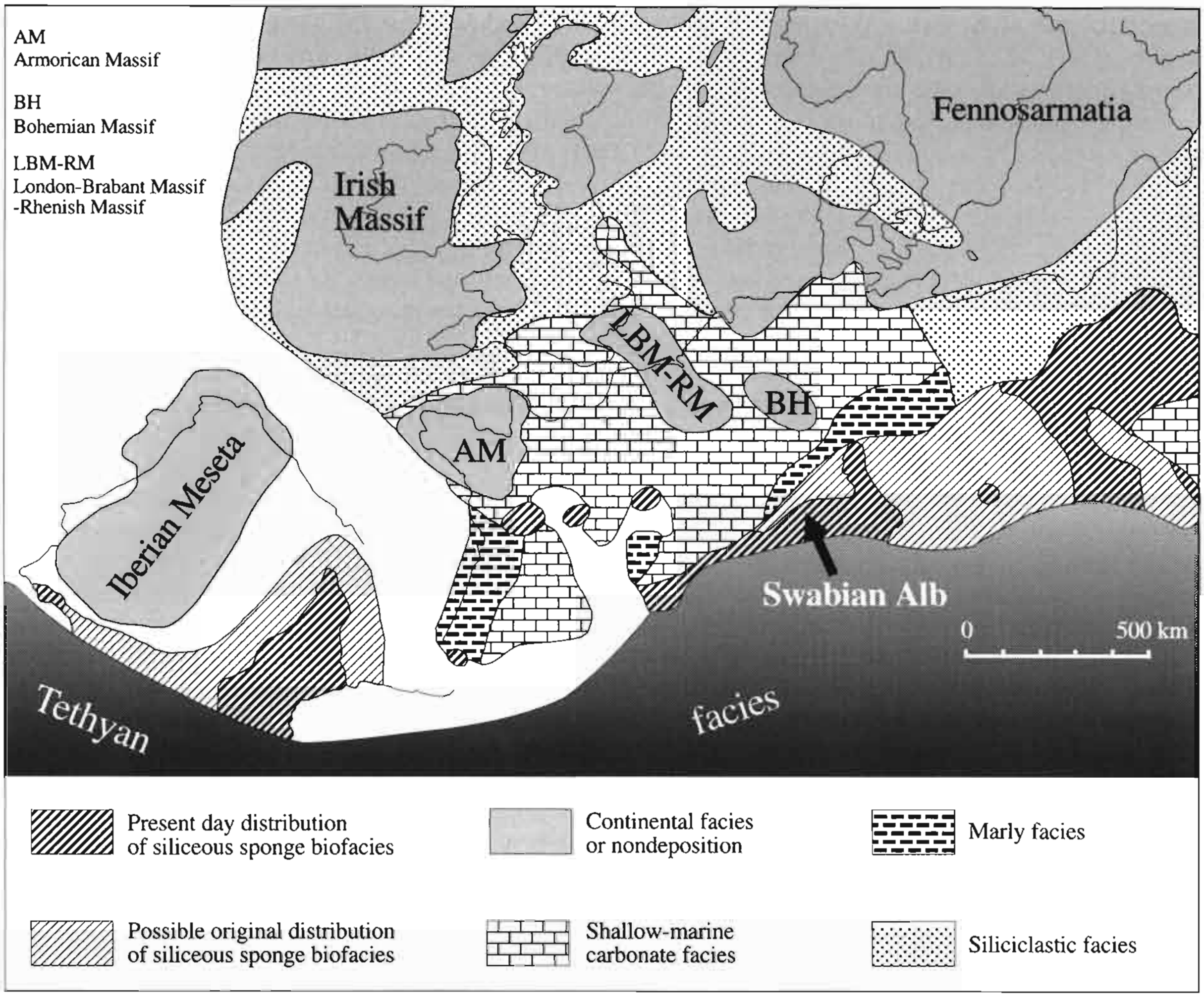


Fig. 1
Paleogeographical situation of the Upper Jurassic sponge biofacies in Europe (shown at its maximum extent during Middle Oxfordian); occurrence in Romania oustide the map; after Matyja and Wierzbowski 1995, modified.

rocks. While both UJSM and Malm Reef Belt stress the lithological aspects of the facies, the term "siliceous sponge biofacies" used in this paper indicates that I deal mostly with faunal contents of these rocks. In space, the Upper Jurassic sponge biofacies in Europe (Fig. 1) extends from Portugal (Ramalho 1988; Leinfelder *et al.* 1993), through Spain (Riba 1959; Behmel 1970; El Khoudary 1974; Aurell 1990; Pisera 1991), France (Gaillard 1971, 1983), Switzerland (Gygi 1986; Gygi and Persoz 1987), Germany (Ziegler 1977; Keupp *et al.* 1990, and literature therein), to Poland (Kutek *et al.* 1977, 1984; Trammer 1982, 1989 and literature therein), and Romania (Antonescu 1929; Barbulescu 1974). The biofacies with abundant siliceous sponges in the Upper Jurassic is not, however, limited to Europe, but has a much wider global distribution (Fig. 9).

Paleogeographically the belt of UJSM is situated between shallow water deposits with coral reefs, oolites etc. to the north (see Fig. 1), and deep water Tethyan facies (red nodular limestones, radiolarites) to the south (Matyja 1976; Gaillard 1983; Gygi and Persoz 1987; Meyer and Schmidt-Kaler 1990).

In all known occurrences sponge megafacies rocks overlie, with a break, Callovian or even older Middle Jurassic usually shallower water deposits. Directly below, there commonly occurs a condensed unit spanning various amounts of time in various sections (from Callovian to Lower Oxfordian) represented by stromatolites, ferruginous oolites or simply a thin layer of very condensed carbonate deposits with molds of reworked fossils, often of several generations. Especially widespread are ferruginous oolites, which are known world-wide in the same stratigraphic position, but not always followed by a sponge biofacies (Fig. 9). The stratigraphical extent of UJSM varies; the oldest deposits with sponges occur in

Poland and are dated as Lower Oxfordian in age; they continue there until the beginning of the Kimmeridgian, when UJSM is substituted with various shallow water limestones with oolites and corals. The youngest known UJSM deposits occur in the Swabian Alb, where they are dated as uppermost Kimmeridgian (SCHWEIGERT 1993, 1994 – earlier these rocks attributed in a classical zonation to White Jurassic Zeta were regarded as Lower Tithonian in age – see GEYER and GWINNER 1984).

As no exact biostratigraphic position is known for each sampled unit or sample, classical QUENSTEDT lithostratigraphy of the Upper Jurassic has been used in the paper. Ammonites collected together with sponges allowed, however, for some biostratigraphic control of lithostratigraphic units; the oldest samples (White Jurassic Alfa) have been dated as Middle Oxfordian (Bifurcatus Zone). The youngest samples which yielded sponges have been collected from coral-bearing limestones attributed to White Jurassic Zeta 1 and 2 – units for a long time considered as Lower Tithonian (GEYER and GWINNER 1984) in age. Most recent ammonite findings (SCHWEIGERT 1993, 1994) suggest that they represent the uppermost Kimmeridgian.

METHODS AND INVESTIGATED SECTIONS

For the purpose of this study several sections covering the time span of sponge occurrences (Figs 2, 3), as well as facies types were chosen and sampled unit by unit, whenever possible. All sponges (also larger fragments) have been collected and later determined to the lowest possible taxonomic level. Most of the specimens were etched in weak acetic acid to reveal spicules, which were also investigated in thin sections. Whenever preservation allowed SEM was used to study spiculation. Over 4700 specimens have been used in quantitative analysis (among them about 4200 have been collected by the author, the rest were from museum collections) and another several hundred specimens from the museum collections were also used in comparative studies. The following sections have been investigated (see Figs 2, 3) and sponges collected:

Plettenberg. — This is a large active quarry located at the top of the mountain called Plettenberg south-east Dotternhausen, south of Balingen. The section covers the White Jurassic Alpha and Beta (Oxfordian), the contact with the underlying Brown (Middle) Jurassic not being visible; total thickness of the Oxfordian outcrop is over 60 meters (HASKELL 1986). Lower part of the section (White Jurassic Alfa) consists of grey marls with thin limestone intercalations (Lochen facies – about 40 meters in thickness after HASKELL 1986). It has been dated by ammonites as the *Perisphinctes bifurcatus* to *Epipeltoceras bimmamatum* Zones (Middle/Upper Oxfordian). Both types of rock contain numerous sponges. In the upper part of this unit numerous small (approximately two meters in size) bioherms are common. Upper part of the quarry is in thick bedded limestones of the White Jurassic Beta (Upper Oxfordian), which sometimes resemble massive limestones; from the uppermost part of the section *Idoceras planula* (HEHL) has been identified. No Kimmeridgian rocks crop out in the area. Limestones of the White Jurassic Beta display also numerous bioherms up to several dozen meters in size. In all levels sponge surfaces are commonly covered with thrombolites and stromatolites.

The details of geology of the outcrop may be found in HASKELL (1986).

Nusplingen. — This is a new outcrop along road cuts just above a new house on the eastern slope of the valley at the northern edge of Nusplingen. There are marls very rich in sponges, similar to those in the lower levels of Plettenberg quarry and at the Lochen Pass. These rocks are attributed to the White Jurassic Alfa (Middle Oxfordian).

Bärenthal. — There are numerous samples collected in the surroundings of Bärenthal, mostly in small outcrops along forest roads, on both sides of the valley above Bärenthal, cutting into uppermost Oxfordian and Lower and Middle Kimmeridgian marls; they yielded numerous well preserved sponge specimens.

– One group of samples was collected from temporary ouctrops along the road leading from Bärenthal (above the cementary) toward Renquishausen, and are attributed to White Jurassic Gamma (Lower Kimmeridgian).

– A second group of samples comes from the forest road which runs in the upper part of the eastern slope above Bärenthal, along the valley to the north, sponges have been collected from marls and marly limestones of the White Jurassic Gamma (*Hypselocyclum* Zone).

– A third group of samples has been collected from the forest road running obliquely through the eastern slope of the valley above the northern end of the village.

– A fourth group of samples came from various small and temporary outcrops located on the western slope of the valley above Bärenthal; sponges have been collected from the marls and marly limestones of the White Jurassic Gamma.

– A fifth small sample came from the small, old abandoned quarry just above the last houses at the southern tip of Bärenthal, located on the western side of the valley; marly limestones from there have been dated as the White Jurassic Gamma (early Platynota Zone).

– The largest collection came from the outcrop along the road from Bärenthal to Kohlplatte. Sponges occur there in rocks representing White Jurassic Alfa, Beta and Gamma (Middle/Upper Oxfordian to Lower Kimmeridgian). The visible section is only fragmentary and highly discontinuous, thus precluding from presentation of a measured section; it was described in Geyer and Gwinner (1984). The White Jurassic Alfa is developed as irregularly bedded marly crumpled limestones intercalated with marls; sponges are very numerous. It has been dated by ammonites as uppermost *Perisphinctes bifurcatus* and *Epipeltoceras bimmamatum* Zones. The White Jurassic Beta is developed as irregularly bedded limestones with subordinate marl intercalations with much less common sponges. At the boundary between the White Jurassic Beta and Gamma occurs a characteristic marly layer very rich in sponges, ammonites and brachiopods; it has been dated by the presence of *Sutneria platynota* (Reinecke) as Lower Kimmeridgian. Above follows irregularly bedded crumpled limestones, sometimes with small bioherms, higher up limestones are intercalated with marls all representing the upper part of the White Jurassic Gamma. The youngest samples have been collected from a marly intercalation just below the dolomites of the White Jurassic Delta (Middle Kimmeridgian). For additional description of the section see Geyer and Gwinner (1984).

Lochen Nordwand. — The sponges have been collected from the well bedded limestones with marl intercalations cropping out along the northern cliff of Lochen, which represent the White Jurassic Beta (Upper Oxfordian).

Beuron. — A small sample was collected from the bedded limestones along the road from Beuron toward Kohlplatte, just above the crossroad to Beuron; they represent White Jurassic Beta (Upper Oxfordian).

Tieringen. — Old abondoned quarry about 1 km east of Tieringen on the road to Hossingen; limestones of the White Jurassic Beta (Upper Oxfordian). For more details see Geyer and Gwinner (1984: p. 152 point b. Tieringen).

Erkenbrechtsweiler. — This is an upper part of the road-cut along the road from Erkenbrechtsweiler to Owen. Sponges have been collected both from the limestones of the lower White Jurassic Delta (Kimmeridgian) in the upper part of the section, as well as from the marls of the upper White Jurassic Gamma (Lower Kimmeridgian) visible below. Numerous sponges from this outcrop, both from the limestones and marls, have their original siliceous skeleton very well preserved.

Wilmandingen. — This is a large active quarry at the outskirts of Wilmandingen; thick bedded limestones with thick marly intercalations in their middle part are visible; some bioherms are also developed. Only one large averaged sample from the whole quarry has been taken; as a result of the fact that the quarry is active and has high walls the sponges were collected from the scree below. According to Ziegler (1987) these rocks represent the White Jurassic Gamma/Delta interval (there is no doubt that only lower part of Delta is present).

Hochwang. — This is a road-cut along the road from Hochwang to Lenningen, described in detail by Geyer and Gwinner (1984) and Wirsing (1988).

Lowermost part of crumpled limestones and marls with numerous small bioherms has been dated by ammonites (*Orthosphinctes* sp.) as the upper part of the White Jurassic Gamma (Lower Kimmeridgian), the rest of the section spans the entire White Jurassic Delta and is developed as limestones with subordinate marl intercalations, but also includes massive limestones in the upper part of the section. The thick marls in the lower part of the White Jurassic Delta yielded numerous sponges with well preserved spiculation.

Genkingen. — This is a large active quarry located to the northeast of Genkingen, to the west of the road from Genkingen to Pfullingen within the Middle Kimmeridgian rocks (White Jurassic Delta) described in Schmalzriedt (1991). Its lower part belongs to the lower White Jurassic Delta as indicated by

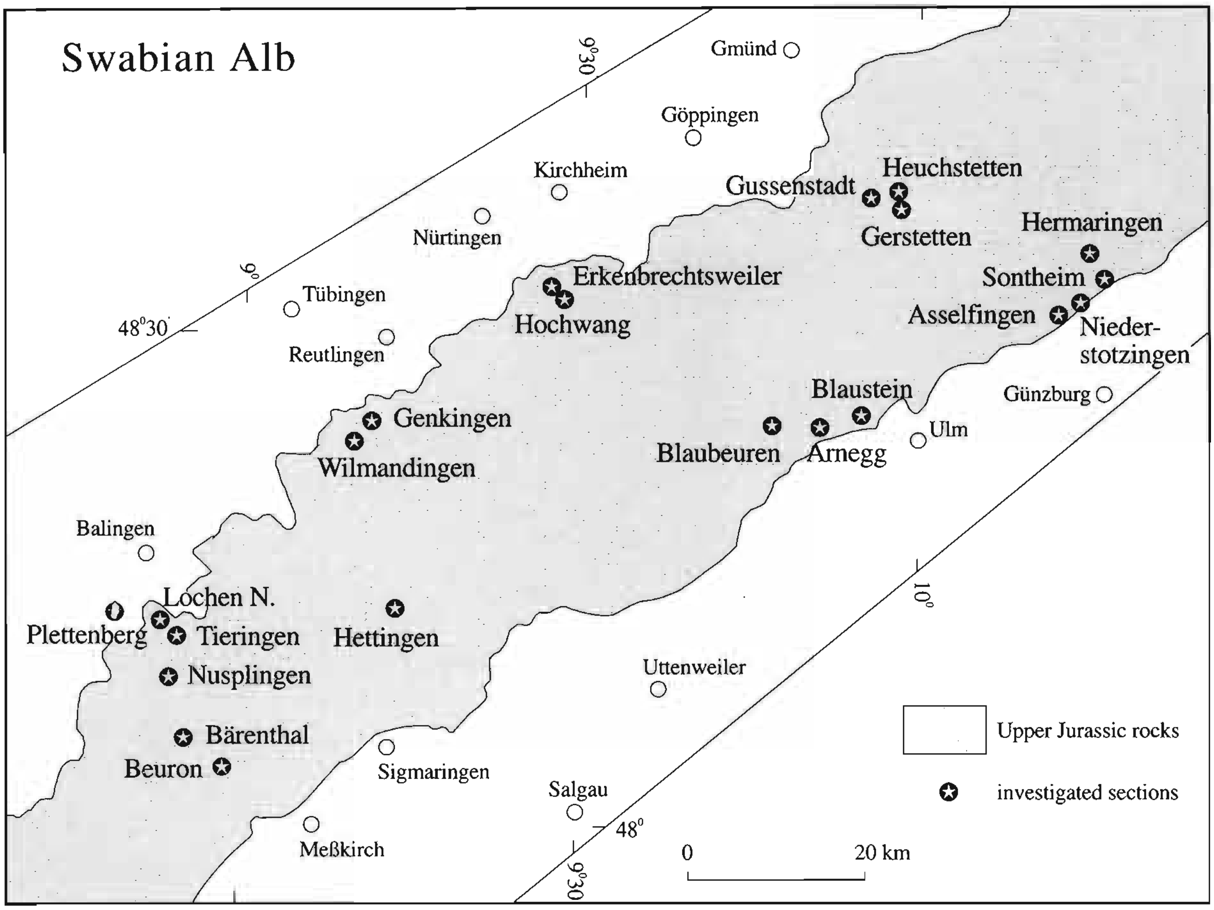


Fig. 2
Location of sampled Swabian Alb sections (partly after GWINNER 1976, modified).

ammonites [*Taramelliceras* cf. *pseudoflexuosum* (FAVRE)] and is represented by well bedded limestones with some marl intercalations. In the upper part poorly bedded or massive limestones of the upper White Jurassic Delta crop out, as indicated by ammonites (*Taramelliceras* cf. *intersistens* HOELDER).

Hettingen. — This is a road-cut north of Hettingen (GEYER and GWINNER 1984: point j. Hettingen) with marly crumpled limestones containing numerous sponges. According to GEYER and GWINNER (1984) they belong to the White Jurassic Delta 2–3 (Middle Kimmeridgian).

Blaubeuren. — Sponges have been collected from the massive limestones cropping out along the road to Schelkingenn, near an electric transformation station, in front of a cement factory (point b. Blaubeuren in GEYER and GWINNER 1984), rocks are attributed to the White Jurassic Delta 4 (Middle Kimmeridgian). Most sponges there have laminated crusts developed on the upper surface.

Hermaringen. — An old abandoned quarry just at the outskirts of Hermaringen. Sponges have been collected from irregularly bedded limestones with marly intercalations draping a massive bioherm attributed to the White Jurassic Epsilon (Upper Kimmeridgian).

Sontheim. — An old abandoned and now built over quarry at the outskirts of Sontheim am Brenz; it was mentioned by KOLB (1910) and SCHRAMMEN (1937) and rocks assigned to the White Jurassic Epsilon (Upper Kimmeridgian). All sponges from this quarry have been investigated in the museum collections in Tübingen and Stuttgart. Most of them have siliceous spicules preserved.

Heuchstetten. — An old abandoned quarry toward the north of the village Heuchstetten with massive limestones attributed to the White Jurassic Epsilon (Upper Kimmeridgian). Most sponges are silicified and numerous of them display well preserved skeletons; this is probably an outcrop from which most of well preserved lithistid sponges described by SCHRAMMEN (1937) were collected.

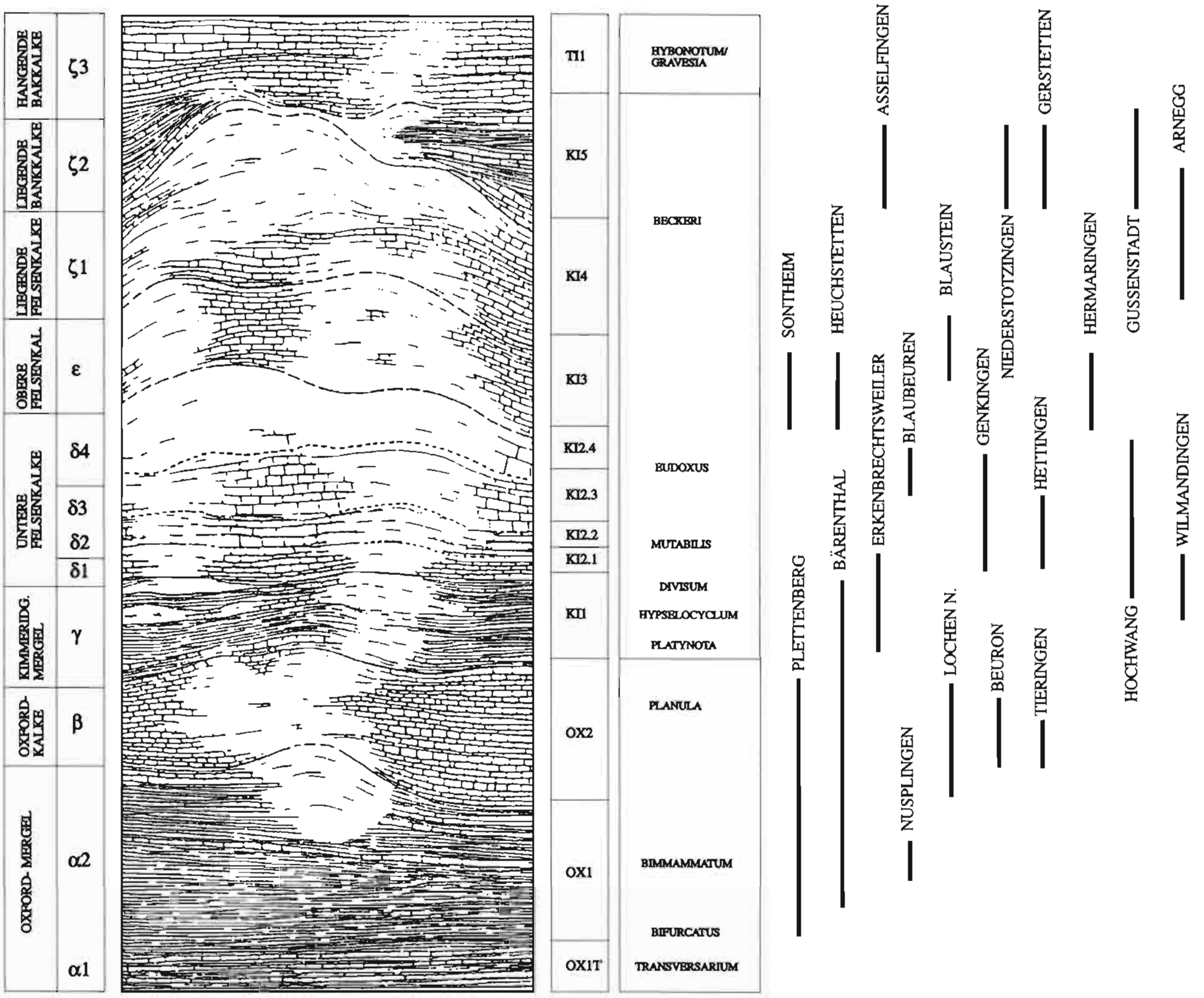


Fig. 3
Generalized lithostratigraphic column of the Upper Jurassic of the Swabian Alb, with approximate biostratigraphic correlation, and the range of sampled sections (Stratigraphy after GWINNER 1976 and LEINFELDER *et al.* 1994, modified).

Blaustein. — An old abandoned quarry on the eastern outskirts of Blaustein; limestones of the White Jurassic Epsilon and Zeta (Upper Kimmeridgian) (GEYER and GWINNER 1984: p. 190, point l. Blaustein) with rare sponges.

Arnegg. — There are two abandoned quarries described in GEYER and GWINNER (1984) with the Upper Kimmeridgian (White Jurassic Zeta 1–2); as point i. Arnegg west and east. In the western quarry the coral reef complex (described in detail by PAULSEN 1964) and limestones with mixed coral-siliceous sponge assemblages are present; in the eastern quarry sponges have been collected from marls and limestones with laminar coral colonies; they are mostly secondarily silicified.

Asselfingen. — This is an old abandoned quarry described in GEYER and GWINNER (1984) in excursion no. 30. o. 1. quarry 1500 m SSE, near “Unholdenstein”. The sponges have been collected both from the massive limestones and bedded marly limestones which have been attributed to the White Jurassic Zeta 2 (GEYER and GWINNER 1984), which according to recent investigations correlates with the uppermost Kimmeridgian.

Niederstotzingen. — An old abandoned quarry described in GEYER and GWINNER (1984) in the excursion no. 30. n. western quarry. The sample of sponges comes from the marls intercalated with thick-bedded limestones (with numerous flat lithistid sponges) topping massive limestone; both massive limestones in the sole, as well as overlying bedded limestones, interfinger with calcareous breccia (rudstone) composed of sponges and limestone fragments. It has been attributed to the White Jurassic Zeta 2 (GEYER and GWINNER 1984), according to the most recent investigations corresponding to the uppermost Kimmeridgian.

Gussenstadt. — Fields around the village Gussenstadt; my specimens come mostly from the fields to the south and southwest around Wanneberg. Both the specimens housed in Stuttgart Museum für Naturkunde (SMNS), recovered during acid preparation of large limestone blocks and those collected in the field, have been investigated. The sponges come from partly silicified limestones containing abundant corals, brachiopods and other fauna; they were dated as Lower Tithonian, more recent data suggest uppermost Kimmeridgian (see SCHWEIGERT 1993, 1994; LEINFELDER *et al.* 1994)

Gerstetten. — The samples have been collected from the Korralenkalk and Zementmergel represented by micritic limestones to marls with bioclasts of corals, echinoderms, brachiopods, bivalves, serpulids, bryozoans and peloids of various origin (see MAGEL and LAUXMAN 1990). The age has been determined as White Jurassic Zeta 2; previously this unit was regarded as Lower Tithonian (GEYER and GWINNER 1984; KAPITZKE and LAUXMAN 1988; REIFF 1988) but according to the most recent biostratigraphical investigations by SCHWEIGERT (1993, 1994), it belongs to the uppermost Kimmeridgian. The fauna comes from the reef talus with displaced corals (Riffschutbanke) (KAPITZKE and LAUXMAN 1988; REIFF 1988; MAGEL and LAUXMAN 1990; LAUXMAN 1991).

PRESERVATION OF SPONGES

Most of the collected sponge material is represented by bodily preserved sponges ("calcareous mummies") with skeletons more or less well preserved but replaced with calcite sparite; only a small fraction of all specimens, mostly from the White Jurassic Gamma, Delta and Zeta (Bärenthal, Hochwang, Erkenbrechtsweiler, Genkingen, Gussenstadt, Gerstetten and Heuchstetten) has original siliceous composition of spicules preserved to various degrees. Other outcrops only rarely yielded material with siliceous spicules. Additionally, loose spicule assemblages obtained by dissolution of the rock in hydrochloric acid have also been analysed. They come mostly from the Upper Kimmeridgian of Nattheim, Heuchstetten, Gussenstadt, Gerstetten, Hochwang and Erkenbrechtsweiler.

It is surprising, but there is no clear correlation between the lithology and preservation. Original siliceous spicules are preserved in Kimmeridgian marls (White Jurassic Gamma) from Erkenbrechtsweiler, and Hochwang (White Jurassic Delta), but also from limestones of the uppermost Kimmeridgian of Heuchstetten, Nattheim, Gerstetten and Gussenstadt (see SCHRAMMEN 1937; REIF 1967).

The process of "mummification" of siliceous sponges (MATYJA 1978) remains obscure, but the problem seems partly artificial, or better, exaggerated by imaging a hexactinellid or lithistid sponge as a soft bodied organism containing siliceous spicules, such as one where the amount of soft parts dominates over a skeleton which is entirely hidden within tissue. There is general agreement, however, that the "mummification" is a very early cementation process (FLÜGEL and STEIGER 1981; BRACHERT *et al.* 1987; MOCK and PALMER 1991). The process of sponge calcification is regarded sometimes as analogous to preservation of a human soft body by mummification, or at least preservation of a fish soft body within carbonate concretion. It is, however, a very misleading model. A better and closer analogy may be drawn between the process of sponge "mummification" and echinoderm ossicles preservation; the only difference is in quantitative relations between volume of the skeleton and skeleton porosity (and of course mineralogy of the skeleton). In fact, what we can see in the fossil hexactinosan or lychniscosan sponges is the morphology of skeletal parts and not the dermal membrane of a soft tissue, unless it included also fused dermal spicules, as is the case of *Cypellia rugosa* (GOLDFUSS 1826), for example. The pattern of "ostia" as visible on the fossil *Laocoetis* POMEL (= *Craticularia* ZITTEL) or *Sporadopyle* ZITTEL, was not visible during the sponge life; they were covered then entirely by the dermal membrane with true ostia (which are much smaller), while what we see in fossil specimens are in fact subdermal (choanosomal) structures. One must also remember that, especially in hexactinellid sponges, the amount of a soft tissue, developed mostly as trabecular strands and choanocytal layer, is very small and the sponge is extremely porous organism with water freely circulating within it. Paradoxically, this may be the reason for that special sponge preservation – there is enough (but not too much) microenvironment to allow for precipitation of micritic cements facilitated by the decaying sponge body and action of associated bacteria (often symbiotically associated with living sponges).

There is, however, a problem of rare lyssacinosan sponges preserved in a similar way, which have hardly a rigid skeleton. The case of *Polygonatium sphaeroides* SCHRAMMEN is simple because it displays a fused skeleton, similar to Hexactinosa. More difficult is the case of *Stauractinella jurassica* ZITTEL, which is a typical lyssacinosan sponge with loose spicules. The only explanation is that it contained considerable amount of spongin, which as a result of very early and rapid cementation, allowed preservation of the intact sponge with details of canalization. The process could have been aided by the presence of spongin cement. Generally, the process of mummification and dissolution of siliceous spicules must have been very rapid as indicated, for example, by the common presence in the skeleton of hexactinellid sponges of borings of the haplosclerid sponge *Aka* JOHNSON, which bores solely in carbonate substrates (see REITNER and KEUPP 1991 and my own observation).

A special role in the process of sponge "mummification" is given to the sedimentation rate. If it were too slow, sponges would be destroyed during the long exposure by either mechanical factors or dissolved by sea-water which is strongly undersaturated in respect to silica. If it were too high they would be simply buried without mummification. The situation must be more complicated, however, for Middle-Upper Oxfordian sediments rich in sponges in Poland reach several hundred meters thick (see KUTEK *et al.* 1977) while the same age deposits in Spain reach only about 20 meters thick (AURELL and MELENDEZ 1990; PISERA 1991), and are usually much thinner. It indicates substantial difference in the sedimentation rate, but in both cases sponges are similarly well "mummified", indicating that a factor independent from the sedimentation rate could also been operating. The most plausible explanation, however, seems that horizons with sponges are condensed ones, while those parts devoid of sponges and composed of thick micrites (the case of Poland) represent periods with high sedimentation rate, thus giving also a high average sedimentation rate for the whole section.

Anyway, the rapid and widespread early cementation of siliceous sponges by micrite is to be explained; in the case of Recent sponges they can remain for a prolonged time, as indicated by removing soft part and encrustation with iron ferroxide, without any mummification in the Western Tropical Atlantic at depths of 200–400 meters (personal observation). What is more interesting, their spicules show no traces of dissolution, rather bioerosion of the whole skeleton took place (boreholes and cavities of various shapes and size) by unknown animals. Cases of mummification are known, however, in relict Pleistocene assemblages from the Mediterranean Sea (ALLOUC 1986, 1987, 1990), from depths reaching even 2 000 meters.

This enigma of sponge cementation may be partly explained by the nonactualistic model of increased alkalinity of the Upper Jurassic Sea, that follows from the model of KAŹMIERCZAK *et al.* (1985) of the stratified sluggish ocean which facilitated micritic cementation. Such a stagnant Late Jurassic ocean is suggested by high sea level during this period, by the common occurrence of dark bituminous deposits, as well as from the isotopic data (PISERA *et al.* 1992) and some theoretical considerations (LEINFELDER 1993; LEINFELDER *et al.* 1994).

SKELETAL STRUCTURE AND CLASSIFICATION OF HEXACTINELLID AND LITHISTID SPONGES

Generally, siliceous fossil sponges have been by paleontologists treated in the same way as all other invertebrates, *i.e.* details of morphology have been used in taxonomic approach without going into details of spiculation. In fact this is basically a false approach as can be deduced from what we know about Recent siliceous sponges. The basic character which should serve as a base of a taxonomic assignment (both at the species, as well as higher level) is spiculation. Similar shapes (usually rather simple) reoccur in widely separated sponge groups, as do canal patterns. Outer morphology of a whole sponge is usually (but not always!) much more variable at the species level than in shelly invertebrates. This is especially true in the case of lithistid sponges which are often asymmetrical and/or irregular in shape (hexactinellids being mostly symmetrical and much less variable morphologically). In effect morphologically various specimens displaying identical spiculation should be regarded as monospecific, while other specimens having identical or very similar morphology but differing in details of spiculation must be treated as separate species. This problem is rather acute in the case of holotypes of GOLDFUSS' and QUENSTEDT's species that were designated much later, without the proper knowledge of spiculation and even general sponge structure, but were based on rather superficial similarities between various specimens. In effect situations are not rare where a holotype of one species (GOLDFUSS' specimen for example) is different from QUENSTEDT's specimens bearing the same name and serving, in fact, (as a result of much better illustration) as a standard with which all latter described specimens have been compared, thus playing the role of the holotype. Because many fossil species were established in the 19th century, on purely morphological bases, and no information about spiculation is given, or available, also when studying original collection, it is often difficult or impossible, to be sure about real taxonomic relationships of many of the fossil species and specimens described and illustrated in paleontological literature. Especially difficult is the estimation of sponge diversity based on the literature.

HEXACTINELLID SPONGES

The taxonomy of fossil Hexactinellida follows that proposed by REID (1963b, 1964) and FINKS (1983) and generally accepted, both by modern and fossil sponge students. Throughout this paper the name Hexactinellida is used in place of Hyalospongea as often the case in recent papers for the reasons presented in details by REID (1963c).

The taxonomy of Recent hexactinellid sponges is based mostly on loose microscleres (see SCHULZE 1887; IJIMA 1927; MEHL 1992), which as a rule are not preserved in a fossil state, and when present, are usually not associated with any particular bodily preserved sponge (see MOSTLER 1989a; and this paper). In addition, neontologists treat choanosomal dictyonal skeleton very generally, or nearly disregard it, as supposedly displaying no important features (see for example LÉVI 1986). Hexactinosan sponges display fusion of hexactines, forming the main choanosomal skeleton, into linear series called dictyonal strands (there may be, however, some secondary hexactines which do not follow this pattern) (REID 1963a, 1964). Growth of strands is longitudinal, and new strands are added in between the existing ones, but usually there is a little growth in thickness of the sponge wall after reaching the adult form. This feature has important consequences for taxonomy as it means that the wall thickness is stable and can be used as a taxonomic character, and that there is not a secondary thickening of the wall (see ZIEGLER 1962). My own observations (see below) may undermine, however, generalization about secondary wall thickening. First of all, there are numerous sponges which differ only in wall thickness, and there is a continuity in this respect, suggesting that we are dealing with one species displaying only variable wall thickness (such observation concerns *Stauroderma* ZITTEL species). But more important is the observation that in some lychniscosan sponges, especially in *Cypellia rugosa* (GOLDFUSS), deep in choanosomal skeleton, single pentactines identical with pentactines from the dermal skeleton occur. Such an observation may indicate in fact that these sponges were able to grow in thickness but resorbed the existing dermal layer composed of pentactines, leaving sometimes only these isolated single pentactines embedded into the choanosomal skeleton as the only remnant of the former position of the dermal surface. One cannot exclude, however, that it is just abnormal development of pentactines within the sponge wall.

The only practical approach to solve the problem of taxonomy of fossil hexactinellid sponges is to investigate in more details the architecture of main choanosomal and dermal/gastral skeleton, as well as details of canalization. The importance and resolving power of such an approach has been already shown in the case of fossil sponges by REID (1958–1964). The next step must concern the Recent hexactinellids, *i.e.* full characterisation of skeletal features such as details of dictyonal skeleton and canalization system in relation to classical taxonomic features used by neontologists.

Separation of Hexactinosa and Lyssacinosa in a fossil state poses itself sometimes a difficulty; some clearly lyssacinosan sponges have partly or entirely fused primary skeletons (i.e. *Euplectella* OWEN, *Staurocalyptus* IJIMA). As it was already noted by IJIMA (1927), the basic difference between lyssacine hexasterophoran with fused (partly or totally) choanosomal skeleton and hexactinosan hexasterophoran is in the fact that the latter have only hexactines as their choanosomal skeleton, while the former contain hexactines to rhabdoactines. On the other hand, diactines were reported by SCHULZE (1900) as accesory spicules (not part of the dictyonal skeleton) from the Recent lychniscosan *Neoaulocystis zitteli* (MARSHALL *et* MEYER). There is, however, another important difference between two groups; and it concerns the way of fusion of spicules, contrary to IJIMA (1927: p. 107) statement "The manner of arrangement of dictyonal hexactines is ...as was pointed out by F. E. SCHULZE and as we now know well, of no essential importance as a differential feature of the Dìctyonina skeleton in general."

In Hexactinosa, hexactines are always organized in dictyonal strands (the concept of dictyonal strands was introduced by REID 1958, 1963a), but the importance of the idea clearly was not fully understood by later authors, or its importance underestimated or even disregarded also in the most recent papers – see for example LÉVI 1986; MEHL 1992); the only exception being perhaps the excellent paper by ZIEGLER (1962). This means that the sucessive hexactines are added to the choanosomal skeleton and fused to it in an organized way by fusion of hexactines in linear more or less vertical series following the sponge growth direction. Particular strands are more or less parallel to each other but hexactines in them may be oriented variously, so lateral fusion of rays usually produces non-cubic meshes in transverse section (contrary to numerous descriptions), but rather triangular ones. Meshes in longitudinal section are usually regular and rectangular or square. This development is never observed in lyssacinosan sponges, which have their spicules fused in more or less random ways (some expression of layering, however, may be present – see FINKS 1960; PISERA and BODZIOCH 1991). There is also an important difference in timing of spicule fusion in both groups. Lyssacinosa fuse their spicules by synapticules only and at various points of contact by synapticular bridges, late in ontogeny, leading either to the fusion of most of the skeleton (as is the case in *Euplectella* – see SCHULZE 1887; IJIMA 1927) or to the fusion of its basal portion only (as is the case in *Rhabdocalyptus mollis* SCHULZE – see IJIMA 1904: p. 262, 1927). To the contrary, fusion into dictyonal strands among Hexactinosa proceeds very early in ontogeny, practically simultaneously with addition of new hexactines [in lychniscosan *Neoaulocystis* ZHURAVLEVA (see IJIMA 1927), however, several of the youngest lychniscs at the growing margin may be loose]. Overlapping tips of the ray tips of the subsequent dictyonal hexactines become enveloped in a common silica layer, in such a manner that no boundary between hexactines can be shown without looking for axial canal extensions. This type of fusion is only known among Hexactinosa and Lychniscosa. Synapticular reinforcement of the skeleton is known also in Hexactinosa [i.e. *Cribrospongia* D'ORBIGNY (= *Tremadictyon* ZITTEL), *Walcotella* DE LAUBENFELS as well as Lychniscosa (i.e. *Cypellia* POMEL – see Pl. 39: 5, 8, Pl. 40: 9, 10)] but is an independent late development. Thus fusion of the choanosomal skeleton in Lyssacinosa on one side, and Hexactinosa and Lychniscosa on the other, cannot be regarded as entirely homologous processes and structures.

Numerous fossil Hexactinosa and Lychniscosa display clearly differentiated superficial dermal and/or gastral skeletons which are composed of, as it was considered for a long time (see ZITTEL 1887; SCHRAMMEN 1937) stauractines. Recently it has been demonstrated that such skeletal layers consist, in fact, mostly of pentactines (MEHL 1992). In the case of *Cribrospongia* (= *Tremadictyon*), MÜLLER (1991) and MEHL (1992) have found true stauractines (see MÜLLER 1991: fig. 3c; MEHL 1992: pl. 2: 5) above canal openings. In the light of observations concerning *Cribrospongia cuccullata* (SCHRAMMEN) presented below, there is a possibility, in fact, that it is a gastral, and not dermal spiculation. Among Recent Hexactinosa and Lychniscosa dermal and gastral spiculation occurs in practically all cases (and where they are absent it concerns macerated specimens) and is composed of pentactines or more rarely hexactines; often there is no difference between dermal and gastral spicules.

A special importance is usually given to these dermal and gastral spicules in fossil hexactinellid taxonomy (see SCHRAMMEN 1937; MEHL 1992). More detailed study of a well preserved *Cribrospongia cuccullata* from the lower White Jurassic Delta (Kimmeridgian) of Erkenbrechtsweiler revealed, however, that there are two different types of superficial, nonchoanosomal spicules. As mentioned above, a very delicate veil of fused stauractines covers canal openings and is attached to the skeletal bridges bordering them on the gastral surface (Pl. 33: 2; Fig. 17a). The other type occurs on the dermal surface, and consists of much more heavy true pentactines fused with the help of proximal rays into the main dictyonal skeleton (Pl. 33: 1, 3; Fig. 17b). These pentactines do not have their proximal rays in continuity with the dictyonal skeleton, and thus are of independent origin and cannot be considered as the outer most hexactines of the main skeleton which have suppressed outer rays. There is no transition between these two types of spicules, therefore they cannot be homologous structures. The pentactines may be considered as true dermalia, while it is not sure if stauractines are of the same genesis, and not just secondary outgrowths of dictyonal skeleton. This and the fact that both occur in one species must influence our view of significance of such structures when used in classification.

A quite different situation is displayed in the hexactinosan *Porospongia marginata* (MÜNSTER *in* GOLDFUSS). Here, the dermal surface has no superficial skeleton but meshes on the surface are narrowed by slightly thickened rays (Pl. 36: 1); on the other hand, gastral surfaces show very well developed layer of pentactines embedded into a siliceous membrane (Pl. 36: 2, 3). Pentactines, however, are a part of the dictyonal skeleton (and these are not homologous with the pentactines described above from *Cribrospongia cuccullata*), being just the outermost hexactines of the choanosomal skeleton with reduced outer rays; as clearly indicated by continuity between the pentactine inner rays and hexactines from the dictyonal skeleton (Pl. 36: 2).

Still different situations are observed in lychniscosan *Cypellia rugosa* (GOLDFUSS) and *Cypellia inberbis* (QUENSTEDT). Both these species exhibit very well developed dermal skeletons composed of pentactines (outer ray suppressed) fused both with the dictyonal skeleton and with themselves along points of contact and with the help of synapticular bridges (Pl. 39: 2, 5). It is difficult to decide at first sight whether they are a part of a dictyonal skeleton or not. They display identical sculpture as the main skeleton but, of course, have no lychniscs developed. As there are known hexactines without lychnisc nodes added in the outermost part of dictyonal skeleton (but independent of it) in Recent lychniscosan forms (SCHULZE 1900), as well as in fossil (Pl. 42: 3b), these spicules in *Cypellia* may be of similar origin, *i.e.* true dermalia not in continuity with dictyonal strands. The dermal layer in *Cypellia rugosa* (and also in other species), as here understood, shows a strong variability in a degree of development of synapticular bridges joining the dermal pentactines. The layer may be composed of pentactines connected only in points of contact (Pl. 39: 1), or may have numerous synapticular bridges added (Pl. 39: 2), or in an extreme case meshes may be nearly occluded with continous siliceous membranes (Pl. 39: 4). This variability served for SCHRAMMEN (1937) as a base of differentiation into subgenera. In fact there is a continuity of this feature even in one specimen, thus undermining SCHRAMMEN's conclusion. Interesting is the fact that such structures are unknown among Recent hexactinellid sponges.

If observation on silica deposition in fresh-water sponges may be applied to the fossil marine deep-water sponges, then differences in degree of silification of the dermal layer, as described above, may be explained by variation in silica content in surrounding ambience. Fresh water sponges tend to produce thicker spicules in waters enriched in silica (PÉ 1973), thus formation of a siliceous membrane may be (*i.e.* genus *Cypellia*) a response to elevated silica contents of sea-water. This suggestion cannot be applied, however, to the species *Porospongia marginata* which always has such membranes well developed.

The case of hexactinosan *Sphenaulax* ZITTEL is similar to that of *Cribrospongia* D'ORBIGNY. It has a well developed dermal layer of strongly sculptured stauractines fused at the points of contacts, as well as with some synapticular bridges (Pl. 35: 1). The stauractines are also fused at some points with the main dictyonal skeleton with the help of synapticular bridges (Pl. 35: 5). There is a clear difference between these ornamented and delicate dermal spicules and the smooth heavy outer spicules forming the dictyonal skeleton with well developed cortex (Pl. 35: 1). This difference clearly indicates that both types of skeleton are of independent origin. The dermal skeleton of pentactines is clearly different from the main dictyonal (choanosomal) skeleton, as is also observed in *Laocoetis* POMEL (PISERA unpublished).

Sometimes a special taxonomic importance is given to the presence or absence of pentactine dermalia and/or gastralia (see MEHL 1992: p. 79), and is regarded as the most important taxonomic feature. In effect, very different forms with extremely different dictyonal skeleton, as well as canalization, such as *Cribrospongia*, *Sphenaulax* and *Porospongia,* are grouped together on a basis of alleged presence of the same type of gastralia. This approach may be questioned in the light of observations presented above, as well as by the fact that pentactine dermalia are very common in various Recent groups and in Recent and fossil Lychniscosa. It seems, thus, that the presence of pentactine dermalia and/or gastralia is a primitive character and that their presence or absence alone cannot be used as the basis of taxonomic grouping, and even less as a phylogenetic feature, especially among fossils where they are preserved only when fused with the main skeleton. In effect their absence may be purely a taphonomical feature.

In some investigated specimens, among both Hexactinosa nad Lychniscosa, there occur globular skeletal bodies (both outside as well as within the dictyonal skeleton) consisting of very irregularly fused hexactines (Pl. 41: 5, 6) closely resembling a basal skeleton (= basidictyonalia of IJIMA 1927). Similar skeletal bodies noted by SCHULZE (1899: pl. 14: 6) in *Rhabdocalyptus mirabilis* SCHULZE, and by IJIMA (1904: pl. 15: 13) in *Staurocalyptus glaber* IJIMA, and by MEHL (1992) in lyssacinosan sponges had been interpreted as vegetative reproductive structures. This interpretation has been questioned by REID (1964), who regarded them rather as a pathological development caused by some kind of infestation. One cannot agree with his opinion, for these bodies are totally different from the main skeleton and sitting on it rather than being its pathological extension. In the case of Lychniscosan sponges the bodies consist of hexactines not lychniscs; and in Recent lyssacinosan sponges they contain only hexactines and not diactines, thus the original interpretation by IJIMA is more convincing.

To make things more complicated, octahedral nodes are often absent in many parts of the skeleton of Lychniscosa, especially near the surface and around canals [see for example *Xenoschrammenum venosum* (SCHRAMMEN) (Pl. 37: 8), or "*Tremadictyon reticulatum*" (TRAMMER 1982: pl. 12: 7b)]. LAGNEAUX-HÉRENGER (1962) treated such cases as examples of a mixed skeletal structure, *i.e.* containing both hexactines and lychniscs, she even suggested that it may lead to a complete transformation of lychniscs into hexactines. In reality, the situation is more complicated. The most common case, which applies to *X. venosum* and perhaps to most fossil species, has been already explained by REID (1963b) and FINKS (1983) as a secondary feature, *i.e.* obliteration of genuine octahedral nodes by a secondary late deposition of silica. The other case, however, is of different genesis for there are genuine hexactines, in addition to the lychniscs, in the main skeleton of the same sponge. Such a possibility had been proved by SCHULZE (1900) in the case of the Recent species *Neoaulocystis zitteli* (MARSHALL *et* MEYER) (but also there hexactines occur only in the outer ?dermal portion of the skeleton, and are not part of dictyonal strands). Among fossils, *Trochobolus* ZITTEL displays the same feature (Pl. 42: 3b). In fact, a similar condition is observed in the fossil *Cypellia rugosa* (and other lychniscosan sponges) where dermal pentactines are of hexactine and not lychnisc origin.

Moreover, there are cases where pseudolychnics occur in hexactinosan sponges; in the Recent such is the case in *Dactylocalyx pumiceus* STUCHTBURY, which was considered a lychniscosan sponge by REID (1957) and only recently REISWIG (1991) has nicely shown that perforated nodes are irregular and developed rather in one plane, being far from the regular octahedral nodes of Lychniscosa. The other nice but fossil example in our material is *Casearia articulata* (SCHMIDEL). Numerous hexactine nodes (Pl. 35: 8, 9) show clear perforations which may be mistaken for lychniscs; in fact they are also developed in one plane, and commonly bear only 3 perforations, instead of 4 perforations observed in true lychniscs (Pl. 38: 9). Such pseudolychniscs are interpreted here as independent developments, most probably of synapticular origin.

The origin of lychnisc structure remains unknown. It has been suggested (see REIF and ROBINSON 1976) that it may have originated through first adding irregular synapticulae for the purpose of skeleton reinforcement, and those additions gradually became regularly developed, finally giving rise to regular lychnisc nodes. In such a case one should observe more or less the same thickness of main hexactine axes within a lychnisc node and outside it. In fact what we find is just opposite, *i.e.* the diagonal struts are thicker than the vertical and horizontal hexactine rays within lychnisc nodes, and approach the thickness of the rays outside of the lychnisc. On the other hand we know that synapticulae are a late addition in ontogeny, appearing only after fusion of the dictyonal skeleton, while lychniscs are early ontogenetical features already existing when particular dictyonalia are still separated (see SCHULZE 1900); this is in contradiction with the order of events postulated by REIF and ROBINSON (1976), allegedly leading to the lychniscs origin. In the light of the above arguments, which are well supported by the observation that in Recent lychniscosan sponges the lychniscs node is filled with primary reticulum, mesolamella with common nuclei and apparently archaeocytes (MEHL and REISWIG 1993), the hypothesis of synapticular genesis of lychniscs nodes as proposed by REIF and ROBINSON (1976) must be rejected, and lychniscs probably should be regarded as independent development from lyssacinosan grade of hexasterophoran hexactinellids. A similar conclusion has been reached by MEHL (1992) based on analysis of microscleres. Additional support of such a hypothesis comes from the presence of diactine spicules in *Neoaulocystis zitteli* (see SCHULZE 1900). If one accepts such supposition then it follows that origin of dictyonal strands in Hexactinosa and Lychniscosa are examples of parallel evolution.

If one agrees that megascleres originated from microscleres, as was supposed for Demosponges by SOLLAS (1888), then the origin of the lychniscs may be sought among hexasters with additional supporting structures around their centre. In fact such hexasters, closely resembling young lychniscs (see SCHULZE 1900: pl. 1: 7) are found in the Recent species *Rhabdocalyptus mollis* SCHULZE (see SCHULZE 1887: pl. 64: 8, 9). If this supposition is correct, then we cannot expect to find a lineage of macroscleres leading from hexactines to lychniscs. More probable is to expect appearance of already formed lychniscs, perhaps still unfused, but with fully developed lychnisc structure. That would imply also that fusion of loose hexactines into organised solid structures developed independently among both Hexactinosa and Lychniscosa, and is a case of parallel evolution. This view is supported by the observation that, with some notable exceptions such as *Cypellia rugosa* (GOLDFUSS), where the skeleton is extremely complicated and irregular, most lychniscosan sponges display extremely regular skeletons which have a cubic character in both longitudinal and horizontal sections (thus rectangular or square meshes in sections). Hexactinosan sponges clearly show, on the other hand, dictyonal strands (also with several exceptions) independent of each other, that thus form triangular meshes in perpendicular planes, and rectangular or square meshes only in longitudinal sections. These differences may suggest difference in how fusion proceeded. On the other hand, common occurrence of genuine hexactines (sometimes fused in short strand-like structures) among main lychniscosan skeletons observed among fossil *Cypellia rugosa* and some *Trochobolus* ZITTEL species, as well as in the Recent *Neoaulocystis grayi* (BOWERBANK) (see SCHULZE 1900: pl. 1: 2), may suggest that both types of skeletons are not so different. This problem needs further study.

At the generic and family level of fossil hexactinosan and lychniscosan sponges, SCHRAMMEN introduced numerous new taxa, often with very vague differentiating characters. For example, there is no difference between the genera *Trochobolus* ZITTEL and *Pachyrhachis* SCHRAMMEN in all characters except the size of skeletal outgrowth of the dermal side of the dictyonal skeleton, thus both genera are here synonymized. Similar is the problem with differentiation of the genera *Cypellia* POMEL and *Paracypellia* SCHRAMMEN, which is based solely on the common coloniality of the latter, all skeletal characters being identical. The same problem concerns the genera *Laocoetis* POMEL (= *Craticularia* ZITTEL) and *Paracraticularia* SCHRAMMEN. In general, the number of genera is clearly exaggerated by earlier authors. This exaggeration is visible also in the case of families; according to SCHRAMMEN (1937) there are 10 families of hexactinosan sponges and 5 families of lychniscosan fossil sponges. REID (1963b, 1964) was able to divide Recent and fossil hexactinosan sponges between 8 families only, and this approach, with some modification, is followed here. More recently MEHL (1992) tried to apply a more strict cladistic analysis to the classification of these sponges, proposing several informal groups including both fossil and Recent forms. Her results, however, are difficult to apply for only some randomly chosen taxa were considered, leaving numerous taxa as incertae sedis, and the scheme resulted in lumping forms on the base of nonhomologous characters.

LITHISTID SPONGES

Classification of demosponges poses even more problems than that of Hexactinellida (see RIGBY 1983). In fact situation is worse as classification of Recent and fossil forms is not even approaching each other (but see attempt to unify them by GRUBER 1993). This follows from the fact that characters used in neontological taxonomy (microscleres, dermal spicules, reproductive features and even genetics) commonly cannot be observed and studied in the fossil record. Uncertainty is also caused by the fact that classification of Recent demosponges is still hotly disputed (see for example LÉVI 1991; VAN SOEST 1991; WIEDENMAYER 1994). Unfortunately, the investigated material discussed here gives no clues to any refinement of existing classification at the higher level, so adopted is the most recent one presented by RIGBY (1983), based on ZITTEL's (1877, 1878b) and SCHRAMMEN's (1910, 1924, 1936) ideas, with some later modifications by REID (1968b). The only common feature of lithistid sponges is their possessions of desmas – spicules of various (often irregular) morphology displaying usually strongly branched tips (and sometimes also strongly sculptured crepis) articulating with tips (or crepis) of other desmas and forming thus a solid, fused skeleton. However, desmas are of clearly polyphyletic origin as they can be monocrepid, tetracrepid, polyaxial or anaxial (DENDY 1921) and spicules of such symmetry existed already in the Paleozoic. Thus, taxonomy of the Lithistida follows a pragmatic approach, possible to apply to fossil material; the present author is being aware of polyphyletic character of this group. The term the Lithistida is thus used in an informal way, which has been found to be useful in general considerations.

Despite the opinion of one of the most prominent student (BERQUIST 1978) of Recent sponges that "There is nothing more boring than descriptions of diversity of spicule forms in sponges, and in the final analysis nothing so misleading as a classification which leans too heavily upon such descriptions", such analysis will be done in this paper, simply because paleontologists are usually left with little more, especially in demosponges, than spicule shapes and associations.

A great problem arises also in subdividing Lithistida into lower ranks, because of the same reason; the bases of subdivision are the types of spicules and canalization. On the other hand, the Rhizomorina pose problems reflecting their generalized structure, with desma shapes being too variable and irregular to be easily used in classification. On the other hand, the way desmas are organized seems useful above the specific level. General morphology (very variable and recurrent in various groups) and canalization structure are used only as specific characters. SCHRAMMEN (1936, 1937) introduced numerous taxa of family rank for the Upper Jurassic sponges from Germany. However, he did not take into account classification of Recent lithistids, thus there is a great discrepancy between neontological and paleontological classification at this level. This causes taxonomic noise, especially where numerous Jurassic forms are very close, if not identical to Recent genera. If effect, I am not subdivinding lithistid sponges into familial ranks in most cases.

REMARKS ON THE HISTORY OF SILICEOUS SPONGES

Among the studied sponges Hexactinosa and Lithistida are very well represented in Recent faunas. Lychniscosa, which are among the most common or equally common in number and species, on the contrary, today are a true relict group represented by only three species.

LYCHNISCOSAN SPONGES

The roots of Lychniscosa have been placed in the Triassic (see VINASSA DE REGNY 1901; HARTMAN *et al.* 1980; FINKS 1983 and others) for a long time; recently however, this has been questioned by several authors (MOSTLER 1990b; MEHL 1992; PISERA and BODZIOCH 1991). There are some new reports of Lychniscosan sponges from the Triassic of Tyrol (KEUPP *et al.* 1989), and China (WENDT *et al.* 1989; WU XI-CHUN 1990), as well from the Lower Jurassic of Italy (BROGLIO LORIGA *et al.* 1991) which are simply misinterpretation and show no lychnisc nodes at all (see also MEHL 1992; PISERA and BODZIOCH 1991). In effect, the oldest known undoubted occurrence of these sponges comes from the Middle Jurassic–Bathonian of Italy (DONOFRIO 1984) and Bajocian of the Mečsek Mountains in Southern Hungary (PISERA 1993). In this latter case at least two different species are present, but it is not clear whether particular lychniscs were fused already or still partly loose.

HEXACTINOSAN SPONGES

Undoubted representatives of Hexactinosa are known to date from the Triassic (PISERA and BODZIOCH 1991). Still unsolved is a problem of the presence of hexactinosans in the Paleozoic (RIGBY *et al.* 1981; PISERA and BODZIOCH 1991; and literature therein); there are rich Devonian faunas which contain sponges similar, in both morphology and skeletal structure to those from the Upper Jurassic, but which may be also of independent origin. On the other hand, MOSTLER (1986b, 1990b) suggested an even older (Ordovician) age of a hexactinosan clade, based on the discovery what he regarded as hexasters. These microscleres have been reinterpreted as demosponge spicules (WIEDENMAYER 1994), thus their presence cannot be used in favour of the presence of hexactinosan sponges in these early rocks.

LITHISTID SPONGES

Although Recent lithistid sponges are often regarded as a relict group, especially when compared with exceptionally rich and diversified Upper Cretaceous lithistid faunas, diversity of Recent forms is comparable with that of the Upper Jurassic of the Swabian Alb. VAN SOEST and STENTOFT (1988) reported 14 lithistid species from Barbados waters, from depths 137–324 meters. Exceptionally large lithistid faunas from the New Caledonia region are composed of 23 species, representing all large lithistid groups (LÉVI 1991). Considering the fact that this represents one time plane, and that deep-water environments are difficult to collect, that diversity may be regarded as comparable to 42 lithistid species described in this paper from the Oxfordian–Kimmeridgian of the Swabian Alb. In effect, the opinion about the relict character of these sponges cannot be longer sustained. High diversity of the Upper Cretaceous faunas may be explained by much higher sea level than today, allowing widening of ecological niches occupied by these sponges.

There was a clear tendency of SCHRAMMEN (1910–1912) and especially ZITTEL (1877, 1878b) to erect separate genera for Jurassic and Cretaceous forms based solely on age differences. In fact, these differences are often so small that many Upper Jurassic and Cretaceous genera of lithistids should be synonymized. This is not only a taxonomic problem of some importance, but also a serious evolutionary one. Accepting ZITTEL's and SCHRAMMEN's approach one sees important evolutionary change and discontinuity between Upper Jurassic and Upper Cretaceous faunas, which according to the present author is partly due to such misleading approachs. In reality, there is continuous change and some Jurassic genera continue even to the Tertiary (*Cnemidiastrum* ZITTEL for example – see BRIMAUD and VACHARD 1986). Another and perhaps the most striking example, are Recent *Corallistes* SCHMIDT and Jurassic *Dicranoclonella* SCHRAMMEN (see Systematic descriptions). Longevity of lithistid sponge genera has been recently proved by the discovery of LÉVI and LÉVI (1983, 1988), on the New Caledonia slopes and Norfolk Rise, of an important living fauna of lithistid sponges that shows Cretaceous affinities, with one Cretaceous genus (*Aulaxinia* ZITTEL) present. The Miocene lithistid fauna from Spain, recently described by BRIMAUD and VACHARD (1986) also reveals close relationships with the Cretaceous faunas. All these facts indicate rather slow evolution rate among lithistid sponges, as well as low susceptibility to the K/T boundary extinction – the fact which may be perhaps explained by the relatively deep-water habitat of these sponges (about 200 meters) which could have protected them from disturbances occurring at the surface. Another factor acting in such catastrophic situation may be rather simple nature of sponges. To draw more specific conclusions about congeneric identity of Jurassic and Cretaceous sponges, the revision of the latter must be also undertaken, which is obviously beyond the scope of the present paper.

THE ROOTS OF THE UPPER JURASSIC SPONGE FAUNAS

NUTSUBIDZE (1965) reported such Upper Jurassic species as *Tremadictyon reticulatum* (GOLDFUSS) and *Craticularia parallela* (GOLDFUSS) from the Lower Jurassic of Georgia. New species of these and other Upper Jurassic genera, such as *Sporadopyle* ZITTEL, *Hyalotragos* ZITTEL, *Cnemidiastrum* ZITTEL and *Cylindrophyma* ZITTEL, were also described. This fauna occurs in red limestones of Liassic age. Numerous specific and generic attributions in this papers raise serious doubts, especially concerning *Cribrospongia reticulata* and *Laocoetis parallela,* as well as the reported presence of *Sporadopyle* which is lychniscosan sponge. In the case of *Cylindrophyma,* the desmas are too poorly preserved for such classification. From what can be judged from illustrations that Liassic fauna really does contain some craticularid species, accompanied by lithistid sponges that closely resemble Upper Jurassic faunas. This occurrence clearly shows that the great Upper Jurassic sponge faunas from Europe are not evolutionary novelties, but they had roots in the Lower Jurassic. This Lower Jurassic fauna from Georgia, and the Middle Jurassic sponge faunas from Hungary (POČTA 1886; PISERA 1993) may be compared to the Recent sponge faunas of the New Caledonia slopes, which worked as refugia.

SPONGE ASSEMBLAGES

Before analysing the composition of fossil sponge assemblage one has to decide how close to reality is the fossil record; in other terms if all the sponges have similar preservation potential. At first it seems obvious that only sponges with fused skeleton are preserved, while others, *i.e.* lyssacinosan Hexasterophora and Amphidiscophora and non-lithistid demosponges, have been lost producing an important bias. Rarity in the fossil record of both groups having loose spiculation apparently support such an idea. However, when one considers the problem more carefully, things are not so obvious. First of all there are conditions under which all sponges, irrespective of their skeletons, are destroyed and only loose spicules or fragments of fused skeleton are preserved. Deep water siliceous limestones from the Triassic of the Alpine region (see MOSTLER 1978, 1990b) may serve as an example. On the other hand, UJSM in Europe seems to be especially favourable to preservation of sponges. In this respect an observation from the Polish Upper Jurassic is interesting for hexactinellids with fused skeletons are very common in biohermal limestones, while nearby coeval marls (located in local basins) contain nearly exclusively selenasters (samples kindly supplied by A. MATYJA). All this indicates that postmortem transport was absent and clear ecological zonation existed. Similar conditions favourable to sponge mummification and preservation also existed during the part of the Middle Jurassic in Spain (see PISERA 1991), and during the Triassic in Poland (see PISERA and BODZIOCH 1991) but the extent of the facies was then much more limited.

Irrespective of the causes of such special preservation, it appears that compositions of the fossil assemblages are close enough to original assemblages to permit a meaningful analysis of pattern of distribution of sponges with solid skeleton, *i.e.* Hexactinosa, Lychniscosa and Lithistida. On the other hand, it is also very probable that distributions of other demosponges and lyssacinosan sponges resemble to some degree, the original one. Even loose spicules are well preserved in the uppermost Kimmeridgian rocks (together with bodily preserved sponges) where original siliceous skeletons are present, but they are nearly absent from Lower Kimmeridgian rocks where sponges are preserved in a similar way. Their record, however, is too limited and difficult to interpret, thus they are omitted in the quantitative analysis.

There is also an important question of relationship between paleontological and zoological species among siliceous sponges, especially lithistids, that has a bearing on estimated diversity. It appears that the number of species is overestimated in the fossil record by putting too much weight on morphology of lithistid sponges, which are very variable. On the other hand the number of species is clearly underestimated in lithistids as a result of the fact that numerous extant lithistids species are indistinguishable morphologically and differ only in character of microscleres and/or dermal spicules, which are not found usually in a fossil state or not preserved together with the main skeleton. Thus, I believe, that both these effects stay more or less in balance, and our estimation of diversity (with the notable exception of data of OPPLIGER, who was an extreme morphological splitter) is not too far from reality, thus permitting a sound analysis.

Only siliceous sponges have been included in the quantitative analysis; generally no calcareous sponges have been investigated. They were the subject of a recent monographic description by MÜLLER (1984). The present author's observations show that calcareous sponges occur in all stratigraphic intervals but are very rare, except in the uppermost Kimmeridgian coral facies. This observation is well supported by MÜLLER'S (1984) results, who found that only isolated and small forms occur in the Oxfordian and Lower Kimmeridgian while calcareous sponges are common in the Upper Kimmeridgian.

Comparison of sponge assemblages of different Upper Jurassic ages is difficult for dating of samples in many cases is only approximate (no detailed modern ammonite stratigraphy was available at the moment) and often based on the old QUENSTEDT lithostratigraphy commonly used by German geologists. Whenever possible ammonites have been collected and later used in dating (determinations and information about stratigraphic importance kindly supplied by Dr. B.A. MATYJA and Dr. R. GYGI). This poses some problems for it seems that earlier correlation of these lithostratigraphic divisions (especially in sponge facies) may be misleading (personal information Dr. G. DIETL and Dr. B.A. MATYJA, see also Geological situation). When comparing the present results with those of TRAMMER (1982, 1989, 1991) from Poland, difficulty arises because my sampling was less detailed and concerned usually lithological units (for example the whole, several meters thick, marly sequence in the Plettenberg Quarry) irrespective of biostratigraphical boundaries (in the Plettenberg case two ammonite zones), while TRAMMER'S results are clearly presented for single ammonite zones. On the other hand, other publications supply no quantitative data at all. Keeping all these limitations in mind I try to present analysis of their distribution and suggest factors causing the observed pattern.

COMPOSITION OF THE SPONGE FAUNA

Totally over 4700 siliceous sponge specimens have been analysed, among them over 4200 in the present author's collection, the rest are from museum collections. Among them about 68% have been determined to the species or genus level, the rest are attributed to various categories such as Lithistida, Rhizomorina, non-rhizomorine Lithistida, Lychniscosa etc. Because most of the analysis has been carried out at the level of such more generalised groups, the results may be regarded as rather reliable. Hexactinellid sponges amount to 59.4% of the whole assemblage (among them lyssacinosan sponges with fused skeleton amount to only 0.13%, while Hexactinosa to about 35% and Lychniscosa to about 21%). Lithistid sponges amount to nearly 41% of the assemblage, among them dominant rhizomorine sponges amount to about 27% and other non-rhizomorine sponges to about 7.9%. The whole assemblage is composed of at least 127 species, among them, demosponges are represented by 44 species, Hexactinosa by 45 species, Lychniscosa by 35 species and Lyssacinosa by 3 species. Real diversity in more narrow stratigraphical horizons is much lower, however, and often such assemblages are dominated in number by a few species, especially in the Upper Kimmeridgian (Fig. 4).

Similarly, as in Poland (see TRAMMER 1982, 1989) the sponge assemblage contains several dozen species but only several of them are common. These are *Cypellia rugosa* (GOLDFUSS) (5.96%), *Stauroderma lochense* (QUENSTEDT) (3.84%), *Cylindrophyma milleporata* (GOLDFUSS) (3.41%), *Hyalotragos pezizoides* (GOLDFUSS) (2.99%), *Walcotella pertusa* (GOLDFUSS) (2.42%), and *Platychonia schlotheimi* (MÜNSTER *in* GOLDFUSS) (2.01%). Other species which amount to more than 1% of the whole assemblage are, in a descending frequency: *Platychonia striata* SCHRAMMEN, *Cypellia prolifera* (ZITTEL), *Cribrospongia elegans* SCHRAMMEN, *C. reticulata* (GOLDFUSS), *Sporadopyle pusilla* SCHRAMMEN, *Laocoetis parallela* (GOLDFUSS), *Ramispongia ramosa* QUENSTEDT and *Hyalotragos patella* (GOLDFUSS). All these together amount to only 31.21% of the whole assemblage. Some other less frequent but common species (with a share above 0.5%) are *Linonema calyx* (SCHRAMMEN), *Ordinatus texturatus* (V. SCHLOTHEIM), *Tremaphorus apertus* (OPPLIGER) and *Porospongia marginata* (MÜNSTER *in* GOLDFUSS). At a generic level, the picture is slightly different with *Cypellia* POMEL being the most common (10.64%), and second in

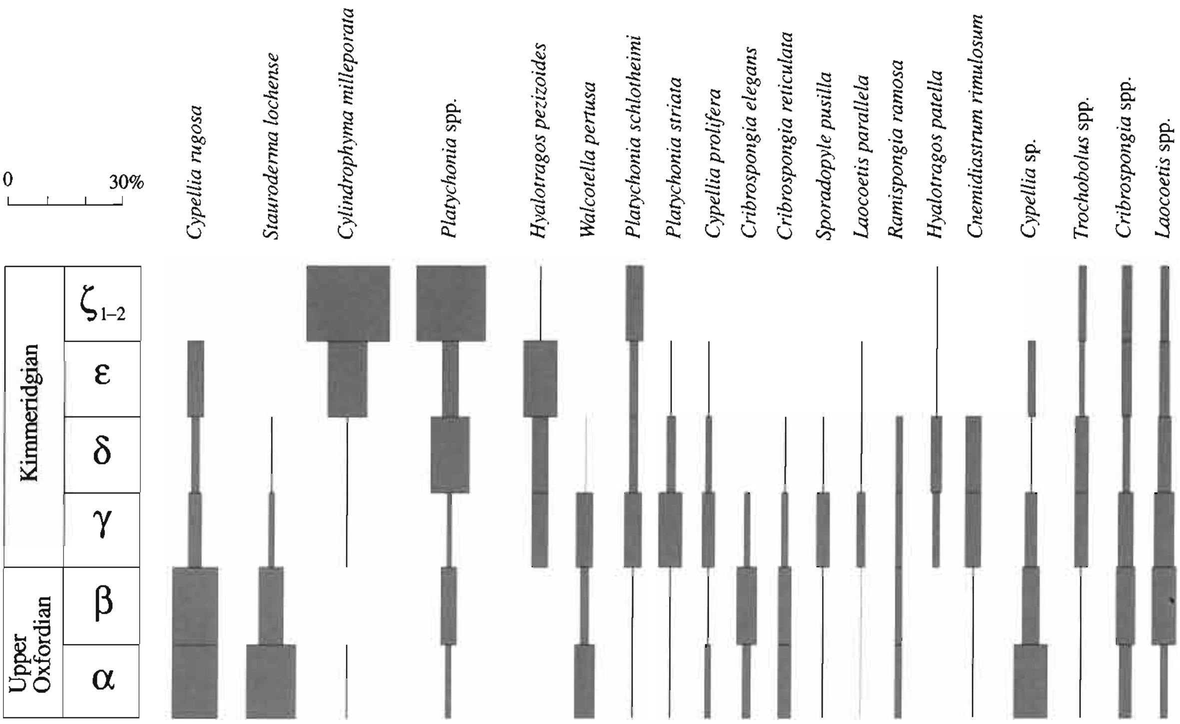


Fig. 4
Diagramm illustrating relative abundance of the most common sponges during the Oxfordian and Kimmeridgian in the Swabian Alb.

abundance *Platychonia* ZITTEL (8.12%). Other common genera (above 1% of share in the assemblage) are, in descending frequency, *Cribrospongia* D'ORBIGNY, *Hyalotragos* ZITTEL, *Laocoetis* POMEL, *Stauroderma* ZITTEL, *Cylindrophyma* ZITTEL, *Walcotella* DE LAUBENFELS, *Cnemidiastrum* ZITTEL, *Sporadopyle* ZITTEL, *Trochobolus* ZITTEL, *Ramispongia* QUENSTEDT, *Lecanella* ZITTEL, *Pachyteichisma* ZITTEL. Sponges of these genera amount to about 59% of the whole assemblage.

All frequent sponges in the Swabian Alb are more or less the same as those in Poland, except for *Trochobolus*, *Lecanella* and *Pachyteichisma* which are rare or very rare in the Polish assemblage. The main difference visible at first glance is high diversity of the whole assemblage (caused without doubts by the wider time-span analysed) from the Swabian Alb, and what follows from it less dominance of the assemblage by few species.

There are, however, strong differences in frequency of particular taxa, or groups of taxa in various stratigraphic horizons, especially among Oxfordian collections versus those of the Kimmeridgian (or particularly Middle-Upper Kimmeridgian). The Oxfordian part of the section is dominated by *Cypellia* and *Stauroderma*, while the Kimmeridgian part (especially Upper Kimmeridgian) is dominated by *Cylindrophyma* and *Platychonia*, which are rare in the Oxfordian (Fig. 4). Most other taxa occur throughout the whole section, in lesser but not very different quantities.

TRENDS IN COMPOSITION OF THE SPONGE FAUNA

The most striking and basic trend is in frequency of lithistid versus hexactinellid sponges (Figs 5, 6). There is a steady increase in a frequency of lithistid sponges from the bottom toward the top of the stratigraphical column, with clear dominance of hexactinellid sponges at the bottom (in the Middle and Upper Oxfordian), high percentage of lithistid sponges in the Lower Kimmeridgian, to the absolute dominance of lithistid sponges in the uppermost Kimmeridgian, especially in coral facies (where also a rich and diversified fauna of soft demosponges had been present, as proved by the assemblage of loose spicules). This trend concerns not only specimen numbers but also species numbers (Fig. 7). Considerable other data point to a shallowing toward the Tithonian, then the most plausible interpertaion of this trend in the Swabian Alb suggests substitution of hexactinellid sponges by lithistid sponges with shallower

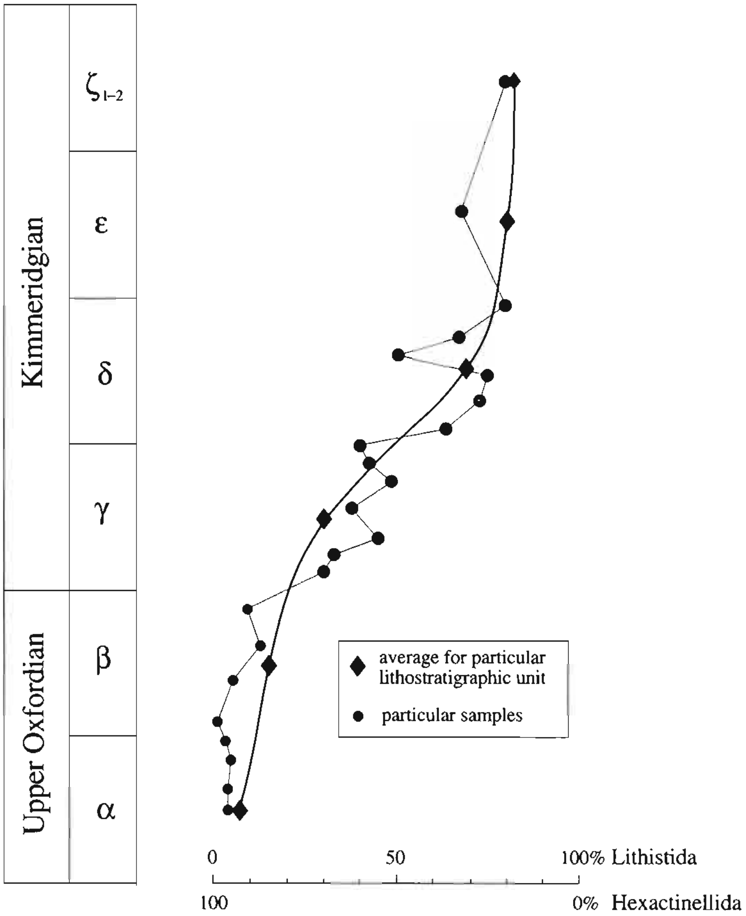


Fig. 5
Changes in frequency distribution (based on particular stratigraphically well located samples and average for lithostratigraphical units) of hexactinellids and lithistids.

depths. What was the major factor associated with depth one may only speculate, pointing to changes in energy level and temperature. This trend also may have been partly caused by clear preference of lithistid sponges to occur in limestones (see below), which are more common toward the top of the section. This cannot be generalised, however, for lithistid sponges are rare in the Oxfordian marls and rather common in the Kimmeridgian marls.

Frequency of hexactinosan and lychniscosan sponges shows the same pattern, *i.e.* there is a steady decrease in their share toward the top of the stratigraphical column, thus it seems that there are no important differences in their ecological requirements.

The above trends are average trends, a more complex picture is revealed by the same measures of frequencies in particular sections. An average situation parallels, of course, the general trend but there are numerous local opposite tendencies (Fig. 6). This may be a response to differences in lithology between particular samples, for it was shown that even in the same stratigraphic level there is not equal distribution of hexactinellid sponges between marls and bioherms (see below).

The general change in lithistid versus hexactinellid frequency is also observed in Poland but seemingly in the opposite direction (see TRAMMER 1989 and Fig. 6), where it is paralleled by changes in composition of carbon and oxygen isotopes (PISERA *et al.* 1992). Such situation, however, indicates that factors controlling lithistid versus hexactinellid sponges distribution worked at the local and not regional scale. One easily imagined factor is a predominating type of food availability – these two groups prefer different food types, which may be more easily controlled on a local scale. These differences in type of food prefered (colloidal matter in hexactinellids REISWIG 1990) may explain, perhaps, an apparent contradiction in sponge assemblage composition and postulated deepening at the begining of the Kimmeridgian (see Figs 5, 6), where lithistids became common. This may be an effect of supply of particulate organic matter to

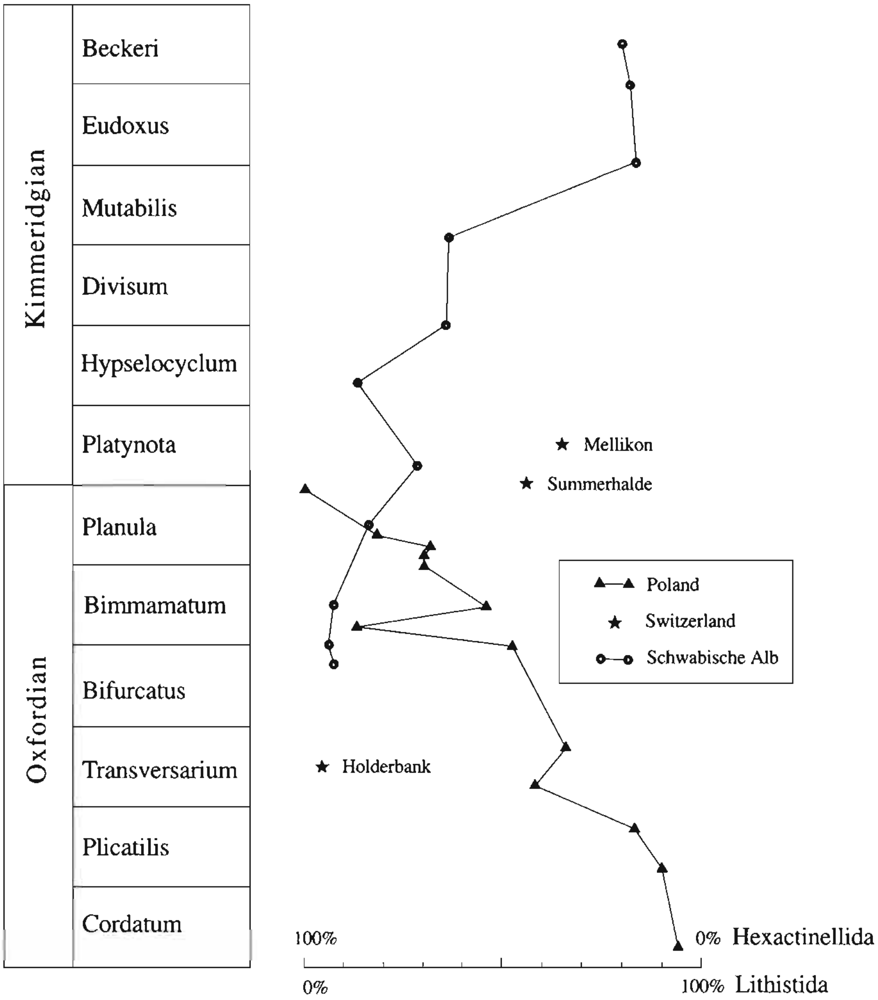


Fig. 6

Changes in frequency distribution of hexactinellid and lithistid sponges during the Oxfordian and Kimmeridgian in the Swabian Alb (only samples with precise biostratigraphic positions used); for comparison samples from the Oxfordian–Kimmeridgian of Switzerland (my own data) and from the Oxfordian of Poland (based on data from TRAMMER 1989) are also shown.

the deeper water in response to increased productivity caused by nutrient delivery from submergence of new land areas by a transgressing sea.

In addition to the trend in time, there are some interesting patterns of distribution of lithistid versus hexactinellid sponges in strictly coeval deposits. I have checked frequency of lithistid versus hexactinellid sponges in bioherms and surrounding marls in two samples from the Kimmeridgian of the Hochwang section (Fig. 8). My samples were small, but in both cases there is a statistically important difference between two strictly coeval deposits: marls and bioherms. Hexactinellid sponges dominate in bioherms, while lithistid sponges are more common in marls (Fig. 8). This would suggest higher resistance of lithistid sponges to turbid water or a slower sedimentation rate – the problem cannot be solved, however, with so limited data, and needs larger samples from various parts of the sections.

There is some difficulty in finding a simple explanation of lithistid versus hexactinellid sponges distribution. The trend observed in Poland (see TRAMMER 1989, 1990) is difficult to compare with that in other areas for only in Poland is the Lower Oxfordian developed in sponge biofacies. Anyway, in the Middle Oxfordian of Poland lithistid sponges compose about 50% of the assemblage (see TRAMMER 1991), while in Spain at the same time their share was negligible, not exceeding 10% (PISERA 1991). The situation in Switzerland is similar (see Fig. 6). Thus the trend is not of general character.

In Poland, just before the appearance of shallow water Kimmeridgian deposits containing hermatypic corals and calcareous oolites, hexactinellid sponges dominate in the assemblage (TRAMMER 1989 – but

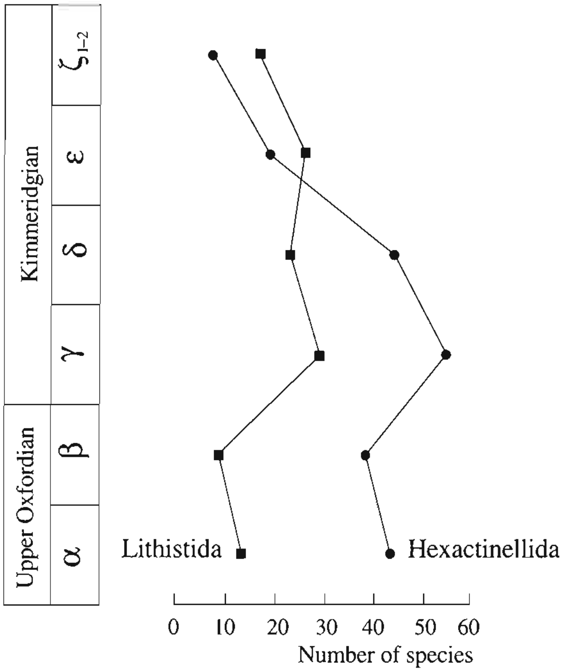


Fig. 7
Species diversity changes of lithistid and hexactinellid sponges in the Oxfordian and Kimmeridgian in the Swabian Alb.

note that his sample was very small), while in Germany at the same time there was a shift toward lithistid dominance. In Germany in the uppermost Kimmeridgian, in similar rocks with corals, the assemblage is dominated by lithistid sponges. Thus there is an opposite situation and contradiction appears. One cannot explain it simply by a very rapid shift in bathymetry in Poland, from deeper to very shallow water. There is continuous sedimentation and no traces of such an event in the Polish sections. The observed pattern of distribution may be rather an effect of local changes in bathymetry superimposed on oceanographic factors, such as dominance of various water masses in different areas (see for example Pisera *et al.* 1992) or hydrodynamic regimes – very calm in case of the hexactinellid sponges and more turbulent in case of the lithistids, as well as modification of effective nutrient dominance (see above).

Another observed pattern in lithistid distribution is the dominance of rhizomorine sponges in the Oxfordian and Lower Kimmeridgian samples, while in the Upper Kimmeridgian except for rhizomorines, nonrhizomorine sponges are not only common but also diversified (*cf.* Ziegler 1977). A similar depth associated pattern may also be observed among Recent lithistid fauna of Barbados (see van Soest and Stentoft 1988), where the deepest zone is occupied exclusively by rhizomorines, while intermediate depths are occupied by nonrhizomorine species (*Vetulina* Schmidt is regarded by me as a rhizomorine – *cf.* Gruber 1994). This clearly indicates that ecological requirements of various lithistid sponges are more or less the same as they were during the late Jurassic time.

A well expressed trend observed in the UJSM concerns siliceous versus calcareous sponges. Usually calcareous sponges accompany corals in shallow water deposits, *i.e.* in the case of the Swabian Alb they are very common in the uppermost Kimmeridgian and ?Tithonian strata (Müller 1984), or in Portugal in the Kimmeridgian (Fürsich and Werner 1991) where the hexactinellid sponges are absent or very rare. Such distributions are generally in conformity with Recent distributions of these two groups (*cf.* Reid 1968a; Vacelet 1988). Occurrences of calcareous sponges, however, have been observed in deposits with hexactinellid predominance which are here interpreted as those of relatively deep-water, but only in smaller numbers. These fit very well into the picture of most recent discoveries of the world-wide occurrence of the Recent Calcarea in the bathyal zone (Vacelet 1988; Vacelet *et al.* 1989). Thus the presence of Calcarea, as such, is not a good depth indicator, but only their dominance should be used in the fossil state as pointing to shallowness. Application of data on Recent calcareous sponges to the fossil record must be done with caution, as today it contains forms with loose spicules, while those with solid skeletons, which are very common as fossils, are rare in the modern seas.

In Spain, sponges are the most numerous in thin marly intercalations, which represent periods of low carbonate production with only background fine clastic sedimentation, and in the clearly condensed horizons in limestones. Generally, however, the whole Spanish UJSM is strongly condensed (Pisera 1991; Krautter 1995) and very rich in sponges. It seems that slow sedimentation rate is a prerequisite for sponge colonization (Leinfelder *et al.* 1993, 1994; Krautter 1995). In my material no root structures, typical of soft bottom conditions have been found, thus suggesting clearly that these sponges needed some kind of hard object for attachment.

The occurrence of siliceous sponges within thick Oxfordian sequences in Poland can be easily explained by the fact that the sponges are concentrated in some intervals that accumulated when sedimentation was slow. Thick micrites, which are interpreted as deposited under high sedimentation rates are devoid of sponges (A. Matyja personal information). These sponges, thus, are also associated with intervals of condensed sedimentation. Rather rapid sedimentation is also most probably responsible for absence of calcareous crust on Polish sponges.

REMARKS ON ECOLOGY OF SOME SPONGES

Only several sponge species are common enough to speculate on their ecological requirements. Among them are *Cylindrophyma milleporata* (GOLDFUSS), *Cypellia rugosa* (GOLDFUSS), *Stauroderma lochense* (QUENSTEDT) and *Platychonia* spp. The species *Cypellia rugosa*, which dominates in the Oxfordian, occurs irrespective of lithology, and although not common reaches the largest size in the Kimmeridgian marls. This pattern suggests some factor other than sedimentation type as governing its distribution. Surprisingly, the distribution pattern for *Stauroderma lochense* is very similar, despite the fact that it represents a different morphological type. It is thus clear that the shape of the sponge, itself, is not so simply and directly connected with water energy as was suggested by TRAMMER (1983), and/or sedimentation rate as postulated by KRAUTTER (1995). The average tendency of lithistid sponges to be more common in marls, as already mentioned (see Sponge assemblage, and Fig. 8), while hexactinellids dominate in bioherms of the same age, points to some control of sediment type in general lithistid and hexactinellid ecology.

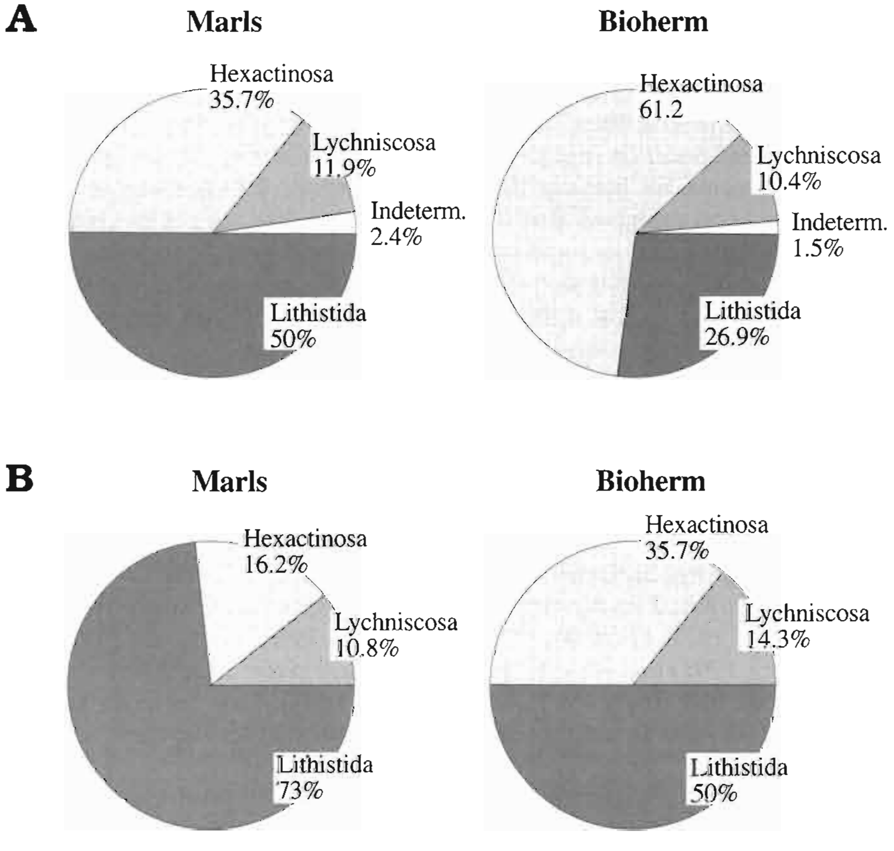


Fig. 8
Composition of sponge assemblages in strictly coeval marls and bioherms from Hochwang:
A – Kimmeridgian (Lower Delta); **B** – Kimmeridgian (Upper Delta).

In the Swabian Alb *Cylindrophyma milleporata* is among most common sponges and present in all levels, and it very common or dominating is in the uppermost Kimmeridgian (see Fig. 4). LEINFELDER *et al.* (1993) suggested that *Cylindrophyma milleporata*, which is common in Portugal microbial mounds, may be adapted to high nutrient/low oxygen conditions, allowing for development of microbial constructions. This is difficult to accept for this species is the most common sponge in the coral facies in Germany, and present in all stratigraphic levels and types of sediment that could have developed, as well, in high oxygen and low nutrient conditions. It seems, rather, that this sponge is a very eurytopic one, able to survive in even adverse environments, being best adapted to relatively shallow depth (tens of meters) and most probably liking semicryptic and cryptic environments, which are common in coral bioherms.

The other common lithistid *Platychonia* spp., parallels the distribution pattern of *Cylindrophyma milleporata*, and may serve as another example of opposite morphological types occurring in the same environment, as was the case with hexactinellids described above.

If lychniscosan and lithistid sponges, and especially hexactinosan sponges, were really deep-water (100 meters and more) dwellers in the Upper Jurassic, then how does one explain their occurrences, however rare in comparison with other biota and calcareous sponges, with hermatypic coral fauna (Gerstetten, Gussenstadt, Arnegg)? First of all, one must remember that these reefs or biostromes are not analogues of the modern shallow water coral reefs and grew also at some depth. Today, depending upon locality, prolific hermatypic corals occur at depths of 60–70 meters, and may be less abundantly found as deep as 90–100 meters (JAMES and GINSBURG 1979). Siliceous sponges (especially hexactinosan sponges), on the other hand, could be a part of cryptic faunas; such occurrence of various deep-water organisms, including lithistid sponges (see VACELET and VASSEUR 1971) and hexactinellid sponges (BOURY-ESNAULT and VACELET 1994), is well known today. Also, the uppermost Kimmeridgian coral facies with siliceous sponges may be of relatively deep-water origin, *i.e.* at least 60–70 meters deep, but perhaps even 100 meters deep.

Sedimentation rate has an important influence on sponges (see above and KRAUTTER 1995). Considerations about relationships between canal size in sponges and character of sedimentation (LEINFELDER *et al.* 1994) (not withstanding fine grained sedimentation) are baseless, for even in the case of large hexactinellid canals they have nothing to do with sizes of particles entering the interior of a sponge which are limited by ostia, that are several times smaller. In reality openings of these canals are not ostia, which are several times smaller and occur on (not preserved) dermal membrane of sponge. Common occurrence of sponges in muddy sediments, *i.e.* marls of the Upper Oxfordian of Plettenberg or Kimmeridgian marls of Erkenbrechtsweiler, may be explained first by supposing that they are not precisely contemporaneous with marl sedimentation and/or that in some cases sponges could have been living on elevated parts of the bottom (bioherms) and only washed into the areas of muddy bottom. This last supposition should be rejected, at least in cases where a clear difference in frequency of lithistid versus hexactinellid sponges in marls and bioherms from strictly coeval sediments has been found.

ENVIRONMENTAL SETTING OF THE SPONGE BIOFACIES

The bathymetry of the sponge biofacies from the Upper Jurassic of Europe is a hotly disputed matter, and no agreement has been found so far between classical interpretation suggesting depths of 100–200 meters (see ZIEGLER 1967, 1977; GWINNER 1976; GYGI 1981, 1986; GYGI and PERSOZ 1987; TRAMMER 1982; MATYJA and PISERA 1991) and some more recent shallow water hypotheses speaking about tens of meters maximum (SCHORR and KOCH 1985; AURELL 1990, 1991). Less common are discussions about other environmental factors such as sedimentation rate and nutrient levels; these will be discussed here later.

There are two possible approaches to answering the question of bathymetric setting: the first is analysis of the sponge-bearing sequence (including the condensed Callovian/Oxfordian boundary horizon), the second is analysis based on ecology of sponges and associated biota.

SEDIMENTOLOGICAL ARGUMENTS

To solve the problem of bathymetric position of the sponge biofacies, one has to consider the whole sequence of sediments composing it, as well as the underlying and overlying rocks. The first step should be an analysis of the strongly condensed sedimentary sequence with numerous gaps and iron oolites in a muddy matrix (see above), that underlie the sponge biofacies nearly universally (Fig. 9). Genetic links exist between the Upper Jurassic sponge facies and those facies directly underlying it, which in most cases is the condensed horizon with stratigraphic gaps of various duration. They belong to the same sedimentary sequence. One must also note that the condensed horizon with iron oolites, when not followed by the sponge facies, as it is in the case of Nepal (GRADSTEIN and VON RAD 1991; GRADSTEIN *et al.* 1991, 1992), is followed by organic-rich shales interpreted as a deep-water, continental slope deposits. The geological event giving birth to this horizon must be of global character and significance. It is known from such distantly separated regions as Argentina (Nequen Basin – LEGARRETA 1991), all over Europe (MATYJA and PISERA 1991), India (FÜRSICH *et al.* 1991, 1992), Nepal (Tahakkola – where ferruginous oolite dated as Callovian is interpreted as a product of a major transgression resulting in reduced sediment supply, without any traces of subaerial exposure), Wombat Plateau and Exmouth Plateau on the Indian Ocean (where the gap spans the whole Jurassic and is interpreted either as a result of uplift and erosion or drowning and extreme condensation, or nondeposition caused by a global transgressive event associated with accelerated sea-floor spreading) (GRADSTEIN and VON RAD 1991; GRADSTEIN *et al.* 1991, 1992).

The stratigraphic hiatus observed below the sponge biofacies is of various duration, depending upon local factors. Locally the whole Callovian may be missing, with Middle Oxfordian resting directly on shallow-water Bathonian oolites (for example in Switzerland – GYGI and MARCHAND 1982; or in Spain – personal observation). The gap clearly depends on how much sediment was removed by submarine erosion and/or corrosion, and also on its duration, *i.e.* when it started. The top of the hiatus is more or less synchronous on a regional scale, and usually the Middle Oxfordian deposits were already present. In Poland however, where the Lower Oxfordian has been recognised, it is missing only its lowermost part (MATYJA and GIŻEJEWSKA 1979; MATYJA and TARKOWSKI 1981). This can be easily explained by the fact that the Polish basin was located far inland, in an inner shelf area where the effects of events postulated below were active for a shorter time.

In places like southern Tibet, where iron-oolites have not been found, the Callovian/Oxfordian boundary is associated with a deepening event, which continued until the end of Kimmeridgian when a rapid and important drop in sea-level occurred (LI XIAOCHI and GRANT-MACKIE 1993).

In many places above this hiatus and/or iron oolites starts carbonate sedimentation, described in the literature as the Upper Jurassic Sponge Megafacies. A different situation occurs in Nepal where thick clastics follow above UJSM. The area was clearly with too high a sedimentation rate and too high a clastic input to allow sponge development (so far bodily preserved sponges are not known from Jurassic clastic rocks).

Currently there are two competing models for genesis of the condensed horizon with iron oolites and the underlying stratigraphic gap. One model suggests that the facies originated during a low-stand sea level, or even emergence that followed the resultant shallowing Callovian sequences. The iron crust covering some erosional surfaces of the Dogger is then treated as continental in origin, while the beds with iron oolites and numerous ammonites are interpreted as deposited in an extremely shallow water, only centimetres (AURELL and MELENDEZ 1990; FERNANDEZ-LOPEZ and MELENDEZ 1994, 1995,) to few meters deep (see AURELL 1990, 1991; AURELL and MELENDEZ 1993). Then, followed the transgressive event of the sponge facies, which must be everywhere of shallow depth of tens of meters at most (AURELL 1990).

The other explanation (here supported) of origin of the iron oolite facies postulates in deep-water, where condensed deposits and hiatuses are results of high sea level (maximum flooding) resulting in basin stravation (GYGI 1981, 1986; GYGI and PERSOZ 1987; MATYJA and PISERA 1991; NORRIS and HALLAM 1995). In places, erosion to various depths could have happened, followed by deposition of the iron crust in most distal areas, above which accumulated condensed deposits with traces of several smaller erosional events. Finally sedimentation caught up and sponges became established in the relatively deep water (up to hundreds of meters, perhaps more shallow in the case of Poland where lithistid sponges dominate, and more deep in the case of Spain or Germany where hexactinellid sponges dominate). This hypothesis has been supported by discovery of Recent deep water (119 and 141 m deep) iron hardgrounds with glauconitic ironstones forming at the shelf-break swept by marine currents causing sediment starvation. The associated biota includes planktic forams, sponges spicules and echinoderm remains (CORSELLI *et al.* 1994), an assemblage identical with those known from the Upper Jurassic sponge biofacies.

If one accepts the shallow water hypothesis of the condensed horizon, then severe problems immediately appear (unless one considers sponge facies as deposited in tens of meters of water, which is rejected here). One should expect transitory shallow-water deposits between the condensed horizon (centimetres to meters of water) and sponge facies (80–100 and more meters), which were never observed. The removal of such an intermediate facies would be difficult to explain. The transition between iron oolites and sponge facies is very abrupt, but iron ooids may be still dispersed in the lower part of sponge facies, suggesting a transitional character of the boundary between the beds. On the other hand, in a deep-water model these difficulties may be avoided for the beginning of the sponge facies must have been in the deep water, with hexactinellid or lithistid sponges dominating depending upon local differences in bathymetry and other environmental parameters.

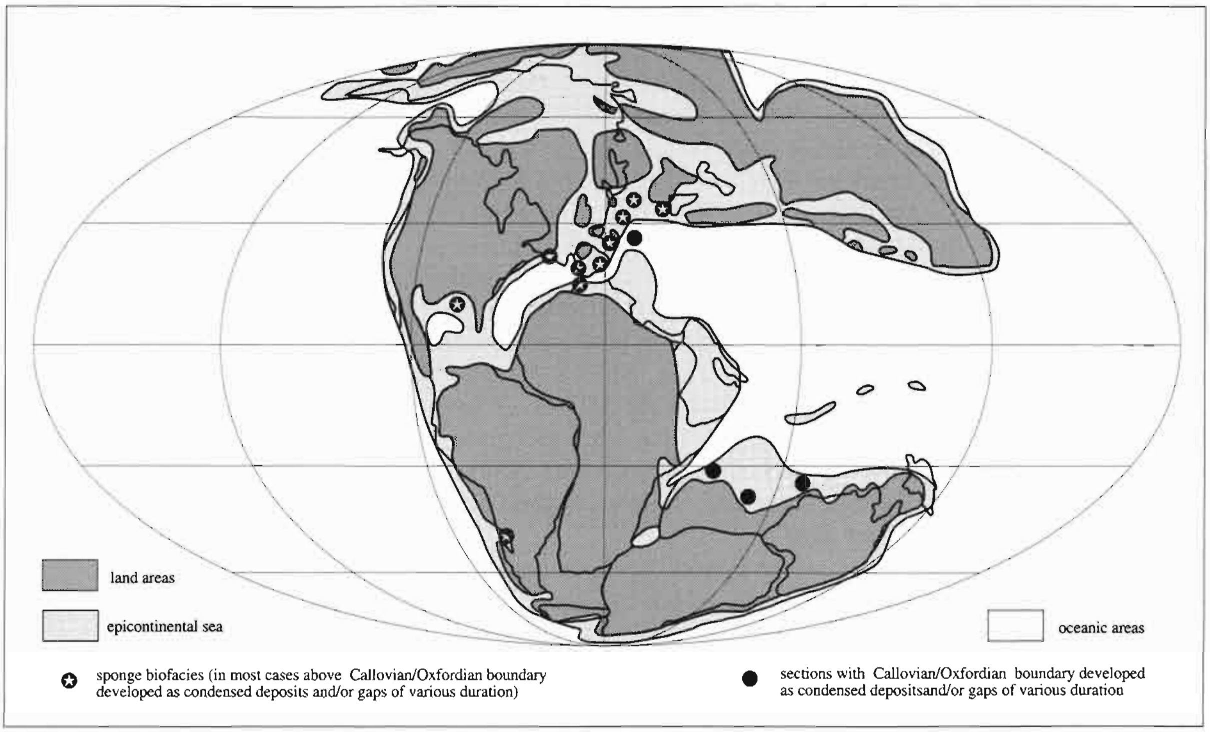


Fig. 9

Global distribution of the Upper Jurassic siliceous sponge biofacies and condensed Callovian/Oxfordian boundary horizon (Paleogeograpgy after SCOTESE 1992, distribution of siliceous sponge biofacies and condensed horizon with iron ooids from BEHMEL 1970; BARIA *et al.* 1982; GAILLARD 1983, CREVELLO and HARRIS 1984; AURELL 1990; LANG and STEIGER 1984; FÜRSICH *et al.* 1991, 1992; GRADSTEIN and VON RAD 1991, GRADSTEIN *et al.* 1991, 1992, LEGARRETA 1991 and references therein).

Global sea level curves (see HAQ *et al.* 1988) so far published show only gradual deepening across the Callovian/Oxfordian boundary. HALLAM (1988), in a critique of the Exxon curve presented a clear-cut regressive event in this interval, only recently changing opinions in favour of sea-level rise producing condensed deposits at this boundary (HALLAM 1992, 1993).

The global distribution of iron ooids (Fig. 9) indicates also that some global iron source must be sought, to explain the situation. Local sources simply seem incompatible with global distribution. Anyway, in the case of Spain for example, the postulated sources of iron are two small emerged areas – islands (AURELL 1990), and the source is clearly too small to explain even Spanish iron oolites. It is also difficult to accept the ooids being dispersed over vast shallow water area from these two small sources. One can look to the Meseta as another possible source but it seems incompatible with the facts. In other areas, like Poland for example, local sources are totally absent. A global source of iron may be volcanic activity invigorated by accelerated spreading rates of the sea floor which produced a very rapid and important sea level rise of eustatic characters caused by the increased volume of newly produced oceanic crust. Such an acceleration event was indicated for the period under consideration (see HAQ 1988; ZIEGLER 1990).

In fact, the presence of iron can be also explained without looking for a special source. If one considers that the deposits under discussion are very condensed then the high percentage of iron in these rock simply may be result of a very slow sedimentation rate of carbonate, while iron was present in the environment at more or less normal concentration.

There are also other problems produced by the shallow water hypothesis. The very striking fact is that similar gaps, usually of unknown duration, but clearly associated with erosive events (the Oxfordian often rests directly on the Bathonian or even Lower Jurassic deposits), are known from the Mediterranean Ammonitico Rosso facies (see for example SEYFRIED 1978). In shallow water hypothesis one would expect the gaps to be smallest in locations that were situated in distal areas and in deeper water, or to see introduction of shallow water facies atop the Ammonitico Rosso. Instead there are larger gaps and non-sedimentation or even erosion. Such sequences can be easily explained, on the other hand, by a deep-water hypothesis as a result of even more intense sediment starvation, which may be expected in more distal and deeper areas.

A different situation has been observed in the Lusitanian Basin and part of the Algarve, Portugal (LEINFELDER *et al.* 1993), where a clear regression occurred at this boundary, while eastern and southern parts of the Meseta display transgressive cycle as indicated by the deepening at the Callovian/Oxfordian boundary. This apparent contradiction may be solved by a different polarity of the same event, caused by the fact that the eastern part of Iberia underwent convergence, while the western part was under an extensional regime (as the result of the motion of the Iberian Plate toward NE), thus resulting in sea-level drop in agreement with the mechanism proposed by JANSA (1991).

When speculating about genesis one must also remember that the condensed horizon with ferruginous ooides is not a true oolite rock – it is composed mostly of micritic matrix with abundant ferruginous ooids and oncoids distributed very irregularly in the matrix. Often they are concentrated in patches, suggesting that they infilled some kind of burrows. The matrix usually contains mostly pelagic fossils – numerous protoglobigerinid forams, belemnites and ammonites, as well as isocrinid crinoids ossicles. Most of the fauna is of reworked character. In effect, any comparison with shallow water classical oolites seems inappropriate. Thus the only plausible hypothesis of the origin of the condensed Callovian/Oxfordian boundary horizon is a deep-water one. As a result the siliceous sponge biofacies which follows is also rather deep-water in genesis from its beginning.

Numerous sedimentological arguments in favour of shallow water origin of the sponge-rich rocks have been also offered. One of the strongest such arguments in favour of shallowness of some sponge bioherms is the presence of carbonate-coated (ooid-like) grains in these buildups (MATYSZKIEWICZ 1989; MATYSZKIEWICZ and FELISIAK 1992; KOCH *et al.* 1994). This argument is loosing its weight with the discovery of identical Recent ooid-like grains with micritic cortices which are widespread in a deep (below 215 meters) hardgrounds around Barbados (STENTOFT 1994), in the same area where a rich fauna of clearly autochtonous lithistid sponges is known (VAN SOEST and STENTOFT 1988).

Similar is the case with arguments that peloidal to coated grains facies (grainstones) within some sponge reefs indicate shallow water deposition (KOCH *et al.* 1994) – grainstone facies occur today on the Nicaraguan Rise at depths of 10 to 40 meters on the top of tectonic highs that are swept by currents (TRIFFLEMAN *et al.* 1992) and thus those grains can be easily transported downslope to much greater depths (HINE *et al.* 1994). Without doubts, similar mechanism could have been working at the tops of sponge bioherms that formed pronounced topographic highs that were the under the influence of currents, which may have been responsible (regardless of depth) for production of grain-rich deposits. An absence of any shallow water faunal elements (which are known from the Nicaraguan Rise), especially reef corals (except of some Kimmeridgian/Tithonian reefs) point to the depths greater than in the Recent examples. Another Recent example undermining the argumentation of KOCH *et al.* (1994), is the presence of large areas of well winnowed coarse sediments (forming also sand waves and with some hexactinellid sponges, to make the analogy closer) at the depth of 200–550 meters on the carbonate ramp of central-west Florida, forming there as a result of Loop Current activity (MULLINS *et al.* 1988; IVANY *et al.* 1994). Similar grainstone lithologies of Recent carbonate sediments are known from depths of 400–600 metres on the New Caledonia slope (RIO *et al.* 1991). Sand fraction (mostly pelagic grains, but occasionally also including grains of very shallow origin such as *Halimeda* and ooids) occurs in lithoherms in the straits of Florida at depths of 600–700 meters (NEUMANN *et al.* 1977). These lithoherms contain rich faunas of siliceous sponges, as well as stalked crinoids, and may be directly comparable to the Jurassic fossil sponge bioherms. The UJSM occurred in a similar environmental setting along the northern Tethyan shelf, which could have been under the influence of Tethyan currents flowing toward the west, thus producing similar sediments.

Another difficulty in accepting a deep-water genesis for the sponge biofacies was the fact that we did not know examples of Recent deep-water carbonate deposition. Recently, however, several areas of the deep-water carbonate sedimentation have been described from the Florida Shelf (MULLINS *et al.* 1988; IVANY *et al.* 1994) representing a ramp setting. Even earlier, deep water lithoherms rich in sponges were discovered on the Bahamas slope at depths of several hundreds meters (NEUMANN *et al.* 1977; MESSING *et al.* 1990). More recently extensive carbonate deposition associated with rich lithistid faunas (associated with hard bottoms) has been also very well documented from the slopes of New Caledonia (LÉVI and LÉVI 1983, 1988; LÉVI 1991; ROUX *et al.* 1991) at the depths of 300–600 meters. The similarity concerns not only sponges but also other faunal elements, especially stalked crinoids, which are of the same type as those known from the UJSM.

One of the causes of disagreement about the bathymetry of the siliceous sponge biofacies is most probably the heterogeneity of the facies itself. Most of the recent papers deal mainly, if not exclusively, with sponge-microbial mounds or reefs (see for example GAILLARD 1983; SCHORR and KOCH 1985; LEINFELDER 1993; BRUNTON and DIXON 1994; LEINFELDER *et al.* 1994). If one considers that the tops of these mounds (being still below the hermatypic coral growth zone) were up to 200 meters (or even more if there was pre-mound relief on which they started) above the surrounding sea-floor where sponges thrived (GWINNER 1976; TRAMMER 1982; MATYJA and WIERZBOWSKI 1994), then it becomes clear that both shallow (100 m) areas and deep-water basins (200 m) may exist at the same moment. When I speak about deep-water setting, I mean in first place, bedded (biostromal) sediments that have been deposited between more shallow mound tops, and which contain more sponges than the mounds themselves.

A simple geometrical exercise may be added here to support my reasoning – if one supposes that the shelf was sloping at 1°, and that sponge biofacies developed about 50 km from the shore (which is a very conservative estimate in many cases), then the depth at this distance could be 875 meters. If we assume a shelf sloping only 0.5°, we still reach a depth of 475 meters. Assuming the existence at this time of an extremely vast, entirely flat shelf not deeping toward the basin seems entirely untenable, and there is a general agreement that the shelf had a character of a ramp.

In light of the above discussions there is no reason to reject the hypothesis of deep-water (100 meters at least, but perhaps as deep as 300–600 meters in the case of some inter-mound muds rich in hexactinellid sponges) setting of the UJSM.

ECOLOGICAL ARGUMENTS

When speaking about bathymetric requirements of any organisms one must keep in mind, however, that depth *per se* is not a controlling factor – it simply acts by pressure, water energy, light conditions, food availability, competition etc. In the case of hexactinosan and lychniscosan sponges a low water energy (associated usually with greater depths), and perhaps also lack of competition of other sessile animals, especially corals, seems to be the most important. Also temperature clearly plays a considerable role, especially in lithistid sponges. The only known Recent example of very shallow (20–30 meters) occurrence of hexactinosan sponges is from British Columbia fjords (REISWIG in MEHL 1992), which are explained by the very low water-energy environments in a protected setting, but perhaps also by low temperatures. Applying actualistic data to the fossil siliceous sponges one should, however, speak about smaller groups than the Hexactinellida: one should consider rather Hexactinosa, Lychniscosa and Lyssacinosa which generally live today in clearly different conditions (REID 1968a; VACELET 1988). A more simple situation concerns lithistid demosponges. We know that it is not a uniform group from the point of view of phylogeny, but it can be treated as morphofunctional group and as such more suitable for paleoecological analysis than a phylogenetic one.

Recent relatively shallow-water communities, rich in hexasterophoran sponges, are known from depths of 30–60 meters from Antarctica (DAYTON *et al.* 1974), but they are composed exclusively of sponges with unfused skeleton. They contribute considerably to the bottom sediments, and may form sponge spicules mat up to 2 meters thick. Hexactinosan-rich Recent communities are typical of tropical and usually deep-water habitats. Recently, however, deep-water (150–240 m deep) large bioherms dominated by hexactinosan sponges have been described from the British Columbia Shelf (CONWAY *et al.* 1991) where the bioherm grows over the glacimarine sediments. As such they cannot serve as a good analogue for the Upper Jurassic occurrences, which are associated with carbonate and warm-water sedimentation. Important is the fact, however, that their occurrence is also controlled by a low sedimentation rate and the presence of a hard substrate.

One can easily accept the supposition that the most shallow deposits under study are those with abundant corals, in our case those from Arnegg, Gussenstadt and Gerstetten. Both hexactinosan, lychniscosan and lithistid sponges do occur in these rocks, but lithistids strongly dominate over hexactinellids. This points to the shallower water preferences of lithistid sponges, which are usually very rare or absent in thrombolite reefs that are regarded as the deepest deposits (LEINFELDER *et al.* 1993, 1994) of the sponge megafacies.

Recent hexactinellid sponges, from groups having dictyonal skeleton and known from the Upper Jurassic, live in modern warm seas in profusion only at depths of 200–800 meters (but may be found exceptionally as shallow as 37 meters – REID 1968a; VACELET 1988) and there is no reason to postulate changes in their environmental requirements. The constructional morphology of these sponges, which is identical in both Recent and fossil sponges, displays adaptations for deep water environments (see TABACHNICK 1991) and excludes the possibility that they inhabited areas of a high energy usually associated with shallow depths. They can live only under conditions of calm water (that does not exclude the presence of currents). Some Jurassic forms, such as *Verrucocoelia* ETALLON, are identical in morphology with some Recent sponges such as *Farrea* BOWERBANK and *Pleurochorium* SCHRAMMEN, typical inhabitants of deep (at least several hundred meters) water. The way of feeding of hexactinellids is mainly on colloidal matter (REISWIG 1990), and they are ineffective in using the cellular part of suspended organic matter, making them well adapted to deep-water habitats where cellular matter is rare. In Recent Pacific waters the amount of phytoplankton drops considerably below 50 meters, reaching a low level only below 100 meters (RHEINHEIMER 1980). Hexactinellids are also not adapted to shallow water habitats for they lack a defense system to protect them from competition for space (but see BRUNTON and DIXON 1994: p. 379).

Another reason for not being adapted to shallow water is their non-specific cell aggregation propensity which excludes hexactinellids from waters rich in living cellular matter (TABACHNICK 1991). There is no reason to believe that these features were different in fossil hexactinellid sponges, thus we should regard them as inhabiting, both today and in the past, similar environments.

Similar conclusions have been reached by BRUNTON and DIXON (1994) who suggested that the mutaually exclusive nature of corals (which inhabit shallow water) and siliceous sponges is most likely due to differences in nutrient requirements and constraints associated with water turbulence (depth associated). On the other hand, Recent hexactinosan sponges inhabit deep water settings not only because of lower water energy, but also because they are cold-water creatures, which prefer water temperatures about 10°C (LÉVI *in* ALLOUC 1990), and it seems that similar adaptation was working in the past, as they are unknown from the Boreal Jurassic.

Lychniscosan sponges, which also live under similar habitats, are known only from tropical deep waters, and are absent among modern cold water faunas which contain hexactinosan sponges. Similarly lithistid sponges occur today abundantly between 100 and 700 meters, depending upon local condition, and temperatures around 10–15°C and occur nearly exclusively in tropical and warm regions (LÉVI and LÉVI 1983; VACELET 1988; VAN SOEST and STENTOFT 1988). There are, however, lithistid genera such as *Theonella* GRAY and *Discodermia* DU BOCAGE which support an environmental interpretation of much higher temperatures and depth for they occur also in very shallow water in coral reefs (VACELET 1988; VAN SOEST 1990). Such species tend to show a reduction of desma fusion that results in a "soft" character of the sponge. No such skeletons have been observed, however, among the Upper Jurassic fauna from the Swabian Alb. It seems reasonable to suppose that their distribution in the UJSM was also controlled by water temperature as indicated by their paleogeographical setting, and occurrence in more shallow settings than hexactinellid sponges.

An interesting hypothesis concerning bathymetric distribution of siliceous sponges in the past and today, bearing on our understanding of the UJSM, was recently put forward by MALIVA *et al.* (1989). They speculated that presumed decline of siliceous sponges in the platform environment resulted from decreased silica content in sea-water in a shallow-water environment related to expansion of planktic diatoms. This would be true if really such sponges decline were observed in rocks younger than Cretaceous, and if they really inhabited shallow environments in profusion greater than deep-water. In fact this observation is rather an artifact produced by lack of studies of sponge faunas younger than Cretaceous. MALIVA *et al.* (1989) themselves cited shallow water Eocene spiculites from Australia, and Palaeocene and Oligocene from Bulgaria. There are at least two large sponge faunas of Eocene age: in northern Spain and southern France (BUSQUET *et al.*1995), Italy (MENIN 1972), and in the USA (FINKS 1983; RIGBY 1983). Two others of Miocene age occur in Spain (BRIMAUD and VACHARD 1986) and Algeria (POMEL 1872, MORET 1924). On the other hand, MALIVA's *et al.* (1989) supposition is based on the observation of cherts, not sponges themselves, thus absence of cherts may be explained by the same mechanisms (*i.e.* low silica content in the shallow water caused by diatoms) causing rapid dissolution of sponge spicules, not by absence of sponges themselves. A most important observation in this context is that in Recent seas silica is not a limiting factor for sponge development (VACELET 1988).

In the case of the Polish Upper Jurassic siliceous sponge biofacies, TRAMMER (1982) reached the conclusion that sponges thrived at the depths not shallower than 150–200 m (in accordance with previous authors, *i.e.* ZIEGLER 1967, GWINNER 1976 estimation for the Swabian Alb). This suggests that in the Swabian Alb sponges lived in more shallow depths (or exceptionally clear water) for they are commonly associated there with so called algal crusts, thus should be within the photic zone. This argument is weakened for today we know that these crusts are cyanobacterial rather than algal in origin and their relations with visible light cannot be proved, especially as cyanobacteria often use red spectrum of light and can thrive even in darkness as chemosynthetic creatures. Very similar crusts are known to occur today even at depths 100–200 meters (JAMES and GINSBURG 1979).

A somewhat similar, but more strict approach has been recently used by GLAUB (1994) who used evidence of trace fossils produced by endolithic organisms living in various calcareous skeletons. She compared the morphology of fossil forms with the same morphological forms known in Recent. As a result she was able to ascribe environmental range for the fossil forms. Among Upper Jurassic examples she studied also some of the sections which were also studied in the present paper, *i.e.* Plettenberg and Hochwang. In the case of Plettenberg, interpretation of the bathymetric position of the Oxfordian marls from the lower part of the section, as deposited in water up to 150–200 m deep (*cf.* ZIEGLER 1967 model) agrees with the results of GLAUB (1994). The upper part of the section (Oxfordian limestones) traditionally has been interpreted as deposited in slightly shallower water, about 100 m in the case of bioherms (HASKELL 1986), and is in agreement with borings analysis, or 150–200 meters in the case of the bedded facies (Bank-fazies), which contradicts analysis of borings that suggests water not more than 100–110 meters (GLAUB 1994).

In the case of the Hochwang section (Kimmeridgian) GLAUB's results agree with WIRSING's (1988) reconstructions, and suggest generally smaller depths than envisaged by ZIEGLER's (1967) model. Similar rather shallow water (20–40 meters depth) is suggested by GLAUB in the case of Oxfordian sponge facies from Spain. These very low depth values causes serious doubts as they stand in total contradiction, especially in the case of Spain, with all other available faunistic (very rich in ammonites, isocrinid crinoids, planktic forams and lack of hermatypic corals) and sedimentological data (condensed deposits without influence of waves, lacking shallow-water grains). GLAUB's analysis (1994), however, depends heavily on rather simple morphological comparisons of the Recent and Upper Jurassic microborings, and is based on similarity ascribing the fossils to the same organisms; this may be severely biased.

The Upper Jurassic was the time of warm climate with ocean temperatures reaching 27°C (FRAKES *et al.* 1992), and high sea-level, which means that large epicontinental areas were flooded, and that large areas of the outer shelf became relatively deep, with a limited supply of sediment from the land, but also (as an effect of depth) with very slow carbonate sedimentation (starvation effect). Such areas today are also ideal places for sponge colonization. The belt of Tethyan sponge biofacies was located in a tropical climate, as indicated by its paleogeographic position and the presence of coral reefs. This also points to considerable depth of sponge biofacies for Recent lithistids and lychniscosans are temperature limited and thus occur in tropical and warm water zones.

In accordance with the above discussion a rather deep-water setting is here supported for the siliceous sponge biofacies of the Swabian Alb. The lower value is difficult to estimate, but may be as deep as several hundred meters (600–700 meters) in the extreme, while in the case of the most shallow sediments, *i.e.* those from the Upper Kimmeridgian containing corals, depth could still range 60–100 meters.

GENESIS OF THE UPPER JURASSIC SILICEOUS SPONGE BIOFACIES

Whereas most recent papers on sponges and rocks of the region deal with so called sponge reefs and focus on facies studies to answer the question of their genesis, this study focuses on the siliceous sponges, *i.e.* the main biotic element of some bedded rocks (marls and limestones) and reefs. I considered also the general aspects of the Upper Jurassic Sponge Megafacies (its position within sedimentary sequences, and its paleogeographic position), to answer the question why sponges were so common and widely distributed during deposition of these rocks. It is worth recalling that the UJSM is a heterogeneous assemblage of facies and, as such, originated under heterogeneous conditions, which can be placed, however, in a wider environmental context.

One of the possibilities is that sponge facies originated as the result of evolutionary process, *i.e.* a result of a sudden radiation of siliceous sponges which colonised new habitats, *i.e.* shallow water environments. This must be rejected in light of occurrences of very similar sponge biofacies in the Middle Jurassic of Spain (SCHEER 1988, WILDE 1988; FRIEBE 1995) and Hungary (POČTA 1886; PISERA 1993), and well known occurrences of siliceous (mostly hexactinellid) sponges in the Middle Jurassic of Great Britain (SOLLAS

1883; HINDE 1893), which consist of more or less of the same genera of sponges as in the Upper Jurassic. Even older is the fauna of siliceous sponges reported by NUTSUBIDZE (1965) from Georgia. He reported rich and diversified faunas composed mostly of genera known from the Swabian Alb (even if some generic and specific attributions seem dubious – see above).

Thus we are left with ecological control of the sponge distribution. Because the siliceous sponges under consideration are rather deep-water creatures, our knowledge of their ecology is rather limited. It is clear, however, that all investigated groups (lithistid demosponges, hexactinosan and lychniscosan hexactinellid sponges) are today nearly exclusively deep-water tropical (but cold water) dwellers. Some lithistid sponges known from very shallow water are cryptic animals – a common case among generally deep-water groups. Thus a scenario very similar to the present occurrences of such sponges can be envisaged for the time before the spreading of the UJSM. Sponges that colonised vast areas in the Upper Jurassic were present much earlier but in refugia along the continental slopes, as is the case today with the New Caledonia slopes, that harbour not only sponges but also echinoderms of clear Mesozoic affinities. Following the Oxfordian transgression, sponges were able to colonise new extensive relatively deep-water areas from which shallow-water competitors such as corals were excluded. Thus the origin of the siliceous sponge biofacies is of ecological character, althought some evolutionary effect at the species level is possible and very probable. To check this conclusion we need more data about earlier, Lower and Middle Jurassic sponges.

LEINFELDER *et al.* (1993) envisaged dysaerobic to anaerobic waters in depths shallower than today during the Upper Jurassic, thanks to more sluggish water exchange system caused by equilibrated climate and absence of ice-caps. Such conditions were indicated already by carbon isotopes investigations pointing to the predominantly stagnant and stratified ocean (PISERA *et al.* 1992). These conditions may have influenced productivity, allowing these dense sponge populations to develop. This scenario is further supported by the observed transition of the Swabian Alb sponge biofacies to the south into dark bituminous marls and limestones of the so called Helvetic Facies (MEYER and SCHMIDT-KALER 1990), as well as in Central Poland, where sponge bioherms pass into black marls and clays of the surrounding basin (MATYJA and WIERZBOWSKI 1985; personal observation).

Although the sponge biofacies in the Swabian Alb spans nearly the entire Upper Jurassic, it is most widespread in Europe, from Portugal to Romania, during Oxfordian time (TRAMMER 1982; GAILLARD 1983), which is also a time of an important transgression. In this respect an interesting coincidence with the distribution of radiolarites occurs in the Tethys. They are widely known from various regions starting from the Middle Jurassic (similar to the sponge biofacies) and reached maximum development during Oxfordian time (BAUMGARTNER 1987; LEFELD 1988; DE WEVER 1989) when they spread widely in the Tethys (but such a spread is most probably a global feature). What is more, the disappearance of both facies is also more or less simultaneous in the Tethys. Because high radiolarian productivity is associated with high productivity (and thus high nutrient concentration), this may be also one of the reasons for rich siliceous sponge populations occurring along shallower (than radiolarites) and closer to the shore areas of the Tethys that were characterized by higher sedimentation rates. One of the mechanisms leading to such nutrient availability may have been broad equatorial convergence zones, as proposed by BAUMGARTNER (1987), or/and regionally widespread, but much weaker, upwellings along the shelves, as postulated by LEINFELDER (1993) or DE WEVER (1989). This last mechanism finds some confirmation in isotopic studies (PISERA *et al.* 1992). Still another possibility may be delivery of dissolved nutrients from former land areas newly covered by sea as result of transgression. Disappearance of the siliceous sponge facies in this area resulted, most probably, from regression during the Tithonian and changes in ocean circulation, which reduced upwellings (*cf.* DE WEVER 1989) and thus high productivity. Such a regression also cut off or reduced nutrient delivery from the land.

In concluding, the Upper Jurassic siliceous sponge biofacies appears not as an unusual feature resulting from operating of some non-actualistic factors, such as high silica concentration in sea water, but rather it was a product of coincidence of several common factors: (i) a high sea level making vast areas of relatively deep-water, (to which hexactinellid and lithistid sponges were and are adapted), available for colonisation by hexactinosan, lychniscosan and lithistid sponges, which were otherwise confined to deep and narrow areas on the outermost shelf and upper slope. Such a situation resulted also in very low sedimentation rates (as a result of distances from the shore and thus absence of clastic input, as well as starvation of the carbonate sedimentation) and occurrence of hard substrates which are prerequisite for sponge colonisation and development; (ii) high nutrient availability resulted from the oceanographic situation in the Tethys, which helped to sustain large sponge populations.

SYSTEMATIC DESCRIPTIONS

Class **Hexactinellida** SCHMIDT, 1870

Remarks. — Names commonly used in paleontological studies such as Triaxonia or Hyalospongea, cannot be regarded as valid synonyms of Hexactinellida, and should be abandoned (see REID 1963c; REISWIG and MACKIE 1983).

Subclass **Hexasterophora** SCHULZE, 1887

Order **Lyssacinosa** ZITTEL, 1877

Genus *Stauractinella* ZITTEL, 1877

Remarks. — This genus has been described from the Upper Jurassic, but HINDE (1883: pp. 149–150, pl. 31: 6) attributed here cylindrical sponges from the Upper Cretaceous of England displaying on their surface large (3 mm) loose hexactines and diactines. This finding needs verification. It is not clear if this genus belongs to Hexasterophora, or Amphidiscophora.

Stauractinella jurassica ZITTEL, 1877

(Pl. 14: 7)

1983. *Baccispongia cidariformis* QUENSTEDT; GAILLARD, p. 194, pl. 9: 4.
1989. *Stauractinella jurassica* ZITTEL; TRAMMER, p. 67, pl. 7: 4 (cum syn.).
1992. *Stauractinella jurassica* ZITTEL; MEHL, pp. 97–98, fig. 22.

Material. — One specimen.

Remarks. — The investigated specimen is identical with QUENSTEDT's originals except that the collar around osculum is not ?preserved. The size of hexactines are up to 15 mm.

Occurrence. — Oxfordian marls (Alfa): Plettenberg.

Genus *Polygonatium* SCHRAMMEN, 1937

Remarks. — Reinvestigation of SCHRAMMEN's original specimens revealed that the choanosomal skeleton consists not only of hexactines but also of rhabdodiactines. They are irregularly fused with the help of synapticulae often forming ladder-like structures (see Pl. 47: 1) typical of lyssacinosan sponges, and showing no dictyonal strands at all, and as such belong to the Lyssacinosa. Recently, RIGBY *et al.* (1993) attributed this genus to the Camerospongiidae SCHRAMMEN, 1912, which are lychniscosan sponges. This is clearly a mistake.

Polygonatium sphaeroides SCHRAMMEN, 1937

(Pl. 21: 7; Pl. 47: 1)

1937. *Polygonatium sphaeroides* sp. n.; SCHRAMMEN, p. 56, pl. 13: 6, 7.
non 1989. *Polygonatium sphaeroides* SCHRAMMEN; TRAMMER, p. 77, pl. 14: 1, 2.

Material. — Two poorly preserved specimens and SCHRAMMEN's originals, one in Tübingen and one in München.

Description. — Clumpy sponge about 55 mm high and 45 mm wide with 20 mm wide osculum located at the top. Surface covered with numerous rugosities several mm high and wide. Canal openings visible as irregularly distributed round to elongated holes 1.5 to 3.0 mm wide. Skeleton fused consists of hexactines and their derivatives (mostly diactines) with numerous synapticular bridges.

Remarks. — The specimens illustrated by TRAMMER (1989) display a hexactinosan type of the skeleton and as such cannot belong to this genus; most probably they represent a new genus; the same concerns specimens described by TRAMMER (1989: pl. 14: 3) as *Polygonatium* sp.

Occurrence. — Kimmeridgian marls (Gamma): Hochwang, Bärenthal.

Genus *Feifelia* SCHRAMMEN, 1937

Remarks. — This genus had been assigned by SCHRAMMEN (1937) to Hexactinosa. Reinvestigation of the original material in SEM (Pl. 47: 7) suggests that fusion of spicules is of irregular type closely resembling fusion in Lyssacinosa; following this observation the genus is included here in the Lyssacinosa.

Order **Hexactinosa** SCHRAMMEN, 1903

Remarks. — Only sponges with fused choanosomal skeleton composed of dictyonal strands are included here. Those having partly or entirely fused choanosomal skeletons of irregularly fused hexactines, or hexactines and their derivatives are included into Lyssacinosa.

Family **Euretidae** ZITTEL, 1877

Genus *Verrucocoelia* ETALLON, 1859

Remarks. — According to REID (1969) *Verrucocoelia* ETALLON cannot be distinguished morphologically from the Recent *Periphragella* MARSHALL. He recommended, however, in paleontology to retain the name *Verrucocoelia* for without a complete set of spicules in fossil forms the problem of identity of the genera cannot be satisfactory solved.

Verrucocoelia verrucosa (GOLDFUSS, 1829)
(Pl. 6: 2; Pl. 21: 1, 2, 5; Pl. 36: 4, 5)

1829. *Scyphia verrucosa nobis*; GOLDFUSS, p. 51, pl. 33: 8a–c.
1878. *Mastospongia verrucosa*; QUENSTEDT, p. 147, pl. 122: 3–5.
1878. *Mastospongia gregaria*; QUENSTEDT, pp. 148–150, pl. 122: 8–10.
1910. *Verrucocoelia verrucosa* GOLDFUSS; KOLB, p. 175.
1910. *Verrucocoelia gregaria* QUENSTEDT; KOLB, p. 175.
1989. *Verrucocoelia gregaria* (QUENSTEDT); TRAMMER, p. 76, pl. 14: 4.

Material. — Eight specimens.

Remarks. — Contrary to theoretical considerations concerning lists of synonyms by MEHL (1992: p. 15), she included into synonymy within this species (see MEHL 1992: p. 68) such forms as *Mastospongia coniformis* (QUENSTEDT 1878: pl. 122: 13). That sponge displays lychniscs, which are clearly illustrated by QUENSTEDT (a fact also recognized by ZITTEL 1878a and KOLB 1910), and the sponge represents a different genus with the name *Phlyctaenium* proposed by ZITTEL (1877). According to KOLB (1910), and my own investigations, another form described as *Scyphia verrucosa* (GOLDFUSS 1826: pl. 2: 11, not pl. 33: 8) was included in *Verrucocoelia* by MEHL (1992). It is in reality *Phlyctaenium coniforme* (QUENSTEDT). The only differences between *V. gregaria* (QUENSTEDT) and *V. verrucosa* (GOLDFUSS) are size and degree of narrowing of the openings of the tubular outgrowths; both these features show a continuous gradient, so I have synonymized the two species.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; crumpled marly limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Plettenberg; Kimmeridgian marls (Gamma): Bärenthal.

Verrucocoelia bipartita (QUENSTEDT, 1858)

1878. *Scyphia bipartita*; QUENSTEDT, p. 149, pl. 122: 11.
1910. *Verrucocoelia bipartita* QUENSTEDT; KOLB, p. 175 (cum syn.).

Material. — One specimen.

Remarks. — This species is very similar to *V. verrucosa* (GOLDFUSS), which often shows bifurcation of particular tubes, and perhaps represents only an early stage of development of the latter species. Small number of specimens does not allow for solution of this problem.

Occurrence. — Oxfordian marls (Alfa): Plettenberg.

Genus *Aulodomus* SCHRAMMEN, 1937

Remarks. — This genus is close to *Verrucocoelia* from which it differs in having solid wall composed of interwined tubes, while *Verrucocoelia* has long tubular outgrowths spreading from the main axis; both genera are very similar in skeletal structure. REID (1963b) regarded it as a junior synonym of Recent *Eurete* SEMPER, 1868 but gave no justification for such an opinion.

Aulodomous farreides (SCHRAMMEN, 1937)
(Pl. 33: 8)

1937. *Aulodomus farreides* n. sp.; SCHRAMMEN, p. 76, pl. 14: 4.

Material. — One specimen.

Remarks. — Thick walled sponges with walls composed of tubes 3–6 mm in diameter are included here. Wall thicknesses of these tubes are 1.2–2.0 mm. Tubes open on the surface with wide openings of that same diameter. The wall of the sponge reaches 1.5 mm in thickness. Skeleton regular with meshes 0.3 × 0.3 mm. This species is so similar to *Phlyctaenium coniforme* (QUENSTEDT) in general morphology that without study of spiculation they cannot be separated.

Occurrence. — Kimmeridgian limestones (Delta): Hochwang.

Family **Craticulariidae** RAUFF, 1893
emended REID 1964, emended MEHL 1992

Emended diagnosis. — Dictyonal framework euretoid showing primary canalization in the form of diplorhysis with epi- and aporhyses in quadrunx arrangement. Dermal skeleton if observed developed as pentactines with distal ray absent, often fused with the proximal one to the choanosomal skeleton and forming tangential veil.

Remarks. — This family is here understood as defined by REID (1963b, 1964), including the Recent species described as *Laocoetis perion* (LÉVI 1986). The reason for emendation is that REID (1964) included in the family Recent genus *Leptophragmella* REID, 1963, which in effect modified the diagnosis. That genus was found by MEHL (1992) to display diarhysis, and as such should be excluded from the family. MEHL (1992) following the old mistake by MORET (1924), considered this family as having a radially folded wall, which is a mistake, and she repeated also an erroneous name of the genus, *Laocaetis* instead of the original *Laocoetis* POMEL (see also below).

Genus *Laocoetis* POMEL, 1872

1872. *Laocoetis* POMEL.
1877. *Craticularia* ZITTEL.
1936. *Paracraticularia* SCHRAMMEN.
1955. *Thyridium* LAUBENFELS (= *Thyroidium* SCHRAMMEN, 1937).
1992. *Laocaetis* MEHL (nom. error.).

Remarks. — Oxfordian and Kimmeridgian specimens of this genus show no special attachment structures, even in the most well preserved specimens. On the other hand, numerous specimens from the coral facies (uppermost Kimmeridgian) are lobophytal. It seems that such a structure is related to the type of a substrate occupied and water energy. In coral facies one may expect common occurrences of hard bottoms, as well higher water energy than in clearly deeper environments where Oxfordian and Kimmeridgian marls and limestones have been deposited. It seems that in the latter case these sponges could live partly buried in the sediment, for they show no traces of larger attachment scars, as was postulated by TRAMMER (1982). This genus has been usually cited from the Upper Jurassic upward, but in fact undoubtful laocoetid species are known from the Bajocian of the Mečsek Mountains, (Hungary) (POČTA 1886) and most probably also Liassic of Georgia (NUTSUBIDZE 1965), but poor illustration in this latter case causes some uncertainties.

Laocoetis parallela (GOLDFUSS, 1826)
(Pl. 7: 1–3; Pl. 8: 4, 8; Pl. 34: 5, 6; Fig. 10)

1989. *Craticularia parallela* (GOLDFUSS); TRAMMER, pp. 67–68, pl. 8: 3 (cum syn.).
1992. *Craticularia parallela* (GOLDFUSS); MEHL, p. 73.

Material. — 53 specimens.

Remarks. — The holotype of the species *L. parallela* was subsequently designated by HINDE (1893) as GOLDFUSS' specimen (1826: pl. 3: 3), but SCHRAMMEN (1937) indicated QUENSTEDT specimens (1878:

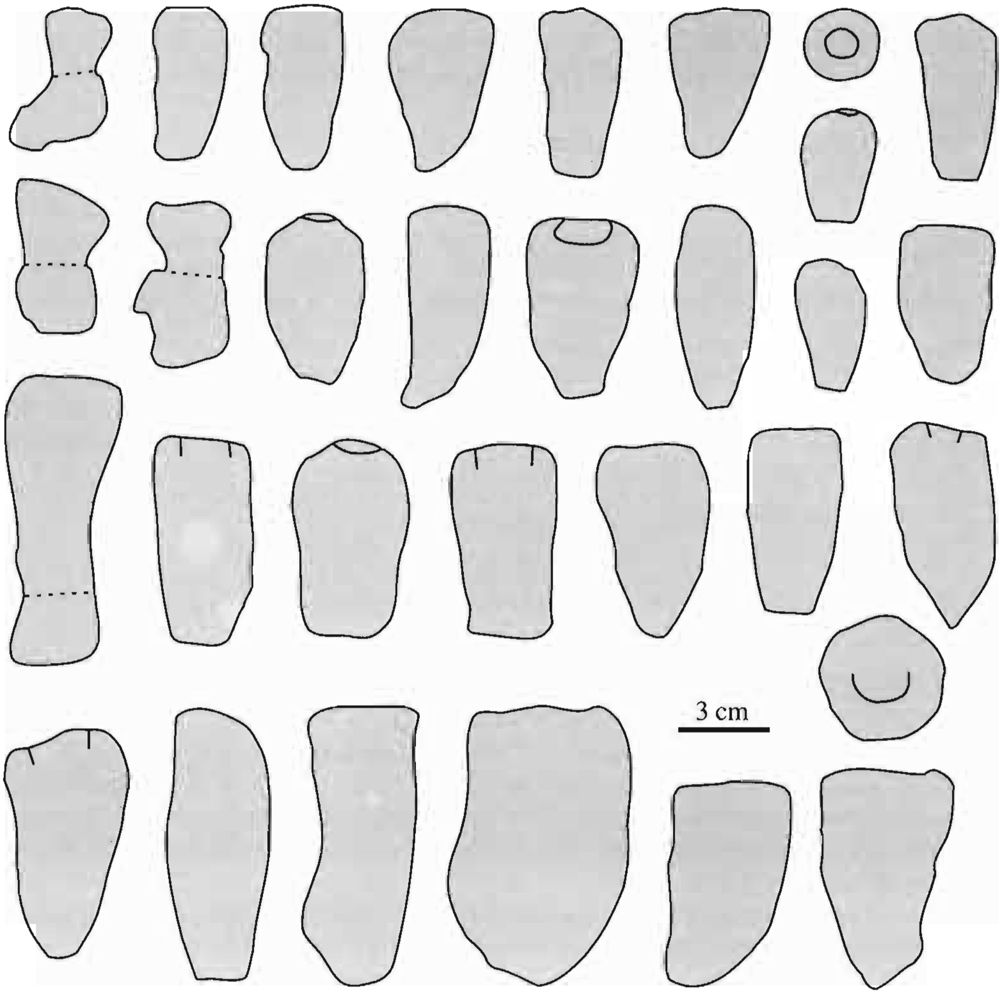


Fig. 10
Shape variability of *Laocoetis parallela* (GOLDFUSS).

pl. 116: 15, 19, 20). KOLB (1910) and others, synonymized among others, the GOLDFUSS species *Scyphia parallela,* with numerous forms described by QUENSTEDT (1878) as *Textispongia intertexta, T. clavitexta* and *T. coarctata* (QUENSTEDT 1878: pl. 116: 15, 19–22). Later on these were used as representing typical morphology of this species (see SCHRAMMEN 1937), despite the fact that they are very different from the holotype. Additionally KOLB (1910) included into synonymy also the forms which were described as *Scyphia procumbens* (GOLDFUSS), later assigned by SCHRAMMEN (1937) to his new genus *Paracraticularia.* KOLB also has included a specimen illustrated by QUENSTEDT (1878: pl. 117: 3) as *Scyphia Schweigerii,* both in synonymy of *Craticularia parallela* and *C. schweigerii* (see KOLB 1910) thus forming a total taxonomical confusion.

Reinvestigations of the original GOLDFUSS' specimen, housed in the Bonn University, shows that QUENSTEDT's forms are very different from the holotype (Pl. 8: 1) in terms of wall thickness and number of ostia per cm^2 (similarly as forms described by SCHRAMMEN (1937)), which are features differentiating species of the genus *Laocoetis* (see SCHRAMMEN 1937; ZIEGLER 1962). On the other hand, forms described as *L. procumbens* (GOLDFUSS) agree well with the holotype of the species *Laocoetis parallela.* This fits well with the opinion of ZIEGLER (1962). On the other hand, the species *L. parallela* and *L. procumbens* differ very slightly in number of ostia (25–30/cm^2 in *parallela* and about 36 in *procumbens*) and wall thickness leaving some doubts about their separation as different species – in fact MEHL (1992) synonymized both species. When well preserved, one may find that *L. parallela* is always narrow conical (while *L. procumbens* is rather tubular), and has a narrowed osculum with a rounded edge, sometimes supplied with a low narrow chimney (see QUENSTEDT 1878: pl. 116: 20). *L. procumbens* has an entirely open osculum without any additional structures. These differences resulted in the decision to keep them as separate species. In material that is incompletely preserved and calcified separating these two species is often impossible. In effect, in quantitative analysis both of these species are treated as one complex *L. parallela–L. procumbens.*

The studied well-preserved specimens that are undoubtedly *L. parallela* sensu SCHRAMMEN (1937) are conical in shape and show a high variability in this respect (Fig. 10). They have a very strong, smooth cortex pierced by 1.0 to 1.2 mm wide round canal openings, which are separated by skeletal bridges 0.8 to 1.2 mm wide. The dictyonal skeleton is very regular inside the wall, with rectangular meshes measuring from 0.25 × 0.18 up to 0.3 × 0.2 mm. On the dermal side occurs a thin veil of dermal skeleton composed of delicate pentactines fused into a regular net with square meshes measuring 0.20–0.25 mm in size.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian crumpled limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Plettenberg, Tieringen; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler; Kimmeridgian marly crumpled limestones (Delta): Hettingen; Kimmeridgian limestones (Delta): Blaubeuren; Kimmeridgian marls (Delta): Genkingen; Kimmeridgian limestones (Zeta): Blaustein.

Laocoetis procumbens (GOLDFUSS, 1826)
(Pl. 6: 4; Pl. 8: 7; Fig. 11)

1937. *Paracraticularia procumbens* GOLDFUSS; SCHRAMMEN, pp. 28–29 (cum syn.).

1989. *Paracraticularia procumbens* (GOLDFUSS); TRAMMER, p. 69, pl. 9: 5.

Material. — 14 specimens.

Remarks. — Holotype of this species, here reillustrated (Pl. 6: 4), is a very poorly preserved colonial sponge in the block of rock showing no details of surface (canal openings) or skeleton. As a result any comparisons must be made to the very well preserved QUENSTEDT material, as is the case with many other Upper Jurassic sponges described and illustrated originally by GOLDFUSS (1826–1833). The species differs from *L. parallela* in being tubular in shape (Fig. 11) and having canal openings of a different size. For more see remarks for *L. parallela.*

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler; Kimmeridgian limestones (Delta): Erkenbrechtsweiler; Kimmeridgian marls (Delta): Genkingen, Hochwang.

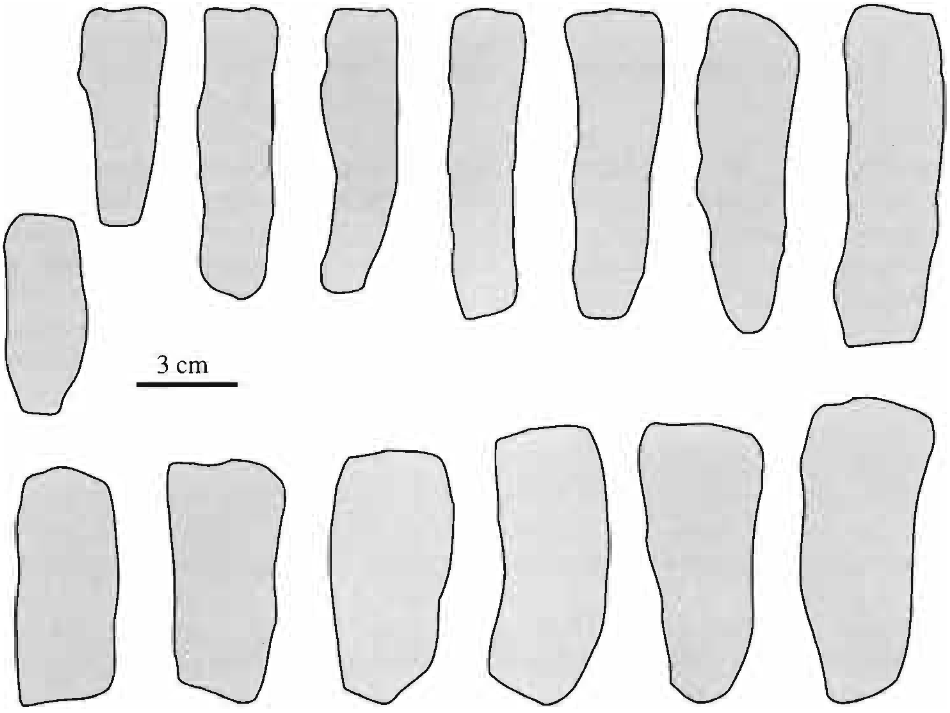


Fig. 11
Shape variability of *Laocoetis procumbens* (GOLDFUSS).

Laocoetis striatopunctata (SCHRAMMEN, 1937)
(Pl. 8: 5)

1937. *Paracraticularia striato-punctata* n. sp.; SCHRAMMEN, p. 30, pl. 13: 4.

Material. — Three calcified specimens.

Remarks. — My material agrees well with SCHRAMMEN's description and shows up to 100 "ostia" (canal openings)/cm^2; they are only 0.5 mm wide and separated with skeletal bands about 0.8 mm wide.

Occurrence. — Kimmeridgian marls (Gamma): Hochwang, Erkenbrechtsweiler.

Laocoetis paradoxa (MÜNSTER *in* GOLDFUSS, 1833)
(Pl. 6: 8; Pl. 7: 7; Pl. 34: 7–9; Fig. 12)

1989. *Craticularia paradoxa* (MÜNSTER *in* GOLDFUSS); TRAMMER, p. 68, pl. 8: 2, pl. 9: 4, pl. 18: 4, 5 (cum syn.).

Material. — Two specimens.

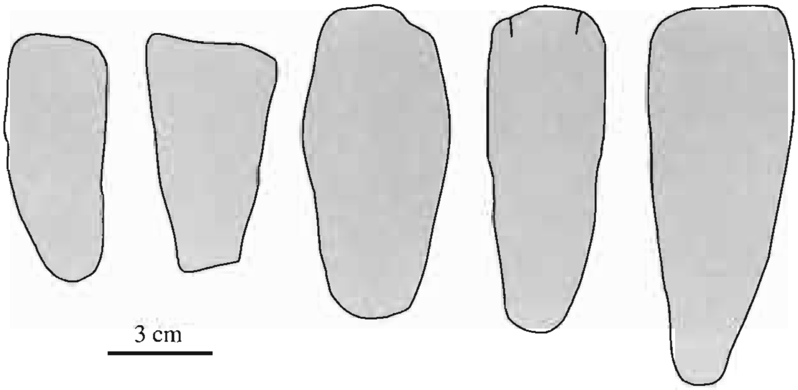


Fig. 12
Shape variability of *Laocoetis paradoxa* (MÜNSTER *in* GOLDFUSS).

Remarks. — I have only two rather poorly preserved specimen, but the size of canal openings as well as their number per square cm, agree well with SCHRAMMEN's (1937) definition of this species. On the other hand, there is a difference between my specimens (see Pl. 6: 8 which is the GOLDFUSS holotype of *L. paradoxa*) and QUENSTEDT's, and any specimens later described. It is a common problem encountered, *i.e.* discrepancy between GOLDFUSS holotypes (usually designated as holotypes much later and only on the base of his very inaccurate illustrations) and the present understanding of the species, which is usually based on QUENSTEDT's illustrations (which are usually rather accurate). The investigated museum collections of this species display low morphological variability (Fig. 12).

Occurrence. — Kimmeridgian limestones (Zeta): Asselfingen, Heuchstetten.

Laocoetis sp. n.
(Pl. 9: 1, 8)

Material. — Seven specimens with calcified skeleton.

Description. — The sponge is represented by large platy fragments which came from a widely conical or plate-like sponge and has walls up to 5 mm thick. One (most probably inner) side with large oval canal openings from 1.4 × 2.0 mm in size in a craticularid pattern. They are separated by very regular longitudinal skeletal bands (1.5 mm wide) giving an impression that they are organized in longitudinal rows. The other side (most probably outer) with smaller (1.0 to 1.2 mm wide) canal openings in less regular craticularid pattern, and more densely spaced. Dictyonal skeleton with cortex on the surface, with regular rectangular meshes measuring 0.2–0.3 × 0.4 mm. Dictyonal strands diverging toward both surfaces, transverse actines at the same level and arched toward the outer margin.

Remarks. — This species differs from *L. schweiggeri* in having much larger canal openings on the ?gastral side, that are also separated by wider skeletal bands. In size of "ostia" it resembles *L. paradoxa* which has, however, much thicker wall and more densely spaced canal openings, as well as usually narrow conical shapes.

Occurrence. — Oxfordian crumpled marly limestones (Alfa) and limestones (Beta): Bärenthal; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler.

Laocoetis clathrata (GOLDFUSS, 1826)
(Pl. 6: 5; Pl. 7: 8; Fig. 13)

1989. *Craticularia clathrata* (GOLDFUSS); TRAMMER, p. 68, pl. 8: 1, pl. 18: 6 (cum syn.).

Material. — Five specimens.

Remarks. — Meshes regular, as in other *Laocoetis* species, but measuring up to 0.3 × 0.4 mm. My specimens are from vase-shaped to nearly tubular and up to 14 cm high. Other features like size of "ostia" are identical to these in the holotype. The museum collections of this species reveal little shape variability (Fig. 13).

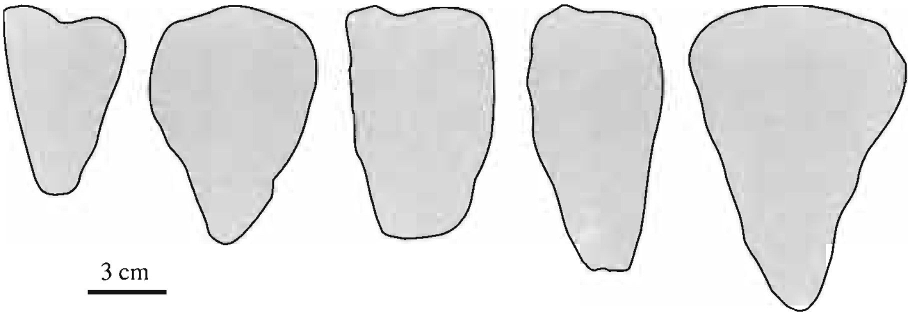


Fig. 13
Shape variability of *Laocoetis clathrata* (GOLDFUSS).

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal, Hochwang; Kimmeridgian limestones (Delta): Hochwang, Erkenbrechtsweiler; Kimmeridgian marls (Delta): Hochwang.

Laocoetis arborescens (SCHRAMMEN, 1937)
(Pl. 7: 4–6)

1937. *Craticularia arborescens* n. sp.; SCHRAMMEN, p. 29, pl. 1: 9, 10; pl. 3: 15–17; pl. 4: 2; pl. 13: 3.

Material. — Three specimens.

Remarks. — No specimens in groups have been found, but the number of canal openings (60 to 70/cm^2), thin wall and tubular forms agree well with SCHRAMMEN's description. Skeletal meshes are very regular, rectangular, and measuring 0.25 × 0.20 mm; dictyonal strands bend toward the dermal surface.

Occurrence. — Oxfordian limestones (Beta): Bärenthal, Plettenberg; Kimmeridgian marls (Gamma): Bärenthal.

Laocoetis tubifera (SCHRAMMEN, 1937)
(Pl. 8: 2, 3)

1937. *Paracraticularia tubifera* n. sp.; SCHRAMMEN, p. 30, pl. 1: 8, pl. 3: 3, pl. 15: 3.
1987. *Craticularia paradoxa* (GOLDFUSS); MEYER *et al*., pl. 3: 12, 13.
?1989. *Paracraticularia tubifera* SCHRAMMEN; TRAMMER, p. 69, pl. 9: 7.

Material. — Three specimens with very well-preserved spiculation.

Remarks. — This small laocoetid sponge differs from other species by having very narrow skeletal bridges between canal openings on the dermal surface of the dictyonal skeleton; in effect dermal surfaces show even more regular patterns than in other laocoetid species which have these openings separated by wider skeletal bands. Canal openings are 0.5 to 0.6 mm wide, while skeletal band between them are only 0.4 to 0.5 mm wide. Meshes of the dictyonal skeleton are very regular and measure 0.2 × 0.3 mm, dictyonal strands bend toward the outer surface.

Occurrence. — Kimmeridgian marls (Gamma): Erkenbrechtsweiler and (Delta): Hochwang.

Laocoetis schweiggeri (Goldfuss, 1833)
(Pl. 6: 1, 6, 7; Pl. 8: 9; Pl. 9: 4, 7; Pl. 13: 8)

1937. *Thyridium Schweiggeri* Goldfuss; Schrammen, p. 31, pl. 9: 4, pl. 21: 1 (cum syn.).
1937. *Thyridium leptophyllum* Quenstedt; Schrammen, p. 32 (cum syn.).
1962. *Thyroidium* cf. *schweiggeri* (Goldfuss); Lagneau-Hérenger, pp. 53–54.
1982. *Thyroidium schweiggeri* (Goldfuss); Trammer, pp. 30–31, pl. 11: 10 (cum syn.)
1989. *Thyroidium schweiggeri* (Goldfuss); Trammer, p. 69, pl. 10: 3, 4 (cum syn.).

Diagnosis. — Large, broadly conical to widely tubular laocoetid with relatively thin walls from 0.5 to 0.7 cm thick. Organization of canal openings very similar on both sides, canals measure from 0.6 to 1.0 mm in diameters. Dictyonal skeleton very regular inside the wall, but irregular and with cortex on the surface.

Material. — 30 specimens.

Description. — This species is usually preserved as large plate-like fragments which belong to a broadly conical or tubular (with large diameter) sponge having relatively thin (if compared to diameter) wall which is usually only 0.5–0.7 mm thick. Canal openings on both sides are organized in a very regular craticularid pattern, and measure on dermal side between 0.6 and 1.0 mm; they are slightly smaller on gastral side where they measure 0.6 to 0.8 mm in diameter. Dictyonal skeleton very regular inside the wall, irregular and with cortex at the surface. Dictyonal strands diverge toward both surfaces, transverse actines at the same level form transverse "strands" which are arched toward the outer margin. Skeletal meshes from 0.2 × 0.3 to 0.4 × 0.6 mm.

Remarks. — There is no difference between *Thyroidium schweiggeri* and *T. leptophyllum* as differentiated by Schrammen (1937). Characters on which they were based, *i.e.* wall thickness and "ostia" size, show a continuous gradation not allowing for delimitation of these two species; "endless" variation has been also noted by Kolb (1910). The problem is even more complicated by the fact that numerous specimens described by various authors as *T. schweiggeri*, if treated in Schrammen's terms (*i.e.* ostia size), are in fact *T. leptophyllum*. As a result both of these species are here considered as synonymous.

Occurrence. — Oxfordian crumpled marly limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Bärenthal, Plettenberg, Tieringen; Kimmeridgian marls (Gamma): Bärenthal; Kimmeridgian crumpled marly limestones (Delta): Hettingen; Kimmeridgian limestones (Delta): Erkenbrechtsweiler, Hochwang; Kimmeridgian marls (Delta): Genkingen; Kimmeridgian limestones (Zeta): Gerstetten, Asselfingen.

Laocoetis lineata (Schrammen, 1937)
(Pl. 9: 3, 5, 6, Pl. 36: 7, 8)

1989. *Thyroidium lineatum* (Schrammen); Trammer, pp. 69–70, pl. 10: 1, 2, 5 (cum syn.).

Material. — 20 specimens.

Diagnosis. — Craticularid sponges with shapes ranging from very wide conical to nearly tubular, and having thin walls. On the inner (gastral) side are low and rounded longitudinal skeletal ridges; outer (dermal) side supplied with thin veil of dermal stauractines fused into regular square net. Dictyonal strands bend toward the gastral side.

Description. — The preserved studied material is fragmentary, but without doubt comes from tubular and conical sponges with thin wall not exceeding 4–5 mm in thickness. Dermal surface of the dictyonal skeleton is pierced by rounded canal openings, measuring in various specimens from 0.4 to 0.9 mm in diameter organized in a typical craticularid pattern; cortex well developed. Above the cortex and canal openings a veil of stauractines occurs, which are fused into regular net with square meshes measuring 0.3 × 0.3 mm. Gastral surface of dictyonal skeleton with well developed cortex and organized into low, rounded skeletal ridges about 0.8 to 1.0 mm wide, and separated by furrows 0.6 to 0.1 mm wide in which oval (0.4 to 0.8 mm wide and 0.8 to 1.2 mm long) canal openings are situated in a craticularid pattern.

Dictyonal strands diverging toward gastral side, transverse rays located at the same level forming transverse "strands" arched in the growth direction; skeletal meshes of varying size, usually rectangular in longitudinal section and measure from 0.16 × 0.20 mm up to 0.2 × 0.4 mm.

Remarks. — One of the characters used by Schrammen (1937) to differentiate various species of his genus *Thyridium*, is the size of "ostia" (= canal openings); unfortunately this may vary with wide limits, and specimens displaying longitudinal ridges on the gastral side typical of *L. lineata* may have "ostia" size falling into the range of *L. schweiggeri*. Thus delimitation of the discussed species on the size of "ostia" alone is doubtful.

Occurrence. — Oxfordian marly crumpled limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Plettenberg; Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Erkenbechtsweiler, Wilmandingen; Kimmeridgian marly crumpled limestones (Delta): Hettingen; Kimmeridgian marls (Delta): Hochwang.

Genus *Pachyascus* SCHRAMMEN, 1937

Remarks. — This genus differs from *Laocoetis* (= *Craticularia*) only in having irregular canal openings instead of rounded to rectangular ones and most probably it should be synonymized with *Laocoetis* (*cf.* REID 1963b) but my material is too limited and too poorly preserved to solve the problem.

Pachyascus formosus SCHRAMMEN, 1937
(Pl. 34: 4)

1937. *Pachyascus formosus* n. sp.; SCHRAMMEN, p. 35, pl. 3: 6, pl. 5: 1, 10, pl. 9: 2, 3, pl. 11: 2, pl. 14: 2–5.

Material. — Four entirely calcified specimens.

Remarks. — My specimens generally well agree with SCHRAMMEN's specimens; they have canal openings 0.8–1.2 mm wide on the dermal surface and meshes of the dictyonal skelton (inside the wall) 0.20–0.25 × 0.25–0.30 mm in size and less regular (Pl. 34: 4) than in *L. parallela*. Dictyonal strands are parallel to the gastral surface through most of the wall and strongly bend toward the dermal surface in the outer part.

Occurrence. — Kimmeridgian marls (Gamma): Hochwang, Bärenthal.

Genus *Pycnocalyptra* SCHRAMMEN, 1937
Pycnocalyptra sp.

Material. — Two poorly preserved fragments.

Remarks. — Character of canal openings, dense cortex and skeleton pattern point to *Pycnocalyptra* as described by SCHRAMMEN (1937); both my specimens are, however, too poorly preserved for any more precise attribution.

Occurrence. — Limestones of the Kimmeridgian (Delta): Hochwang; limestones of the Kimmeridgian (Zeta): Blaustein.

Genus *Sphenaulax* ZITTEL, 1877
Sphenaulax costata (GOLDFUSS, 1826)
(Pl. 10: 1, 2, 7–9; Pl. 35: 3–5; Fig. 14)

1915. *Sphenaulax costata* GOLDFUSS; OPPLIGER, p. 28.
1992. *Sphenaulax costata* (GOLDFUSS); MEHL, pp. 81–82, pl. 14: 1, 2 (cum syn.).

Material. — 14 specimens, some with siliceous spicules preserved.

Description. — Narrow to widely conical sponges (Fig. 14) with walls up to 1 cm thick, bearing wide (up to 3.2 mm) skeletal ridges separated by more narrow (up to 2 mm wide), deep (up to 3.5 mm) furrows in which canal openings are situated in a regular craticularid pattern. These openings are rounded to oval and measure up to 2.5 mm in length and 1 mm in width. Inner surface displays similar structure but with more narrow ridges and furrows. Dermal skeleton well developed and composed of a veil of pentactines and stauractines (there is continuous range between these two types of spicules). Those spicules which are close to ridges are pentactines, and those in the middle of furrows and above ridges are stauractines attached directly to the ?synapticular bridges extending over furrows and attached to the sides of skeletal bridges. Dermal spicules are organized in square meshes which have various orientation, and measure 0.4 × 0.4 mm on average. A similar veil occurs on the gastral surface but meshes have various shapes and size. Cortex medium developed on dermal side. Dictyonal skeleton very regular with meshes 0.3 × 0.4 mm and strands bend toward the dermal surface.

Remarks. — This species shows great morphological variability from narrow to wide cones (see Fig. 14) and accordingly varies also in wall thickness. It differs from *Sphenaulax progenis* SCHRAMMEN in having a less developed cortex, more narrow and less regularly developed skeletal ridges and furrows and less sculptured dermal spicules.

Occurrence. — Oxfordian limestones (Beta): Plettenberg; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler, Hochwang, Wilmandingen; Kimmeridgian crumpled marly limestones (Delta): Het-

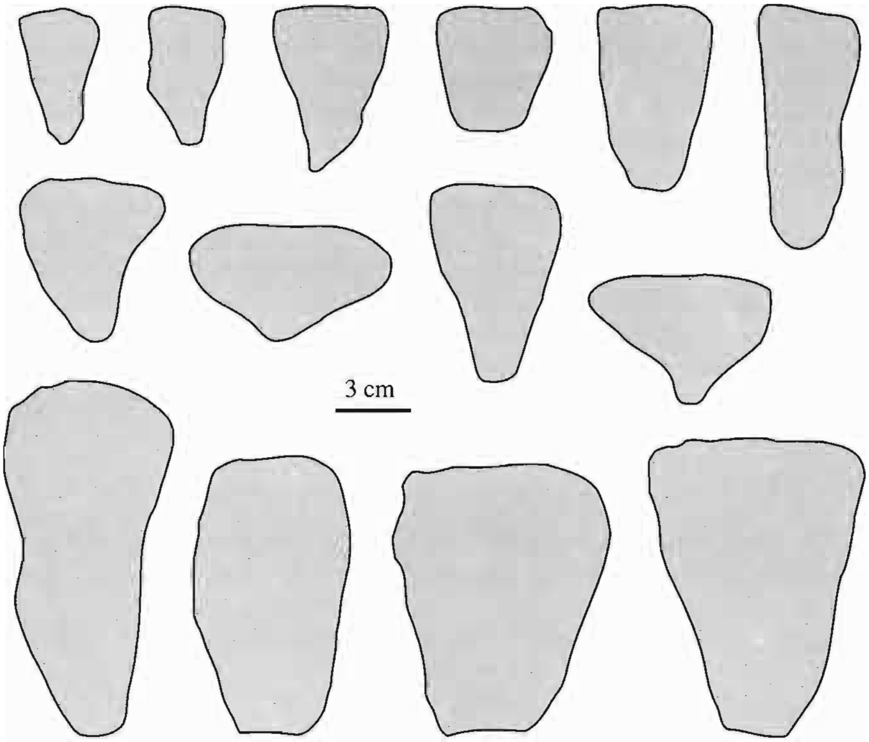


Fig. 14
Shape variability of *Sphenaulax costata* (GOLDFUSS).

tingen; Kimmeridgian limestones (Delta): Hochwang, Erkenbrechtsweiler; Kimmeridgian marls (Delta): Genkingen.

Sphenaulax progenis SCHRAMMEN, 1937
(Pl. 10: 4; Pl. 35: 1, 2)

1937. *Sphenaulax progenis* n. sp.; SCHRAMMEN, p. 45, pl. 27: 2.

Material. — One specimen from SMNS and the holotype have been investigated.

Remarks. — This rare species differs from *S. costata* (GOLDFUSS) in having wider and more regular skeletal ridges, better developed cortex and dermal spicules sculptured with numerous tubercles on the surface and numerous synapticular spines.

Occurrence. — The illustrated specimen from SMNS has no locality or age indicated, SCHRAMMEN's (1937) holotype is from the Kimmeridgian limestones (Epsilon) from Sinabronn.

Sphenaulax irregularis sp. n.
(Pl. 10: 5, 6; Pl. 38: 4, 5)

?1893. *Craticularia clathrata* GOLDFUSS; HINDE, pp. 198–199, pl. 11: 5.

Holotype: Pl. 10: 5, specimen ZPAL Pf.VIII/205.

Type horizon: Kimmeridgian limestones (Delta), Upper Jurassic.

Type locality: Erkenbrechtsweiler, Swabia, Germany.

Derivation of the name: From Latin *irregularis* – irregular, referring to irregularity of skeletal ridges on the surface.

Material. — Three specimens with preserved siliceous skeleton.

Diagnosis. — *Sphenaulax* with very irregular (not continuous) skeletal ridges composed of shorter elements which are convex in cross section, and with a heavy cortex of dictyonal skeleton.

Description. — Tubular to narrow conical sponge up to 10 cm high (I have only fragments) with walls about 1 cm thick and with 2.5–3.0 cm wide paragaster. Entire outer surface of dictyonal skeleton sculptured with very irregular vertical, rounded skeletal ridges which are several mm high. They are not continuous but broken by passes and thus composed of shorter segments; these ridges may branch or join each other.

At the top of these ridges are located small and randomly distributed (about 0.5 mm in diameter) rounded openings leading to much larger canals which run from the opposite surface and end below the ridges. The ridges are 2–3 mm wide and separated by furrows 1–2 mm wide in which canal openings are situated. Canal openings elongated up to 3.2 mm long and 1.6–2.0 mm wide. Dermal surface of dictyonal skeleton with very heavy cortex. Dictyonal skeleton regular inside the wall with meshes up to 0.3 × 0.4 mm. Canalization in irregularly craticularid pattern.

Remarks. — This species most closely resembles *S. costata* (GOLDFUSS), from which it differs in having much more irregular skeletal ridges (convex in cross section) that are not continuous, and in having a very heavy cortex. HINDE (1893) illustrated a sponge from the Middle Jurassic of Great Britain, under the name *Craticularia clathrata* GOLDFUSS, a sponge which closely resembles *Sphenaulax irregularis* sp. n. as here described (and which definitely cannot be attributed to *L. clathrata*), but nothing about the details of spiculation is known, thus there is uncertainity in attribution.

Occurrence. — Kimmeridgian marls (Gamma): Erkenbrechtsweiler; Kimmeridgian marls (Delta): Hochwang; Kimmeridgian limestones (Delta): Erkenbrechtsweiler.

Genus *Leptolacis* SCHRAMMEN, 1937

Remarks. — This genus has been established on material from the Upper Jurassic (Kimmeridgian), but recently range of the genus has been extended to the Upper Bajocian (see FRANZ and MÜLLER 1988).

Leptolacis striata SCHRAMMEN, 1937
(Pl. 38: 1–3)

1937. *Leptolacis striata* n. sp.; SCHRAMMEN, p. 61, pl. 3: 11.
1988. *Leptolacis* aff. *striata* SCHRAMMEN; FRANZ and MÜLLER, pp. 220–224, pl. 2: 3, 4; pl. 3: 1–3.

Material. — Two specimens in author's collection, and SCHRAMMEN's (1937) holotype (Tübingen).

Description. — Thin walled plates only 2–3 mm thick. Outer(?) surface covered with low longitudinal skeletal ridges about 1 to 2 mm wide, separated with narrow, 1 mm wide, furrows in which oval canal openings, 1 × 2 mm in diameter, are located in a quadrangular organization. These furrows are often covered with skeletal bridges originating from the cortex. On the other (inner?) surface openings are round and average 1.0 to 1.2 mm in diameter, and irregularly distributed. Cortex developed on both sides, but not very thick. Skeleton regular inside the wall with meshes 0.20–0.24 × 0.30 mm in size.

Remarks. — This species is close to *Laocoetis lineata* (SCHRAMMEN) in morphology, the main difference being in organization of canal openings which are in a laocoetid pattern on both sides in *Laocoetis lineata*, while in *Leptolacis striata* they are irregularly distributed on the inner side. *L. striata* also has a thinner wall and less well developed cortex. The specimens illustrated by FRANZ and MÜLLER (1988: pl. 3: 4, 5) as *Leptolacis* cf. *striata* from the Kimmeridgian of the Swabian Alb, belong rather to *Laocoetis lineata* (SCHRAMMEN).

Occurrence. — My specimens come from the limestones of the Kimmeridgian (Zeta) in Asselfingen and Kimmeridgian marls (Gamma) from Bärenthal.

Family **Cribrospongiidae** ROEMER, 1864

Genus *Cribrospongia* D'ORBIGNY, 1849 (= *Tremadictyon* ZITTEL, 1877)

Remarks. — The nomenclatorical problems concerning this genus have been explained by REID (1963b) and more recently by SALOMON (1990) and MEHL (1992). There is, however, another serious problem concerning the genus; *Scyphia reticulata* GOLDFUSS was selected subsequently by HINDE (1893) as the type species, and with a lectotype designated later by SCHRAMMEN (1936), the specimen illustrated by GOLDFUSS (1826: pl. 4: 1c – other pictures of fig. 1 on this plate represent different specimens). That is how the situation has been recently explained by SALOMON (1990) in her revision of the genus *Cribrospongia* (= *Tremadictyon*). My own investigations of GOLDFUSS' originals revealed that his drawing is extremely schematic and differs strongly from the original specimen; actually the upper (inner) surface is not visible, while on the figure it is clearly marked as identical with the lower surface. Furthermore, the general shape, architecture of choanosomal skeleton, the thick (up to 1.5 cm) wall, as well as the presence of cavaedia on the upper surface (visible on the cross section of the specimen) clearly indicate that this particular specimen corresponds to the species *Stauroderma lochensis* (QUENSTEDT). This situation, when a type species is a hybrid one, explains the common difficulties in determination of the species *Tremadictyon reticulatum*; perhaps it is why it is one of the most commonly cited hexactinellid species in the whole Mesozoic. This genus badly needs revision based on well preserved specimens displaying spiculation to give sound diagnoses of particular species; I was able to do this only in one case, i.e. *T. cucullatum* (QUENSTEDT).

Contrary to MEHL's (1992) diagnosis, root clods are not characteristic features of this genus but may be present, however, in some situations; most of the investigated specimens had no specialized attachement structures.

Cribrospongia reticulata (GOLDFUSS, 1826)
(Pl. 3: 1–3, 6; Pl. 13: 5, 6; Pl. 33: 6, 7; Fig. 15)

1826. *Scyphia neesi* nobis; GOLDFUSS, p. 93, pl. 34: 2.
1937. *Tremadictyon reticulatum* GOLDFUSS; SCHRAMMEN, p. 23.
non 1982. *Tremadictyon reticulatum* (GOLDFUSS); TRAMMER, pl. 11: 5, pl. 12: 7.
1989. *Tremadictyon reticulatum* (GOLDFUSS); TRAMMER, pp. 70–71, pl. 11, pl. 14: 5–7.
1990. *Cribrospongia reticulata*; SALOMON, pp. 35–41, pl. 1.
1991. *Tremadictyon radicatum* (QUENSTEDT); MÜLLER, pp. 36–39, figs 1, 2, 3a, b, 4 (cum syn.).
1992. *Cribrospongia reticulata* (GOLDFUSS); MEHL, pp. 82–83, pl. 14: 5, 6.

Material. — 78 specimens.

Remarks. — For the discussion of the specimen usually indicated as a holotype see remarks to the genus. This species, being among the most commonly cited in the Upper Jurassic sponges in Europe is very poorly defined, and has many characters in common with *Stauroderma lochense* (QUENSTEDT) (see below). In effect, it has been often mistaken with the latter species. On the other hand, narrow conical forms resemble *Walcotella pertusa* (GOLDFUSS), and young forms may be easily mistaken. I am including into this species forms which have narrow to wide conical or tubular shapes only (Fig. 15), thus this species is treated in a similar way as was done by SCHRAMMEN (1937). Those which are triangular-compressed, and earlier synonymized as *Scyphia polyommata* GOLDFUSS and *S. reticulata* GOLDFUSS, but recently included by MEHL (1992) in *Cribrospongia reticulata*, are excluded and attributed to *C. cuccullata* (QUENSTEDT, 1878). The specimen illustrated by GOLDFUSS (1826: pl. 34: 2), and reillustrated here on Pl. 13: 6, under the name *S. neesi* nobis, is identical with *C. reticulata* as here understood. On the other hand, there are no difference between *C. reticulata* and *C. radicata* (QUENSTEDT), beyond preservation state (usually silicified) and the fact that *C. radicata* has root clods, the fact noted also by MÜLLER (1991). As a result the species are here synonymized.

My specimens have walls up to 1.5 cm thick, with canal openings up to 3–4 mm long, that are often rounded in the lower portion of the sponge and elongated in the upper portion, and are separated by skeletal bands 1.0–1.2 mm wide. Both sides with well developed and rather smooth cortex. Dictyonal skeleton irregular, with canal surfaces having strongly narrowed meshes, normal meshes up to 0.6 × 0.4 mm, usually only 0.3 × 0.4 mm.

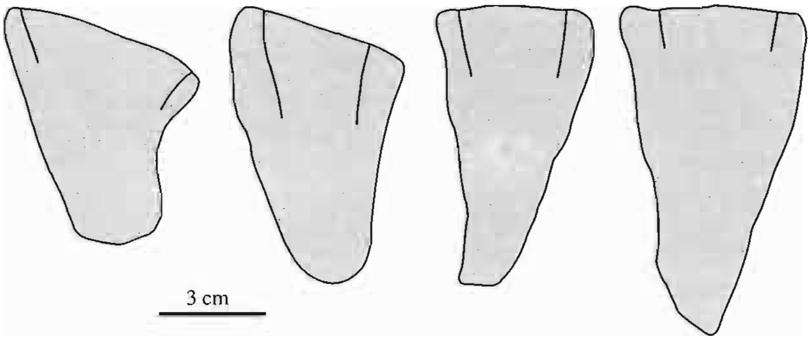


Fig. 15
Shape variability of *Cribrospongia reticulata* (GOLDFUSS).

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian crumpled marly limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Plettenberg, Bärenthal, Beuron; Kimmeridgian marls (Gamma): Bärenthal, Hochwang; Kimmeridgian marls (Delta): Hochwang; Kimmeridgian limestones (Delta): Hochwang.

Cribrospongia? *tesselata* (Quenstedt, 1878)
(Pl. 2: 1, 2; Pl. 11: 9)

1878. *Retispongia tesselata*; Quenstedt, p. 48, pl. 116: 7.
non 1878. *Retispongia crateriformis* Quenstedt, p. 50, pl. 116: 1.
1907. *Tremadictyon crateriformis* Etallon; Oppliger, pp. 5–6, pl. 2: 2.
1991. *Tremadictyon* sp.; Pisera, fig. 8A.

Material. — 44 specimens, all calcified.

Diagnosis. — Plate-like, medium sized sponge with characteristic rhombohedral lumps sculpturing the surface that are organized in a regular alternating pattern on the inner side, and oval canal openings in vertical rows and alternating on the lower (outer) side.

Description. — Plate-like to shallow vase-shaped sponges with walls 0.5 to 1.0 cm thick and reaching the size of several cm (according to Oppliger (1907) 30 cm, I have only fragments). Inner (upper) side covered with very characteristic rhombohedral low lumps clearly alternating and measuring in size up to 3 × 5 mm (but there is a strong variation of size in various specimens and regions of the same specimen). Lumps are separated by furrows 0.8–1.2 mm wide and about 1 mm deep. These lumps are formed over canal openings which are located at the top of low skeletal chimneys; the openings are not free but overgrown entirely with a one-layer veil of secondary skeleton. On the outer (lower) side, canal openings are oval and not elevated. They measure 2 × 1 mm across and are separated by skeletal bands 1.2 mm wide and are arranged in very regular vertical rows in alternating position. Meshes of the dictyonal skeleton, which are not very regular, measure up to 0.4 mm across.

Remarks. — In Oppliger's (1907) synonymy, Etallon (1860) and Fromental (1859) are indicated as authors of this species; in fact both papers contain neither description, nor illustration, or even reference to such name as *crateriformis*. On the other hand, Oppliger's (1907) material is identical with the sponge described as *R. tesselata* by Quenstedt (1878) and, in effect, Oppliger's species must be considered as a younger synonym. Assignment of this species to the genus *Cribrospongia* (= *Tremadictyon*) may be questioned for it has canal openings at the top of the low chimneys and, as well, they are entirely covered by the veil of secondary skeleton. In the genus *Cribrospongia* such openings may be covered by a veil of stauractines instead, which are rather of dermal origin. Better preserved material is needed to solve this problem. It is not a rare species in Germany, but has not been widely reported because it was earlier included into *C. reticulata,* and is very common in Spain (Pisera 1991, and unpublished).

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian crumpled marly limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Beuron; Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Erkenbrechtsweiler.

Cribrospongia? *rugata* (Quenstedt, 1878)
(Pl. 1: 4, 5)

1878. *Retispongia rugata*; Quenstedt, pp. 46–47, pl. 116: 2–4.
1989. *Tremadictyon rugatum* (Quenstedt); Trammer, p. 71, pl. 12: 8 (cum syn.).

Diagnosis. — Very large, up to 1 m in diameter, shallow vase-like sponges with walls covered by concentric folds. Canal openings on the outer side in a regular alternating pattern and protruding over the surface (coverd with skeletal veil?).

Material. — Two calcified specimens.

Description. — Very large sponges reaching to 1 m in diameter with walls 1.5 cm thick, folded into horizontal, concentric folds. Outer (lower) side covered with rhombohedral lumps, up to 4 mm in height and 2–3 mm wide, separated by furrows about 1 mm wide, with rounded upper surface, and organized in regular alternating rows. These lumps are, in fact, elevated canal openings which are most probably covered with skeletal veils [as is the case with similar lumps in *C.*? *tesselata* (Quenstedt)], but not visible in poorly preserved calcified material.

Inner side (not visible in my material, but illustrated by Quenstedt) shows a clear striation. Dictyonal skeleton very irregular with meshes up to 0.4 mm in size.

Remarks. — This species resembles *C.*? *tesselata* (Quenstedt) in protruding areas where canal openings are located; it differs by its very large size, folded wall and convex character of the surface of these protrudings, which is flat in *C.*? *tesselata*. One cannot exclude, however, that they are simply extremely large specimens of *C.*? *tesselata* (Quenstedt). To solve the problem material with well preserved skeletons of both species is needed, but all my specimens are calcitized. For the discussion of generic assignment see remarks to *C.*? *tesselata*.

Occurrence. — Oxfordian marls (Alfa) and limestones (Beta): Plettenberg.

Cribrospongia elegans (SCHRAMMEN, 1937)
(Pl. 2: 3, 5)

1937. *Tremadictyon elegans* n. sp.; SCHRAMMEN, p. 25: pl. 7: 1, 2.
1987. *Tremadictyon elegans* SCHRAMMEN; MEYER *et al.*, p. 68, pl. 5: 2.

Material. — 67 calcified specimens.

Diagnosis. — Plate-like *Cribrospongia* with thin wall and small, rounded canal openings organized in a regular alternating pattern on the lower side and a less regular one on the upper side.

Description. — This is a plate-like sponge reaching 30 cm in diameter and having rather thin walls 5–8 mm thick. Both sides of the dictyonal skeleton with medium developed cortex; upper side supplied with dermal skeleton of ?pentactines. Canal openings on the lower side 1.6 to 2.0 mm long and 1.2–1.6 mm wide separated by skeletal bands 0.8–1.0 mm wide and in regular alternating pattern. Canal openings on the inner (upper) side slightly smaller, irregularly rounded and measure about 1.2 mm in diameter, distributed in irregular alternating pattern. Meshes of the medium regular dictyonal skeleton from 0.25 × 0.30 mm up to 0.3 × 0.4 mm.

Remarks. — In my material I have fragments which come from specimens about 30 cm in diameter, *i.e.* twice as large as reported by SCHRAMMEN (1937). The rest of characters are identical with the holotype.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian crumpled marly limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Plettenberg, Bärenthal; Kimmeridgian marls (Gamma): Bärenthal, Hochwang; Kimmeridgian marls (Delta): Hochwang.

Cribrospongia cucullata (QUENSTEDT, 1878)
(Pl. 1: 2, 3; Pl. 2: 4; Pl. 33: 1–5; Figs 16, 17)

1826. *Scyphia polyommata*; GOLDFUSS, p. 8, pl. 2: 16.
1878. *Scyphia reticulata cucullata*; QUENSTEDT, pp. 36–38, pl. 115: 9, 10, 22.
1937. *Tremadictyon cucullatum* QUENSTEDT; SCHRAMMEN, p. 24, pl. 6: 4.

Material. — Twelve specimens some with well-preserved siliceous spicules.

Diagnosis. — Triangular in shape, compressed *Cribrospongia*, with fissure-like paragastral cavity; on the gastral side canal openings covered with delicate cupolas composed of fused stauractines attached to the dictyonal skeleton. Dermal side and upper edge covered with a dermal skeleton composed of irregularly arranged stout pentactines.

Description. — This medium-sized, up to about 15 cm high, sponge is triangular in shape and compressed, with a very narrow, fissure-like paragaster (Fig. 16). Walls up to 8 mm thick, show diplorhysal canalization with a typical cribrospongid pattern. Canal openings on both sides arranged in an alternating pattern and range from rounded to oval or irregular in shape. On the dermal side they measure 2.0 × 1.5 mm. The entire dermal side and upper edge are covered by dermal skeleton composed of stout pentactines (Fig. 17b) with thick unpaired rays attached to the dictyonal skeleton, and fused into the irregular net with the help of synapticulae on the upper edge, and into the regular net with more or less square meshes on the dermal side. These pentactines measure 0.6 mm in size. On the gastral side, canal openings are slightly larger and measure up to 2.8 × 3.6 mm, but usually 2.8 × 2.0 mm, and above them are delicate cupolas of the skeleton composed of delicate fused stauractines (Fig. 17a) attached to the skeletal bands of dictyonal skeleton between them. These stauractines form a regular net with square meshes measuring 0.20 to 0.25 mm in size. On both sides the dictyonal skeleton is supplied with a very strong cortex, which has a very rough surface as a result of numerous high and irregular outgrowths. Canal surfaces show plate-like thickening of hexactine rays and strong narrowing of meshes. Skeleton is rather irregular with meshes about 0.3 mm in size.

Remarks. — Many authors attributed specimens of this species to *C. reticulata* (GOLDFUSS), considering its flat shape as probable effect of compaction. Clear differences in the dermal skeleton, and persistence of flat specimens in layer which have other sponges otherwise preserved and not compressed, indicate that this shape is the primary one, and we deal with it as a separate species. Dermal spiculation as here described has been earlier reported by KOLB (1910: pl. 11: 3, 5, 6) from *Tremadictyon reticulatum*

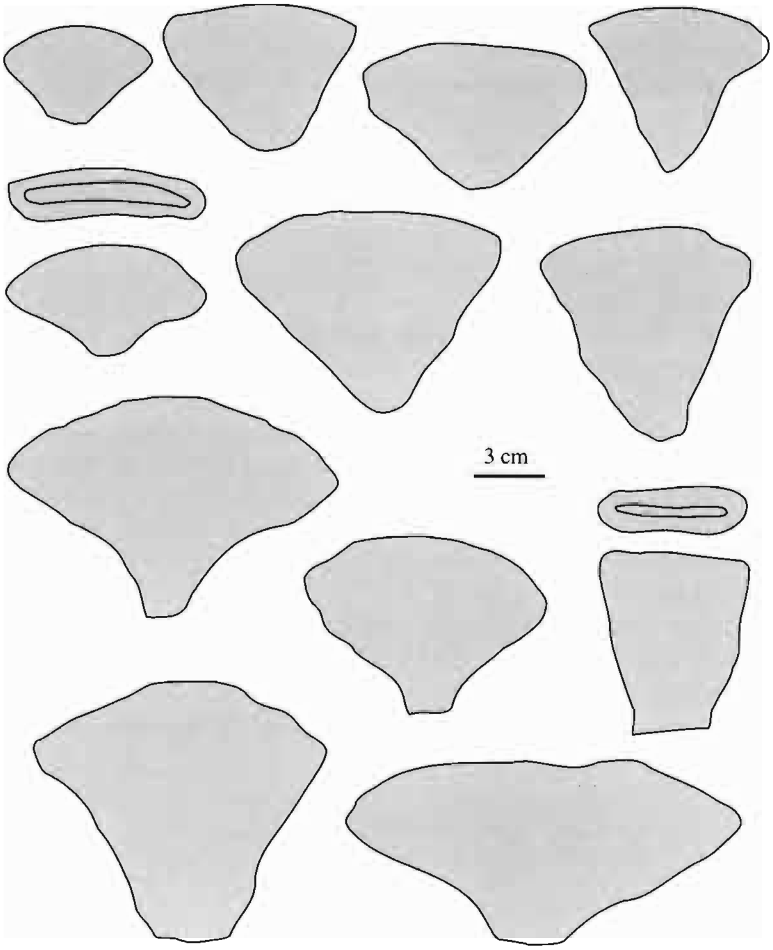


Fig. 16
Shape variability of *Cribrospongia cucullata* (QUENSTEDT).

(GOLDFUSS), and was most probably derived from *C. cucullata,* as here defined, because he included into his synonymy various species that are here differentiated.

Occurrence. — Oxfordian limestones (Beta): Beuron; Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Erkenbrechtsweiler, Wilmandingen; Kimmeridgian limestones (Delta): Erkenbrechtsweiler.

Genus *Tremaphorus* SCHRAMMEN, 1937

Remarks. — This genus has been synonymized with *Xenoschrammenum* DE LAUBENFELS (= *Amphiblestrum* SCHRAMMEN) by TRAMMER (1982) because WAGNER (1963) indicated very slight differences between them. Unfortunately, both WAGNER and TRAMMER had only very poorly preserved specimens, and were not able to investigate spiculation, which is lychniscosan in *Xenoschrammenum*, while *Tremaphorus* clearly has hexactinosan spiculation. As a result the genus *Tremaphorus* is revived here. On the other hand, several species described by OPPLIGER (1897, 1915, 1926) as belonging to *Sporadopyle* ZITTEL, and showing hexactinosan spiculation, are assigned to this genus, based on canalization character and structure of the dictyonal skeleton.

Tremaphorus apertus (OPPLIGER, 1915)
(Pl. 12: 6, 7; Pl. 36: 6)

1915. *Sporadopyle aperta* n. sp.; OPPLIGER, p. 24, pl. 2: 4.
1937. *Tremaphorus punctatus* n. sp.; SCHRAMMEN, p. 62, pl. 15: 8, pl. 24: 2.
1989. *Xenoschrammenum punctatum* (SCHRAMMEN); TRAMMER, pp. 72–73, pl. 12: 4, 5.

Material. — 39 specimens, all calcified.

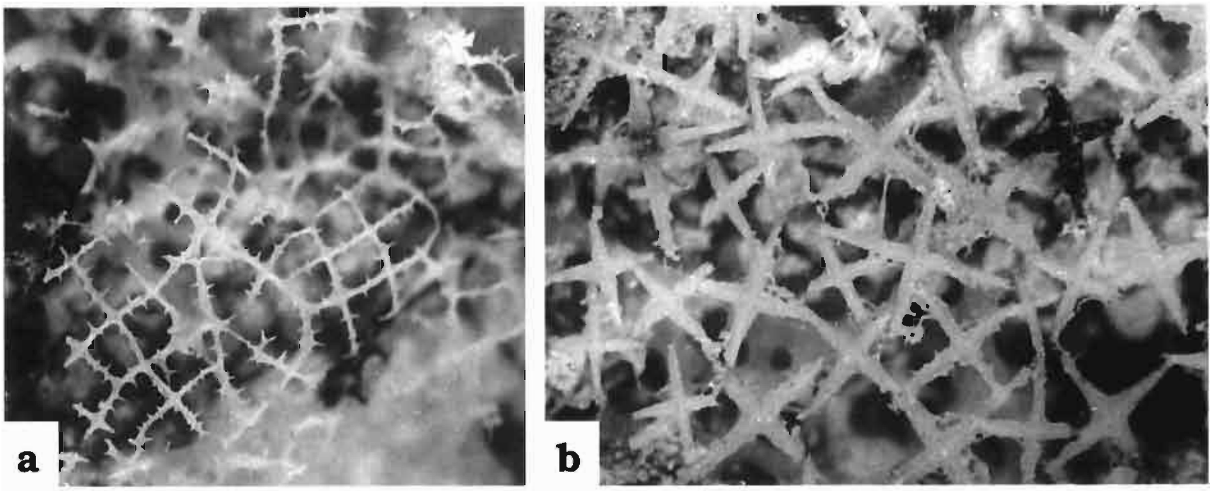


Fig. 17
Cribrospongia cucullata (QUENSTEDT), ZPAL Pf.VIII/327, Erkenbrechtsweiler, Kimmeridgian limestones (Delta); *a* veil of gastral stauractines, × 30; *b* dermal skelton of strong pentactines, × 40.

Description. — Plate-like to broadly conical sponge with thin wall not exceeding 3–4 mm. Inner surface covered with oval canal openings, arranged in alternating pattern, that measure 0.8 × 0.6 mm and are separated by skeletal bands about 0.4 mm wide. The other, lower surface with round, slightly smaller (0.6 mm in diameter) canal openings also in alternating pattern. Both surfaces of dictyonal skeleton with cortex and having very regular meshes 0.20 × 0.10–0.15 mm in size inside the wall. Dictyonal strands diverge toward both surfaces.

Remarks. — Overall morphology, size and distribution of canal openings agree very well in *T. punctatus* SCHRAMMEN and *S. aperta* OPPLIGER; the only difference is that OPPLIGER's (1915) specimens are small and intact, while SCHRAMMEN's (1937) only one is fragmentary. As a result both species are synonymized here, with the specific name *aperta* having priority. On the other hand, because *Sporadopyle* is a lychniscosan genus, SCHRAMMEN's (1937) generic name *Tremaphorus* is used.

Occurrence. — Oxfordian crumpled marly limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Plettenberg, Bärenthal, Lochen Nordwand, Beuron; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler, Wilmandingen; Kimmeridgian limestones (Delta): Erkenbrechtsweiler, Genkingen.

Tremaphorus favrei (OPPLIGER, 1907)
(Pl. 8: 6)

1907. *Sporadopyle Farrei* ETALLON; OPPLIGER, pp. 7–8, pl. 2: 3.
1915. *Sporadopyle Favrei* (ET.) OPPLIGER; OPPLIGER, p. 26, pl. 2: 6.
1926. *Sporadopyle favrei* OPPLIGER; OPPLIGER, p. 14.

Material. — One calcified specimen.

Description. — My specimen is only a fragment several cm across of a plate-like sponge with a wall 5 mm thick. One side (upper one) is covered with the system of more or less longitudinal to irregularly oriented rounded skeletal ridges about 1 mm wide which may merge with one another. In furrows between them are situated canal openings about 2–3 mm long and only 0.6 mm wide; and between them there are other much smaller openings as well. These furrows are not continuous but divided from time to time by coalescense of ridges. The other side (lower one) with sunken rounded canal openings which are only 0.8 mm in diameter, and densely but irregularly distributed. On both sides a well developed cortex is observed. Dictyonal skeleton is not very regular, with meshes about 0.3 × 0.3 mm.

Remarks. — My specimen is identical with OPPLIGER's (1907) material that he attributed to the lychniscosan genus *Sporadopyle*. It shows, however, character which allows its attribution to the hexactinosan genus *Tremaphorus*.

Occurrence. — Oxfordian marls (Alfa): Plettenberg.

Tremaphorus? *tenuis* (OPPLIGER, 1915)
(Pl. 21: 6)

1915. *Sporadopyle tenuis* sp. n.; OPPLIGER, p. 27, pl. 2: 7.

Material. — Two calcified specimens with well preserved skeleton.

Description. — Widely conical to plate-like sponge which could be several cm in diameter (I have only fragment of larger specimen), with walls 4–5 mm thick. Outer side with alternating round canal openings arranged in regular longitudinal rows; these openings measure 0.6 mm in diameter and are separated with skeletal bands of the same width. The other (inner) side has canal openings of the same size and character but irregularly and very densely distributed; skeletal bands separating them are only 0.2–0.4 mm wide. Cortex is very poorly developed on both sides. Dictyonal skeleton very regular, with dictyonal strands diverging toward both surfaces, meshes usually square 0.2 × 0.2 mm (but may be 0.15 × 0.20 to 0.2 × 0.3 mm) in size.

Remarks. — This species was assigned originally to the genus *Sporadopyle*, but in fact it is hexactinosan, not a lychniscosan sponge. It resembles *Tremaphorus*, but too scarce material precludes decisive generic assignment.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian limestones (Beta): Bärenthal.

Genus *Walcotella* DE LAUBENFELS, 1955

Walcotella pertusa (GOLDFUSS, 1833)
(Pl. 4: 1–5, 7, 8; Pl. 34: 1–3)

1937. *Rhopalicus cingulatus* sp. n.; SCHRAMMEN, p. 37.
1982. *Walcotella pertusa* (GOLDFUSS); TRAMMER, p. 31, pl. 11: 2 (cum syn.).
non 1982. *Walcotella pertusa* (GOLDFUSS); TRAMMER, pl. 11: 1.

Material. — 114 specimens.

Remarks. — This is a very variable species; variability concerns both gross morphological features such as shape (from tubular to conical) size, thickness of the wall (from 5 to 15 mm), size of canal openings (from 0.8 to 1.5 mm) and their organization and density on the surface, but what is more important also skeletal features such as regularity of the meshes (from very regular square to rectangular) and meshes size (from 0.24 to 0.35 mm). All these may indicate that 2 or more closely related species may be included under this specific name. Better preserved material (*i.e.* with siliceous spicules preserved) is needed to establish the criteria for differentiation. On the other hand, the species *Walcotella cingulata* SCHRAMMEN differs only slightly in shape and as such is included here into synonymy of *W. pertusa*. The specimen illustrated by TRAMMER (1982: pl. 11: 1) as *W. pertusa* displays lychniscs and most probably represents a new lychniscosan species.

Occurrence. — Oxfordian marls (Alfa): Plettenberg, Lochen, Nusplingen; Oxfordian crumpled marly limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Bärenthal, Plettenberg; Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Erkenbrechtsweiler, Wilmandingen; Kimmeridgian limestones (Delta): Hochwang, Bärenthal; Kimmeridgian marls (Delta): Genkingen.

Walcotella sp. n.
(Pl. 21: 3)

Material. — Five specimens.

Description. — Narrow conical sponge up to 9 cm high and 7 cm in diameter; paragaster 4.5 cm wide and wall 1.0–1.2 cm thick. The entire outer surface is covered with a dermal layer composed of small irregularly organized ?pentactines forming rectangular or square meshes 0.4–0.6 mm in size. Canalization diplorhysal. Canal openings on the dermal surface irregularly rounded and about 1.0–1.5 mm in diameter. Dictyonal strands bend toward both surfaces; meshes of the dictyonal skeleton 0.4 × 0.4–0.5 mm, but may be as small as 0.4 × 0.2 mm.

Remarks. — In character of the skeleton and general morphology it resembles *W. pertusa* (GOLDFUSS), but this species has no dermal skeleton of pentactines, and it has smaller meshes of dictyonal skeleton as well.

Occurrence. — Oxfordian marls (Alfa) and limestones (Beta): Plettenberg; Oxfordian crumpled marly limestones (Alfa): Bärenthal.

Genus *Ordinatus* DE LAUBENFELS, 1955
Ordinatus texturatus (V. SCHLOTHEIM, 1820)
(Pl. 4: 6, 9, 10)

1833. *Scyphia texturata* V. SCHLOTHEIM; GOLDFUSS, p. 6, pl. 2: 9.
1878. *Scyphia texturata* V. SCHLOTHEIM; QUENSTEDT, p. 126, pl. 120: 61.
1989. *Ordinatus texturatus* (V. SCHLOTHEIM); TRAMMER, p. 73, pl. 12: 1–3 (cum syn.).
non 1991. *Ordinatus texturatus* (V. SCHLOTHEIM); SCHMALZRIED, p. 68, pl. 11: 9.

Material. — 39 specimens.

Remarks. — My specimens have only very slightly thickened dermal surface of dictyonal skeleton which is pierced by canal openings 0.6 to 0.8 mm wide, rounded or oval in shape. Dictyonal skeleton is very regular inside the wall, with rectangular to square meshes measuring 0.18–0.20 × 0.20–0.25 mm. Dictyonal strands diverge toward the outer surface of the wall.

The specimen illustrated by SCHMALZRIED (1991), as I have found during examination of the collection in Tübingen, is an Upper Cretaceous sponge (exactly from Opole, as indicated by the original label still in place, and as one can conclude considering the lithology of the attached rock), and has nothing in common with *O. texturatus* which is an Upper Jurassic species.

Occurrence. — Oxfordian crumpled marly limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Plettenberg, Bärenthal; Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Erkenbrechtsweiler; Kimmeridgian crumpled marly limestones (Delta): Hettingen; Kimmeridgian marls (Delta): Hochwang, Genkingen; Kimmeridgian limestones (Delta): Hochwang, Erkenbrechtsweiler.

Genus *Erineum* SCHRAMMEN, 1937
Erineum minutum SCHRAMMEN, 1937

1937. *Erineum minutum* n. sp.; SCHRAMMEN, p. 39, pl. 10: 6.
1989. *Erineum minutum* SCHRAMMEN; TRAMMER, p. 73, pl. 7: 6.

Material. — Twelve poorly preserved specimens.

Remarks. — All my specimens are poorly preserved, but the shape, character of the dictyonal skeleton and canalization agree with SCHRAMMEN's (1937) description and the holotype, as well as with TRAMMER's (1989) specimen. Canal openings (up to 0.8 mm wide) are irregularly distributed over the dermal surface.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Wilmandingen.

Genus *Ramispongia* QUENSTEDT, 1878; emended SCHRAMMEN, 1937
Ramispongia ramosa QUENSTEDT, 1878
(Pl. 3: 7; Pl. 11: 4, 5; Pl. 47: 8)

1989. *Ramispongia ramosa* QUENSTEDT; TRAMMER, p. 76, pl. 13: 1–5 (cum syn.).

Material. — 53 specimens.

Remarks. — Morphology of this species has been described in detail by SCHRAMMEN (1937), he did not observe, however, a dermal skeleton. In my material several well preserved specimens show such a specialized dermal layer consisting of small fused pentactines up to 0.3 mm in size; they were also observed by KOLB (1910).

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian crumpled marly limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Bärenthal, Plettenberg, Lochen Nordwand; Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Erkenbrechtsweiler; Kimmeridgian crumpled marly limestones (Delta): Hettingen; Kimmeridgian marls (Delta): Hochwang; Kimmeridgian limestones (Delta): Hochwang, Blaubeuren, Bärenthal.

Ramispongia? *nodosa* (QUENSTEDT, 1878)

1878. *Ramispongia nodosa*; QUENSTEDT, p. 142, pl. 121: 13, 14.
1897. *Sporadopyle nodosa* OPPLIGER; OPPLIGER, p. 30, pl. 5: 1.

Material. — One specimen.

Description. — Small branching sponge with branches not exceeding 1.5 cm in diameter and 10 cm long. Oscula single at top of branch and much narrower than the branch diameter measuring only 4 mm. There is a dermal layer of pentactines organized in a regular manner forming rectangular to square meshes reaching up to 0.6 × 0.6 mm. Smaller meshes originate by insetting smaller spicules in between the larger ones. No cortex or canal openings visible below. Dictyonal skeleton regular with very large meshes reaching up to 1.4 × 1.0 mm, average 1.0 × 0.8 mm. Dictyonal strands diverge toward the outer surface.

Remarks. — In a character of dictyonal skeleton, as well as in the absence of canalization this species strongly resembles *Porospongia marginata* (MÜNSTER *in* GOLDFUSS); but its shape, and character of dermal spiculation is very different. One cannot exclude the possibility that it should be attributed to the genus *Porospongia*, but limited and not very well preserved material precludes such action.

Occurrence. — Oxfordian marls (Alfa): Plettenberg.

Family **Staurodermatidae** ZITTEL, 1877

Genus *Stauroderma* ZITTEL, 1877

Stauroderma lochense (QUENSTEDT, 1858)

(Pl. 3: 4; Pl. 5: 2, 6; Pl. 8: 10, 11; Pl. 41: 7–10; Fig. 18)

1878. *Spongites lochensis*; QUENSTEDT, pp. 35, 44, pl. 115: 4, 28.
1878. *Retispongia disciformis*; QUENSTEDT, pp. 42, 44, pl. 115: 26, 27.
1977. *Stauroderma lochense* (QUENSTEDT); ZIEGLER, pl. 8: 1.
1982. *Stauroderma lochense* (QUENSTEDT); TRAMMER, pp. 28–29, pl. 11: 9, pl. 12: 3 (cum syn.).
1987. *Stauroderma lochensis* (QUENSTEDT); MEYER *et al.*, p. 68, pl. 2: 2.
1989. *Stauroderma lochense* (QUENSTEDT); TRAMMER, p. 72, pl. 12: 9 (cum syn.).

Material. — 181 variously preserved specimens.

Remarks. — If inner surface of this sponge can be examined then its recognition is easy; outer surface is, however, practically identical to that in *Cribrospongia (= Tremadictyon)*, which makes identification based solely on the outer surface, virtually impossible (see SCHRAMMEN 1937). That is the reason why some specimens in the collection have been determined as *Cribrospongia* or *Stauroderma*, especially in

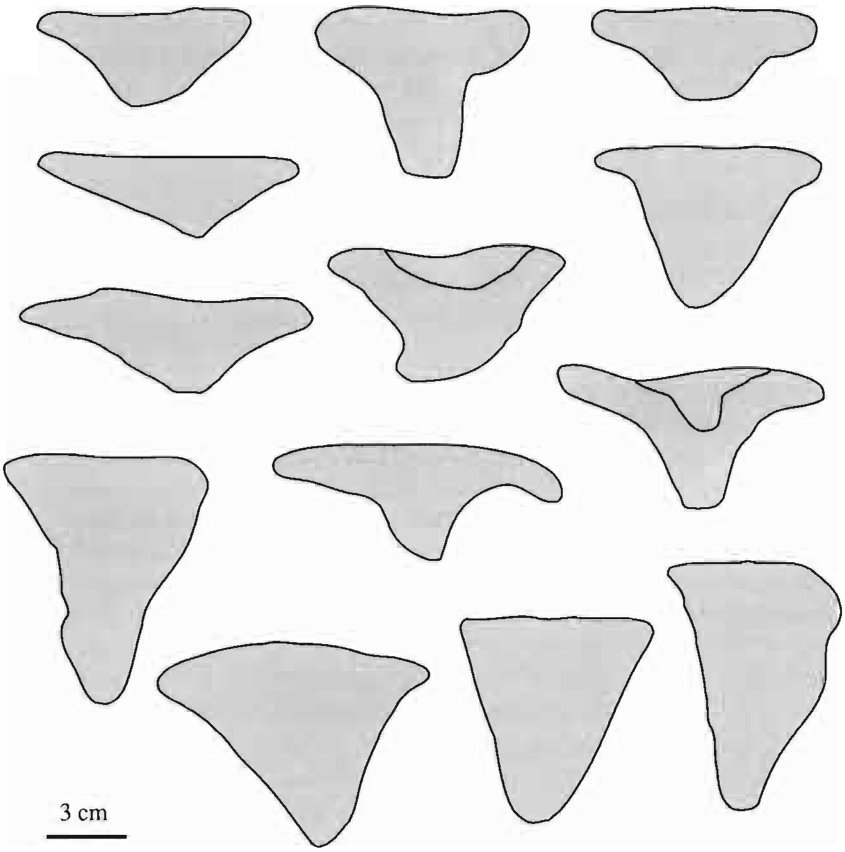


Fig. 18
Shape variability of *Stauroderma lochense* (QUENSTEDT).

cases where the skeleton is poorly preserved. It was usually thought that this species is a wide cone or flat plate-like sponge. In effect all narrow conical sponges with inner surface inaccessible are usually included into *Cribrospongia reticulata* (GOLDFUSS). As it was found here by sectioning, this species of *Stauroderma* also may be of narrow conical shape (Fig. 18), thus some determinations based only on general shape and character of ostia can be erroneous. As a result of complex canalization (see description in REID 1958–1964) dictyonal skeleton is irregular with meshes of various shapes and sizes up to 0.4 mm in diameter. Dictyonal strands, where observed, bend toward the upper surface. Canal openings on the outer (lower surafce) up to 4–5 mm in length and 2 mm wide, in alternating rows and separated by skeletal bands 1.6 mm wide; there is, however, large variability in this respect among specimens from various samples. Canal openings on the upper (inner) surface are much smaller and measuring 1.2–1.5 × 2.0 mm; they are densely and irregularly distributed.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian crumpled marly limestones (Alfa): Bärenthal, Lochen, Nusplingen; Oxfordian limestones (Beta): Plettenberg, Bärenthal, Beuron; Kimmeridgian marls (Gamma): Bärenthal, Hochwang; Kimmeridgian marls (Delta): Hochwang; Kimmeridgian limestones (Delta): Hochwang.

Hexactinosa incertae sedis

Genus *Casearia* QUENSTEDT, 1858

Remarks. — This Upper Jurassic genus has been described from the Triassic of Germany by FREYBERG (1928), but because no spiculation was seen it could as well be a calcareous sponge. Recently KEUPP *et al.* (1989) reported it (with a question mark) from the Lower Carnian of Italy, but the illustration given shows the spiculation clearly different from that known of the type species, and in fact fits with other hexactinosan sponges, so this occurrence must be also rejected. The only probably case of occurrence of this species in the Triassic has been reported by WENDT *et al.* (1989) from China, but the photograph shows too few characters for unquestionable attribution of the specimen to *C. articulata* (SCHMIDEL) as was done by MEHL (1992).

Casearia articulata (SCHMIDEL, 1780)
(Pl. 11: 3; Pl. 35: 6–9)

1974. *Casearia articulata* (SCHMIDEL); MÜLLER, pp. 1–19, pls 1–4.
1987. *Casearia articulata* (BOURQUET); ZIEGLER, pl. 7: 2.
1992. *Casearia articulata* (SCHMIDEL); MEHL, p. 78, pl. 13: 2 (but not her synonymy!).

Material. — One specimen.

Remarks. — The studied material, which includes one specimen with the outer part of the original siliceous spicules preserved, is identical with earlier described material, which was thoroughly reviewed by MÜLLER (1974). He interpreted presence of very sparse hexactines in aporhysal zone as primary, while it seems to be only diagentic effect – very delicate hexactines from this zone underwent preferential dissolution, while more stout ones in the subdermal zone, and thickened ones around the canals, are preferentially preserved; such an effect has been noted among numerous sponges. Contrary to the schemes presented by MÜLLER (1974), hexactines in subdermal layer are much more stout and less regularly arranged (Pl. 35: 6) and commonly display pseudolychnisc nodes (Pl. 35: 6, 8, 9); their true nature can be easily recognized only in SEM. In thin section or light microscope they can be mistaken for genuine octahedral nodes. These pseudolychniscs, however, never show 4 openings in one plane, as expected in a genuine lychnisc, but rather 3 holes; often they are developed only in one plane (Pl. 35: 9), while octahedral nodes are three-dimensional structures.

There is a question of the genesis of the very regular dermal layer, with meshes 0.12 to 0.30 mm across (Pl. 35: 7), that differs strongly from the spicules underlying it, and which define meshes from 0.3 × 0.6 mm to 0.6 × 1.0 mm (most common 0.5 × 0.6 mm). Despite these differences it seems that the layer is a part of the dictyonal skeleton but formed by thickened actines of dictyonal hexactines, with reduction of their distal rays and narrowing of the meshes as a result of adding the smaller spicules into the meshes, but it is not a genuine dermal skeleton composed of specialized independent spicules, as in the genus *Sphenaulax* ZITTEL, for example.

Contrary to the MEHL's (1992) opinion, difference between the species *C. articulata* (SCHMIDEL) and *C. depressa* KOLB, as redescribed by MÜLLER (1990), when compared with Recent hexactinosan sponges, allows for considering them as two distinct species. She also included into her synonymy several Triassic hexactinosan sponges that show in thin section a structure similar to the discussed species – but in all these cases there are definitely not enough characters to substantiate such action; those sponges can be determined only as Hexactinosa.

Occurrence. — Kimmeridgian marls (Gamma): Erkenbrechtsweiler.

Genus *Porospongia* D'ORBIGNY, 1849; emended ZITTEL, 1877

Remarks. — This genus was grouped by MEHL (1992) together with *Cribrospongia* and *Sphenaulax* based on supposed homology of dermal pentactines. In fact, spicules forming the dermal layer of *Porospongia* are a part of the dictyonal skeleton (*i.e.* dictyonalia with outer ray reduced), contrary to MEHL's (1992) opinion, and are undoubted pentactines contrary to REID's (1963b) opinion. Thus they are not homologous with those of *Cribrospongia* and *Sphenaulax*. REID (1963b), on the other hand, assigned (with a question mark) *Porospongia* to Tretodictyidae F. E. SCHULZE 1886, which are characterized by schizorhysal canalization. I disagree with his opinion, for *Porospongia* shows no skeletal canalar structures at all, and most probably canals passed among the very large meshes.

Porospongia marginata (MÜNSTER *in* GOLDFUSS, 1829)
(Pl. 12: 3–5; Pl. 36: 1–3)

1878. *Textispongia mammillata*; QUENSTEDT, p. 65, pl. 117: 8.
1962. *Porospongia marginata* (MÜNSTER) var. *micropora* QUENSTEDT; LAGNEAU-HÉRENGER, p. 72.
1989. *Porospongia marginata* (MÜNSTER *in* GOLDFUSS); TRAMMER, p. 74, pl. 7: 3 (cum syn.).
1992. *Porospongia marginata* (GOLDFUSS); MEHL, p. 81, pl. 13: 4–6.

Material. — 37 specimens.

Remarks. — The form described by QUENSTEDT (1878: pl. 117: 8) as *Textispongia mammillata* is undoubtedly *P. marginata*; the illustration shows the organization of dictyonal strands and what is left of oscula after removal of the dermal layer of pentactines embedded in siliceous membrane. *Porospongia marginata* shows great variability in all its morphological features, *i.e.* shape which may be from plate-like to club-like; sizes of openings in the ?gastral siliceous membrane (which may be from 2 to 5 mm in diameter) and their distribution on the surface (from 10 to 20–30 mm apart). Also wall thickness varies from 4 to 9 mm. Dictyonal strands, on the other hand, are always very regular and diverge toward the gastral and dermal surfaces approaching the latter at a narrow angle (Pl. 36: 3). The skeletal net also is always very regular with very large meshes with spicular centers 0.4 to 0.6 mm apart (Pl. 36: 3). Hexactines are covered with low tubercles. Dermal pentactines are in continuity with the dictyonal skeleton and are clearly of dictyonal origin. They bear a small knob in place of outer ray. No canals are visible, and most probably passed between large meshes.

Occurrence. — Oxfordian crumpled marly limestones (Alfa): Bärenthal; Oxfordian marls (Alfa): Plettenberg; Oxfordian limestones (Beta): Bärenthal, Plettenberg; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler; Kimmeridgian limestones (Delta): Hochwang, Genkingen; Kimmeridgian marls (Delta): Hochwang.

Genus *Multiloqua* DE LAUBENFELS, 1955 (= *Polyphemus* SCHRAMMEN, 1937)

Multiloqua fungulus (QUENSTEDT, 1878)
(Pl. 22: 1, 2; Pl. 32: 4; Fig. 19)

1878. *Spongites fungulus*; QUENSTEDT, p. 337, pl. 131: 34.
?1937. *Polyphemus strombiformis* n. sp.; SCHRAMMEN, p. 48.

Material. — Two specimens in the author's collection, and numerous specimens in MÜLLER's collection in SMNS.

Diagnosis. — Mushroom-like to conical (Fig. 19) hexactinosan sponge with convex upper surface covered with siliceous membrane and single osculum.

Description. — The sponge is mushroom-like to conical (Fig. 19). The investigated specimens are small, 18 to 23 mm high and up to 30 mm wide at the top each, with a single osculum 5–8 mm wide. Upper surface convex to hemispherical and smooth, suggesting that it was covered with a siliceous membrane. Lower conical part (stem) shows large (1–2 mm) irregularly distributed canal openings. Dictyonal skeleton with square meshes 0.2–0.3 mm wide. The specimens from SMNS are several cen-

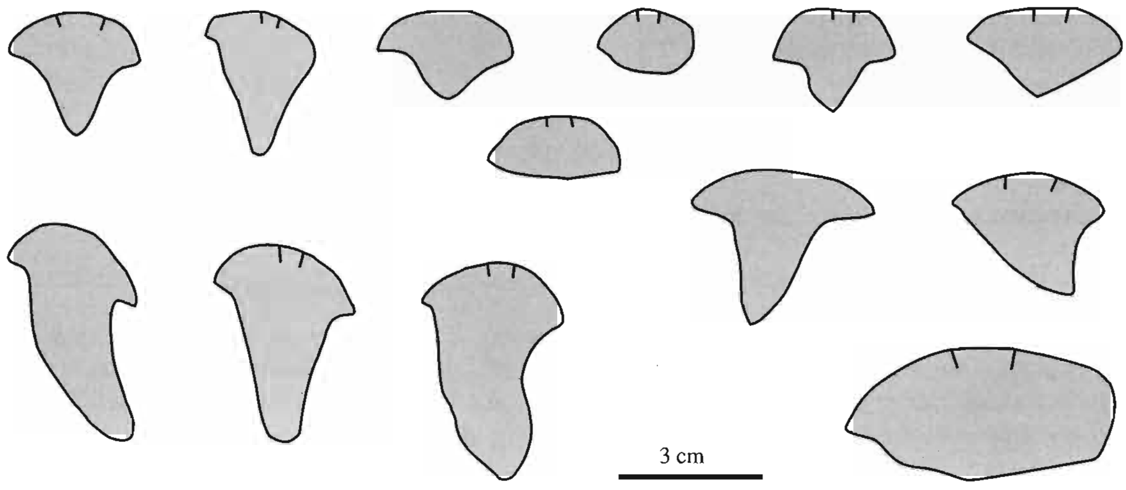


Fig. 19
Shape variability of *Multiloqua fungulus* (QUENSTEDT).

timeters in diameter, and show large variability from typical mushroom-like to double-conical or discoidal shape and have a well developed thick ledge around the osculum.

Remarks. — SCHRAMMEN (1937) did not illustrate his new species, and I was not able to locate his specimens in collections in Tübingen and München. A very short description by him fits well the specimen illustrated by QUENSTEDT (1878) as *Spongites fungulus*, which is also identical with the studied specimens in my collection; the only difference is that SCHRAMMEN's specimen is much larger, as are also specimens in SMNS. This species differs from *Multiloqua fungiformis* in its mushroom-like shape.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal. Specimens in SMNS came from the White Jurassic Gamma and Delta from various localities (mainly Obernheim and Wilmandingen).

Genus *Megalodictyon* OPPLIGER, 1926

Remarks. — In character of the dictyonal skeleton this genus resembles *Porospongia*; it lacks other typical features of the latter, however.

Megalodictyon fretreulensis OPPLIGER, 1926

1926. *Megalodictyon fretreulensis* sp. n.; OPPLIGER, pp. 35–36, pl. 2: 7, fig. 1.

Material. — Five poorly preserved specimens.

Diagnosis. — Cup-shaped and several cm large hexactinosan sponges with thick walls and very coarse and regular dictyonal skeletons.

Remarks. — In character of the skeleton this species resembles *Porospongia marginata* (MÜNSTER *in* GOLDFUSS) but it differs in lacking numerous oscula on the gastral surface and any traces of pentactins embedded in the siliceous membrane. It also differs in wall thickness and general shape. Dictyonal strands diverge toward both surfaces and reach them at narrow angles. Transverse beams at the same level form a very regular pattern. Spicular centers 0.7–1.0 mm apart. Walls about 15 mm thick. No canalization has been observed, as canals were clearly passing through the very large meshes of the dictyonal skeleton.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian crumpled marly limestones (Alfa): Bärenthal.

Genus *Polypyge* SCHRAMMEN, 1937

Polypyge pusilla SCHRAMMEN, 1937

(Pl. 10: 3)

1937. *Polypyge pusilla* n. sp.; SCHRAMMEN, pp. 61–62, pl. 11: 9.

Material. — One specimen.

Description. — Small lumpy sponge, 25 × 13 mm across and about 15 mm high (attached to platy *Cribrospongia* sp.), with several oscules located at the top of short tubes. The rest of the surface covered with irregular outgrowths. Walls of oscular tubes 0.4–0.5 mm thick and 1.0–2.2 mm in diameter. Dictyonal skeleton regular with square meshes 0.2 × 0.2 mm.

Remarks. — This very rare sponge is so characteristic that it cannot be mistaken for any other Jurassic species. Contrary to SCHRAMMEN's (1937) description, this species has a regular dictyonal net inside the wall; most probably he had seen only dermal and subdermal parts of the skeleton, which are always complicated.

Occurrence. — Oxfordian crumpled marly limestones (Alfa): Bärenthal.

Genus *Linonema* DE LAUBENFELS, 1955 (= *Linosoma* SCHRAMMEN, 1937)

Remarks. — This genus originally included two species, *L. calyx* SCHRAMMEN and *L. infundibuliformis* SCHRAMMEN. Investigation of the holotype skeleton of *L. infundibuliformis* revealed that it consists of lychniscs which can be partly occluded (Pl. 33: 9, 10); in effect this species must be excluded from the genus *Linonema*, and most probably attributed to *Trochobolus* ZITTEL.

Linonema calyx (SCHRAMMEN, 1937)
(Pl. 14: 2, 5, 6; Pl. 33: 11; Fig. 20)

1937. *Linosoma calyx* n. sp.; SCHRAMMEN, pp. 55–56, pl. 6: 3; pl. 15: 2.

Material. — 40 specimens.

Description. — Narrow conical to tubular sponge (Fig. 20) reaching 15 cm in length and 7 cm in width, having 1.5–2.0 cm thick walls. Outer surface covered with irregular low outgrowths of the dictyonal skeleton that are 2–4 mm long and 2 mm high. In furrows between these outgrowths, are 2–4 mm long and 2 mm wide oval to elongated canal openings. Such canal openings have also been observed, but never commonly, on the sides and tops of small skeletal outgrowths. Paragaster surface, as far as seen on polished sections, has the same character. The wall is pierced with curved canals that are oval in transverse section and 2 mm wide, and that run from both surfaces but never entirely pierce the wall. Skeletal net relatively regular usually with rectangular meshes measuring 0.25 × 0.40 mm; square meshes within the same size range are also present. Dictyonal strands parallel to the gastral surface through most of the wall, only near the dermal surface they are inclined toward it at a very narrow angles. Meshes of the dictyonal skeleton are only slightly thickened on the dermal surface.

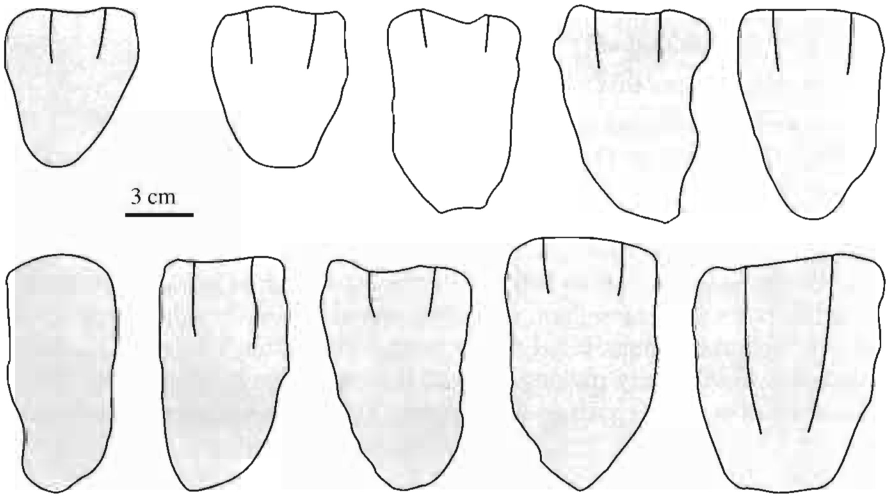


Fig. 20
Shape variability of *Linonema calyx* (SCHRAMMEN).

Remarks. — The specimens in SCHRAMMEN's (1937) collection are sometimes much larger. He also thought that this sponge has a folded wall; in fact only surficial parts of the dictyonal skeleton display irregular outgrowths, but inside the wall there are no traces of folding.

This species has been reported only by SCHRAMMEN (1937) and is common in the Swabian Alb, being unknown in other areas of the UJSM development. Having in mind that it can be easily mistaken for *Trochobolus* and *Pachyrhachis*, and when the outer surfaces are not well preserved also for *Cypellia rugosa*, one may suspect that occurrences in areas other than Swabian Alb could be hiding under those names, especially in more general papers.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian crumpled marly limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Bärenthal, Plettenberg; Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Erkenbrechtsweiler; Kimmeridgian marls (Delta): Hochwang.

Genus *Nitidus* DE LAUBENFELS, 1955 (= *Epaphroditus* SCHRAMMEN, 1937)

Remarks. — According to REID (1963b) *Nitidus* does not seem distinguishable from the living *Psilocalyx* IJIMA; having no material for comparison I was not able to decide about this problem.

Nitidus nitidus (SCHRAMMEN, 1937)
(Pl. 38: 8)

1937. *Epaphroditus nitidus* sp. nov.; SCHRAMMEN, p. 62, pl. 10: 1.

Material. — Only SCHRAMMEN's holotype in Tübingen has been investigated.

Remarks. — Only the skeleton from the holotype of this poorly known species is here illustrated, because it has never been shown before.

Occurrence. — Oxfordian (Alfa): Streitberg.

Genus *Rhabdium* SCHRAMMEN, 1937
Rhabdium angustatum SCHRAMMEN, 1937

1937. *Rhabdium angustatum* n. sp.; SCHRAMMEN, pp. 63–64, pl. 12: 7.

Material. — Five specimens.

Remarks. — My material is very poorly preserved and always with calcified spicules. This small sponge is 5–6 cm high and about 1.0 to 1.5 cm wide, with thin walls, 5 to 6 mm thick. Canal openings round and irregularly distributed on the dermal surface, and measure about 1 mm in diameter. Skeletal meshes are square inside the wall and measure from 0.25 to 0.40 mm; near the surface they are irregularly arranged because of adding new hexactines in different orientations. Dictyonal strands diverge toward both surfaces. No cortex has been observed. All these characters agree with the description of *R. angustatum* by SCHRAMMEN (1937).

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal; Kimmeridgian marls (Delta): Hochwang.

Hexactinosa gen. et sp. n.
(Pl. 37: 1–5)

Material. — Four specimens, two of which have partly preserved original siliceous choanosomal and dermal skelton.

Description. — Narrow conical sponge up to several cm high and walls up to 1 cm thick, with a morphology resembling *Cypellia rugosa* (GOLDFUSS). Outer surface with canal openings rounded and measuring 0.7 mm in size, and distributed without any order over the entire surface. Canalization ?diplorhysal. Choanosomal skeleton with well developed cortex, irregular in subdermal region, inside the wall regular with meshes measuring 0.2 × 0.3 mm. Dictyonal strands diverge toward both surfaces. Dermal layer composed of hexactines with very short distal rays with proximal rays longer than the rest and fused with the dictyonal skeleton. Hexactines measure 0.7 mm acrosss and are arranged irregularly, often with tangential rays fused by synapticulae.

Remarks. — This species externally very much resembles the lychniscosan *Cypellia rugosa*, and without studying spiculation cannot be differentiated from it. None of the Jurassic or younger genera of hexactinosan sponges known to me, have a dermal layer consisting of hexactines, although a similar dermal layer is known in the Triassic *Hexactinoderma* PISERA and BODZIOCH, 1990, but it is an undoubted lyssacinosan sponge. My Jurassic material is, however, very limited, thus does not allow for detailed description and establishment of a new taxon.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Kimmeridgian marls (Gamma): Erkenbrechtsweiler, Hochwang.

Order **Lychniscosa** SCHRAMMEN, 1903

Remarks. — A common problem in attributing some forms to Lychniscosa or Hexactinosa (see for example the case of *Xenoschrammenum*) are frequent cases of parallel morphological evolution (or homeomorphy) occurring in both groups. The only way to recognise the true position of a sponge is to study the spiculation – without that study one suspects that numerous mistaken assignments have been made and synonymization of some specimens known only morphologically is an extremely dangerous practise. Additionally, occlusion of lychniscs in the subdermal region is a common case.

According to the most recent diagnosis of Lychniscosa by FINKS (1983) these are hexasterophoran sponges with dictyonal strands in which central crossing of each hexactine bears struts that outline the edges of octahedron. This means, and is often observed in practise in both Recent and fossil examples (see below), that not all spicules in this group of sponges are lychniscs. Secondary spicules occurring in canals and subdermal spaces, as well as dermal spicules, are usually genuine hexactines, and not lychniscs. It clearly demonstrates also that dictyonal skeletons and secondary or dermal skeletons are not homologous.

Family **Cypellidae** SCHRAMMEN, 1937

Emended diagnosis. — Lychniscosan sponges with well developed epi- and aporhyses variously organized. Dictyonal skeleton irregular near surface with numerous synapticulae. Dermal skeleton composed of irregularly organized pentactines fused with dictyonal skeleton and with their tangential rays.

Genus *Cypellia* POMEL, 1872

1872. *Cypellia* POMEL.
1936. *Paracypellia* SCHRAMMEN.
1936. *Phanerochiderma* SCHRAMMEN.
1936. *Cryptochiderma* SCHRAMMEN.
1937. *Sporadopyge* SCHRAMMEN.
1937. *Rhombedonium* SCHRAMMEN.

Emended diagnosis. — Tubular, conical to plate-like lychniscosan sponges, usually with thick wall. Dermal skeleton always fused into more or less irregular net, composed of coarse pentactines. Choanosomal skeleton irregular with numerous synapticular bridges, especially in subdermal region, but regular inside the wall. Canals branched and interconnected. May be solitary or multiindividual.

Remarks. — Genus *Sporadopyge* shows all the features typical of the genus *Cypellia,* as here understood, so it is regarded as its synonym. On the other hand, the genus *Rhombedonium* was assigned by SCHRAMMEN (1937) to the Hexactinosa incertae sedis. Reinvestigations of the holotype of *R. cypelliaeforme* (Pl. 18: 3, Pl. 43: 12) revealed that, in fact, it consists of lychniscs with octahedral nodes occluded in the subdermal region. Other features agree with the diagnosis of the genus *Cypellia.* The genus *Paracypellia* differs mostly in forming multi-tubed groups, but it does not seem to substantiate a separate genus.

Cypellia rugosa (GOLDFUSS, 1826)
(Pl. 16: 1; Pl. 20: 7, 8; Pl. 39: 1–6; Fig. 21)

1989. *Cypellia rugosa* (GOLDFUSS); TRAMMER, pp. 77–78, pl. 15: 4–8 (cum syn.).
1992. *Cypellia rugosa* (GOLDFUSS); MEHL, pp. 133–135.

Material. — 281 specimens.

Remarks. — Recently MEHL (1992) synonymized with *Cypellia rugosa* (GOLDFUSS) (based clearly only on appearances) several species which fall outside the variability range generally accepted for lychniscosan sponges, of concern especially are such forms as *Sporadopyge speciosa* SCHRAMMEN and *Cypellia trabeculata* (QUENSTEDT). On the other hand, *Spongites bidolosus* QUENSTEDT (1878: pl. 130: 4), sometimes included here, displays schizorhysal canalization, a regular skeleton and an irregular surface suggesting that it represents the genus *Trochobolus.*

Contrary to the MEHL's (1992) opinion, concentric folds of the outer sponge surface are not characteristic feature of this species, but such folds are only an expression of ecological conditions, for both smooth and folded surfaces are observed. Also the thickness of the wall in this species is much greater than indicated by MEHL (who probably measured it on *Sporadopyge speciosa*, which I exclude from the

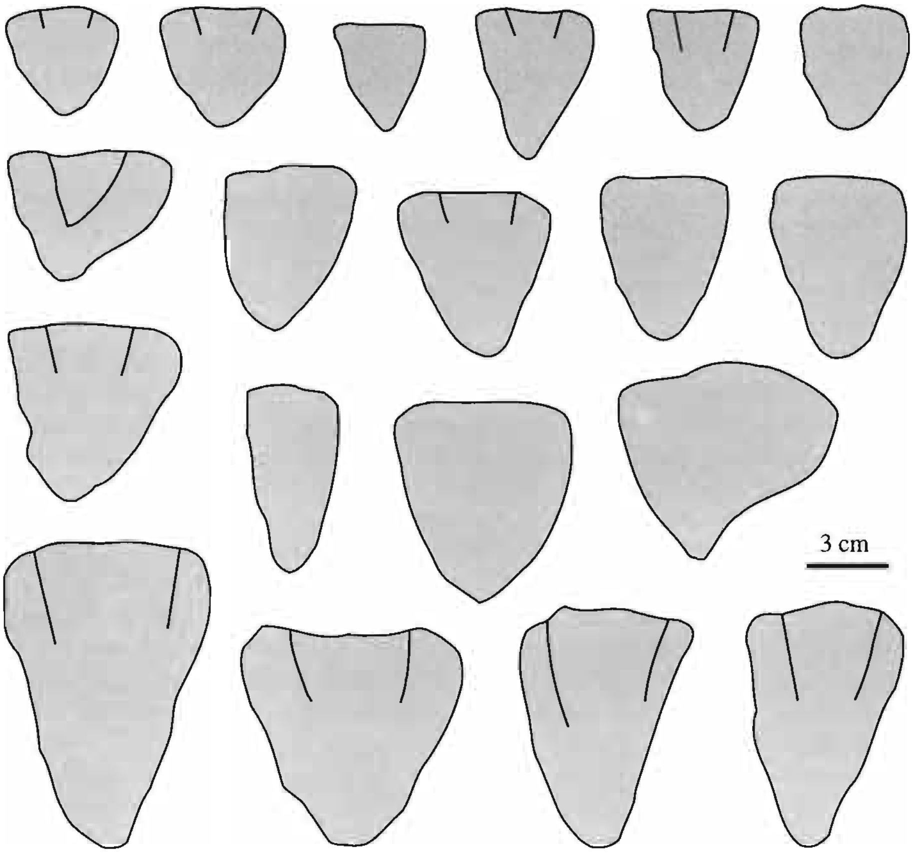


Fig. 21
Shape variability of *Cypellia rugosa* (QUENSTEDT).

synonymy of *C. rugosa*) and in adult individuals amounts to 13–18 mm. Canals piercing the wall from both directions are 1.5–2.0 mm in diameter and branching. They open on the outer surface of the main skeleton below the dermal skeleton, with irregularly round openings. Dictyonal skeleton is regular inside the wall and parallel to wall surfaces, but only close to them diverge toward the outside. Subdermal skeleton very irregular, with numerous supporting elements and synapticulae, very dense. Skeletal net covered densely with low spines and tubercles; meshes rectangular 0.3 × 0.4 mm in size. Dermal skeleton composed of large pentactines bearing the same sculpture as dictyonal skeleton. Some specimens may be rather large and may reach up to 20 cm high. This species is known so far only from the Upper Jurassic, but it clearly occurs also in the Bajocian of Spain (PISERA unpublished).

Occurrence. — Oxfordian marls (Alfa): Plettenberg, Lochen, Nusplingen; Oxfordian crumpled marly limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Plettenberg, Bärenthal, Beuron, Lochen Nordwand, Tieringen; Kimmeridgian marls (Gamma): Bärenthal, Wilmandingen; Kimmeridgian crumpled marly limestones (Delta): Hettingen; Kimmeridgian limestones (Delta): Blaubeuren, Erkenbrechtsweiler, Hochwang; Kimmeridgian marls (Delta): Genkingen; Kimmeridgian limestones (Epsilon): Blaustein.

Cypellia inberbis (QUENSTEDT, 1878)
(Pl. 11: 6; Pl. 13: 4; Pl. 39: 7, 8)

1937. *Cryptochiderma inberbis* QUENSTEDT; SCHRAMMEN, pp. 14–15, pl. 4: 8.
1989. *Cypellia inberbis* QUENSTEDT; TRAMMER, p. 78.

Material. — Four specimens entirely calcified.

Remarks. — My specimens are identical with the QUENSTEDT holotype; SCHRAMMEN (1937) also described larger and widely conical specimens, which most probably belong to other species. In my material, specimens are only up to 6 cm long and 2.0–2.5 cm wide, with wall 5 mm thick. Meshes of the dictyonal skeleton measure 0.4 × 0.4–0.5 mm, while pentactines in the dermal skeleton form square meshes about 0.4 mm in size.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Kimmeridgian marls (Gamma): Bärenthal.

Cypellia caliciformis OPPLIGER, 1907
(Pl. 3: 8; Pl. 5: 1)

1907. *Cypellia caliciformis* sp. nov.; OPPLIGER, p. 10, pl. 4: 2.
?1913. *Cypellia aspera* ZITTEL; SIEMIRADZKI, p. 27.
1937. *Sporadopyge speciosa* n. sp.; SCHRAMMEN, p. 16, pl. 6: 2.
1989. *Sporadopyge speciosa* SCHRAMMEN; TRAMMER, pp. 79–80, pl. 18: 7.
non 1991. *Sporadopyge speciosa* SCHRAMMEN; SCHMALZRIED, p. 57, pl. 10: 8.

Material. — 42 specimens, all calcified.

Remarks. — The sponge illustrated as *Sporadopyge speciosa* by SCHMALZRIED (1991) is an Upper Cretaceous sponge from Opole (as is evidenced even by the lithology of attached rock). The locality is also shown on the original label still present in the collection in Tübingen.

There is no difference whatever between *S. speciosa* and *C. caliciformis* as described and illustrated by OPPLIGER (1907). SCHRAMMEN (1937), for some unknown reason totally disregarded OPPLIGER'S publications, but in effect his species must be regarded as a younger synonym. In a later paper OPPLIGER (1926) synonymized this species with *C. aspera* ZITTEL. This decision cannot be accepted for ZITTEL (1877) only illustrated the dermal layer of (as then supposed) stauractines (which may belong to any other species as well), and no description or other details. SIEMIRADZKI (1913) described a sponge identical with this discussed under the name *C. aspera* (but gave no illustration), but OPPLIGER'S (1907) name *C. caliciformis* has priority.

This widely conical to plate-like species is up to 9 cm in diameter, and 6 cm high, but fragments indicate that it may be also much larger, with walls 0.5–1.3 cm thick. Canals extend from the opposite sides and commonly branch and interconnect. Canal openings on the lower (outer) surface are oval, measuring 1 × 2 mm, or rounded and 1 mm in size; openings on the upper side are alternating and of similar size. Outer surface displays dermal layer composed of large (up to 2 mm in size) pentactines irregularly organized. Dictyonal strands generally parallel to the surface; skeletal net irregular and complicated in the subdermal regions by addition of numerous supporting elements and synapticulae. Deeper subdermal skeleton regular with meshes 0.40 × 0.25 mm.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian crumpled marly limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Bärenthal, Plettenberg; Kimmeridgian marls (Gamma): Bärenthal.

Cypellia prolifera (ZITTEL, 1877)
(Pl. 6: 3; Pl. 20: 4–6, 10; Pl. 40: 1–6; Fig. 22)

1937. *Paracypellia prolifera* ZITTEL; SCHRAMMEN, pp. 13–14, pl. 1: 1, pl. 2: 7, pl. 10: 7.
1937. *Paracypellia minor* n. sp.; SCHRAMMEN, p. 14, pl. 1: 2, pl. 4: 7.
1989. *Paracypellia prolifera* (ZITTEL); TRAMMER, p. 78, pl. 15: 1.

Material. — 71 specimens, partly with preserved original siliceous spicules.

Diagnosis. — Tubular *Cypellia* with relatively thin walls and each with wide paragaster; often in groups. Dermal skeleton of irregularly organized pentactines.

Description. — Tubular lychniscosan sponges (Fig. 22) reaching 10 cm in height and 3 cm in diameter; often occurring in groups. Wall relatively thin, 5–6 mm thick, pierced by diplorhysal irregular canals about 1 mm in diameter. Osculum wide, simple. Dermal surface with dermal layer of irregularly organized pentactines of various sizes to 2 mm in diameter. In some specimens or even regions of the same specimen, pentactines may be embedded in a siliceous membrane. Some parts of the choanosomal skeleton include isolated pentactines identical with those from the dermal layer, suggesting a previous position of the dermal surface. Subdermal dictyonal skeleton irregular and only slightly thickened with curved rays and synapticular bridges, inside the wall quite regular with dictyonal strands running towards both surfaces. Dictyonal meshes rectangular 0.4 × 0.2–0.4 mm wide. On the dermal side dictyonal skeleton bears strong thick, spine-like outgrowths surrounding canal openings (Pl. 40: 5, 6).

Remarks. — The occurrence of isolated pentactines, identical with dermal pentactines, within the choanosomal dictyonal skeleton is interesting and they may mark some former positions of the sponge surface. It suggests also a possibility that these sponges were able to resorb earlier deposited spicules

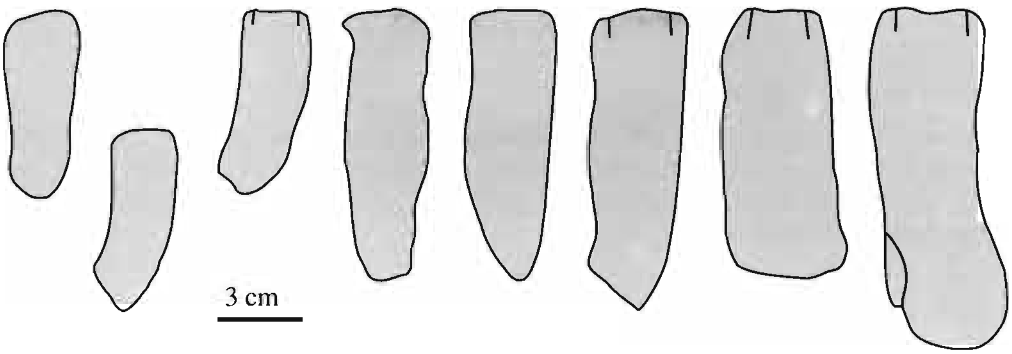


Fig. 22
Shape variability of *Cypellia prolifera* (ZITTEL).

during their growth and thus to thicken the wall. Similar pentactines within dictyonal skeleton were also observed in *Cypellia rugosa*.

Occurrence. — Oxfordian marls (Alfa): Nusplingen; Kimmeridgian marls (Gamma): Bärenthal, Hochwang; crumpled marly limestones of the Kimmeridgian (Delta): Hettingen.

Cypellia trabeculata (QUENSTEDT, 1878)
(Pl. 20: 9)

1982. *Tremadictyon reticulatum* ZITTEL; TRAMMER, p. 29 (*partim*), pl. 11: 5, pl. 12: 7.
1989. *Cypellia trabeculata* (QUENSTEDT); TRAMMER, p. 78 (cum syn.).

Material. — 13 calcified specimens.

Description. — Broadly conical to conical sponge with thick walls (up to 1.8 cm thick) which may be 8–10 cm high and about 6 cm wide at the osculum. Outer surface covered with oval to irregular and densely spaced canal openings up to 2–3 mm in size. Skeletal bands separating them narrow and not exceeding 1 mm; canals extend from opposite sides of the wall, and branch. Choanosomal spiculation regular with meshes 0.3 x 0.2 mm to 0.4 x 0.3 mm; dictyonal strands diverge slightly toward both surfaces.

Remarks. — This species has been attributed to the genus *Cypellia* on the basis of general shape, canalization type and character of canal openings. No dermal spiculation has been observed, which makes this attribution tentative. From *C. rugosa* it differs in having very densely spaced canal openings on the outer surface and in a much more regular dictyonal skeleton.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; crumpled marly limestones of the Oxfordian (Alfa): Bärenthal; Oxfordian limestones (Beta): Bärenthal, Plettenberg; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler.

Cypellia? sp. n.
(Pl. 40: 7–10)

Material. — 29 specimens, all except one poorly preserved, and entirely calcified.

Remarks. — In general shape this species is identical with *C. rugosa*, but has less densely distributed canal openings on the dermal surface; the most important difference, however, is in the character of the dictyonal skeleton, which in the new species is extremely complicated by development of numerous synapticules and production of very irregular meshes. Most of my material is very poorly preserved, however, and entirely calcified. Only one fragmentary specimen has the skeleton preserved and it is highly irregular, with numerous synapticulae and secondary genuine hexactines attached to the lychniscosan skeleton. The most important are dermal spicules developed as smooth pentactines 1 mm in size. Canalization consists of irregular tubes and cavities which are interconnected. The species is very similar to *Rhopalicus parvulus*, as described by SCHRAMMEN (1937), who insisted, however, that his species has no lychniscs; I was not able to verify that.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; crumpled marly limestones of the Oxfordian (Alfa): Bärenthal.

Genus *Placotelia* OPPLIGER, 1907

1907. *Placotelia* OPPLIGER.
1915. *Discophyma* OPPLIGER.

Remarks. — For discussion of identity of *Placotelia* and *Discophyma* see TRAMMER (1982). I place this genus together with *Cypellia* POMEL, 1872 into one extinct family, the Cypellidae SCHRAMMEN, 1937, based on their similarity in skeletal structure (irregular dictyonal skeleton with synapticulae, dense dermal layer of pentactines) and canalization type.

Placotelia marcoui (ETALLON, 1860)
(Pl. 5: 5; Pl. 21: 8)

1860. *Cribrocoelia marcou*; ETALLON, p. 141.
1878. *Retispongia disciformis*; QUENSTEDT, p. 49, pl. 116: 12.
1907. *Placotelia marcou* ETALLON; OPPLIGER, p. 14, pl. 5: 3 (cum syn.).
1915. *Placotelia Marcoui* OPPLIGER; OPPLIGER, p. 41, pl. 5: 2.
1926. *Discophyma marcoui* OPPLIGER; OPPLIGER, p. 22.
1926. *Discophyma cribratum* sp. n.; OPPLIGER, p. 24, pl. 1: 7.
1982. *Placotelia marcoui* (FROMENTAL); TRAMMER, p. 34, pl. 16.

Material. — 22 fragmentary specimens with calcified spicules.

Description. — Plate-like sponge with walls up to 1.2–1.5 cm thick and reaching (as may be judged from fragments) up to 50 cm in diameter. On the upper surface canal openings are rounded to oval and measure up to 6 × 4 mm (average 2–3 × 4 mm) across. They are separated by skeletal bands 3–10 mm wide. These openings are arranged in more or less concentric and radial patterns. On the lower surface canal openings are rounded to irregularly oval in shape and distributed without any order; they measure up to 2 mm in size but may be as small as 0.3 mm. On the lower surface pentactines up to 1 mm in diameter compose a dermal layer. Dictyonal skeleton irregular inside the wall, with strands more or less parallel to both surfaces. There are common synapticular bridges, and meshes of the skeleton measure from 0.4 × 0.3 mm up to 0.6 × 0.5 mm.

Remarks. — There is a great variability in shape, size and regularity of canal openings on the upper (gastral) surface, but they are always in concentric patterns. *P. cribratum* (OPPLIGER) differs only in having more irregular and/or elongated canal openings on some parts of the upper surface. In my collection there is a complete spectrum of structures between typical *P. marcoui* and *P. cribratum*, and thus they are synonymized here.

Occurrence. — Oxfordian marls (Alfa): Plettenberg, Nusplingen; crumpled marly limestones of the Oxfordian (Alfa): Bärenthal; Oxfordian limestones (Beta): Bärenthal, Plettenberg; Kimmeridgian marls (Gamma): Bärenthal.

Placotelia laciniata (OPPLIGER, 1926)
(Pl. 5: 4)

1926. *Discophyma laciniata* OPPLIGER; OPPLIGER, p. 23, pl. 1: 6.
1987. *Discophyma laciniata* OPPLIGER; ZIEGLER, fig. 28.

Material. — Two fragmentary specimens.

Diagnosis. — Large, plate-like *Placotelia* with elevated ledge surrounding the sponge periphery and with radially oriented low and irregular, convex skeletal ridges on the rest of the upper (inner) surface.

Description. — This plate-like sponge can be up to 30 cm in diameter and 1.5 cm thick; around the edge of the upper (inner) surface occurs a wide (18 mm) ledge; the rest of this surface is covered with low skeletal ridges (3–4 mm wide) in radial orientation, separated by deep furrows 2.0–2.5 mm wide. At the bottom of the furrows large (up to 2–4 mm long and strongly varying in size) oval canal openings (?cavaedia) occur. Lower (outer) surface covered with a dermal skeleton composed of stout, irregularly organized pentactines 1–2 mm in diameter. Dictyonal skeleton composed of large and irregular meshes up to 0.2–0.5 mm large.

Remarks. — OPPLIGER (1926) included the species *Stauroderma disciformis* OPPLIGER, 1897, as a synonym. However, in the earlier paper no illustration of the sponge was given, only a poor drawing of the skeleton, and the description presented there does not fit the morphology of later described *Discophyma laciniata*. For this reason I am not including *S. disciformis* here as a synonym.

Occurrence. — Oxfordian limestones (Beta) and Kimmeridgian marls (Gamma): Bärenthal.

Placotelia? sp. n.
(Fig. 23)

Material. — Three fragments with calcified but well preserved spicules.

Diagnosis. — Thin-walled, plate-like lychniscosan with peculiar dermal pentactines having tangential rays enlarged into vertical massive plates (Fig. 23).

Description. — Plate-like sponge with thin (0.5 cm thick) wall, reaching sizes over 20 cm. No canal openings visible on either surface; most probably canalization was realized through large skeletal meshes which are 0.2 × 0.4 mm to 0.4 × 0.7 mm in size. Dictyonal skeleton poorly regular with numerous triangular meshes and curved rays of lychniscs; dictyonal strands more or less parallel to both surfaces. Outer? surface covered with large (up to 1 mm in diameter), massive, peculiar pentactines with tangential rays enlarged vertically into thick plates.

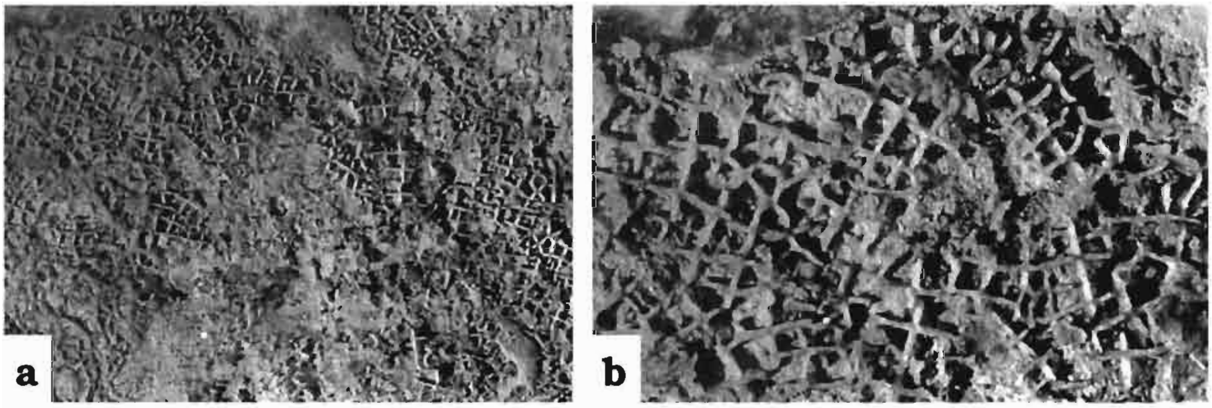


Fig. 23
Placotelia? sp. n.; ZPAL Pf.VIII/56, Bärenthal, Oxfordian limestones (Beta); *a* × 3; *b* × 10.

Remarks. — The attribution of this species to *Placotelia* is only tentative for it shows no characteristic large canal openings or cavaedia on the gastral surface, which are typical of this genus, but the general shape and thick layer of pentactines does suggest a relationship with this genus. The most peculiar feature, *i.e.* massive dermal pentactines of this shape, are neither known in other species of *Placotelia* nor in any other fossil hexactinellid sponge, so perhaps it may be a new genus, but limited material precludes more precise determination. This species is close in morphology to *Discophyma levigatum* OPPLIGER, but differs from it in having the peculiar dermal pentactines and no knots on the lower side.

Occurrence. — Oxfordian limestones (Beta): Bärenthal.

Placotelia dolata OPPLIGER, 1907
(Pl. 21: 9)

1907. *Placotelia dolata* ETALL sp.; OPPLIGER, p. 14, pl. 5: 3.
1926. *Discophyma dolata* OPPLIGER; OPPLIGER, p. 22.

Material. — One fragmentary specimen.

Description. — Thin walled (about 6 mm thick) plate-like sponge, which may reach 15 cm in diameter. Its upper surface covered with numerous rounded (1.5 to 2.0 mm in size) canal openings which are irregularly distributed over the entire surface. These openings are separated by skeletal bands of the same width. Dictyonal strands are more or less parallel to both surfaces, with dictyonal skeleton irregular in the wall interior, with numerous synapticulae.

Remarks. — Contrary to TRAMMER's (1982) opinion, *P. dolata* seems to be a separate species. It differs from *P. marcoui* in having smaller canal openings, which are also rounded, not elongated, and in their completely irregular distribution over the surface.

Occurrence. — Oxfordian limestones (Beta): Lochen Nordwand.

Lychniscosa sp. n.
(Pl. 19: 12–14)

Material. — Five calcified specimens.

Description. — Small (up to 5 cm tall), narrow to widely conical (up to 4 cm in diameter) sponge with deep paragaster and 4–5 mm thick wall. Canal openings on the outer surface, (which are 0.6 to 1.0 mm in diameter) irregularly oval to rounded and very densely and evenly distributed, separated by very narrow skeletal bands about 0.2 mm wide. Dictyonal skeleton very irregular with numerous synapticulae.

Remarks. — This is definitely a new species, but material is too limited and poorly preserved for more precise description and attribution. It resembles *Cypellia* sp. n., but it is smaller and differently shaped, as well as having much more densely oragnized canal openings, resulting in a more loose dictyonal skeleton and thinner wall. In both cases there are numerous synapticulae enforcing the dictyonal skeleton and making it very irregular.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal.

Family **Sporadoscinidae** SCHRAMMEN, 1912

Genus *Sporadopyle* ZITTEL, 1877

Sporadopyle obliqua (GOLDFUSS, 1833)
(Pl. 19: 1–6, 8–10; Pl. 42: 1–3)

1937. *Sporadopyle obliqua* (GOLDFUSS); SCHRAMMEN, pp. 17–18, pl. 2: 6, pl. 11: 1.
1937. *Sporadopyle consorbina* n. sp.; SCHRAMMEN, p. 18.
1962. *Sporadopyle obliqua* (GOLDFUSS); LAGNEAU-HÉRENGER, p. 91, pl. 1: 9, fig. 13: 3.
1982. *Sporadopyle obliqua* (GOLDFUSS); TRAMMER, pp. 32–33, pl. 14.
1987. *Sporadopyle obliqua* (GOLDFUSS); MEYER *et al.*, p. 67, pl. 3: 2–5.

Material. — 31 specimens, some with well preserved siliceous spicules.

Description. — Small, only few cm tall, conical to elongated conical sponge with canal openings that measure from 1.0 × 0.6 mm to 1.6 × 1.0 mm and are organized in more or less regular vertical columns, in an alternating patterns. Canals straight. Dictyonal skeleton near dermal surface complicated, inside the wall very regular with mostly square meshes measuring from 0.12 × 0.20 mm to 0.2 × 0.2 mm, covered with short spiny rugosities. Dictyonal strands diverge toward both surfaces. In many places inside the lychniscosan-type skeleton one can find attached genuine hexactines with the same sculpture as lychniscs.

Remarks. — The only difference, according to SCHRAMMEN (1937), between *S. obliqua* and his new species *S. consorbina* is the size and number of "ostia" (= canal openings) on the dermal surface; I have found continuity of this character, as well as spiculation, in my material that points to conspecifity of these forms. The studied material contains also some specimens which are slightly larger than SCHRAMMEN's specimens and measure up to 4 cm in height. One must treat with some caution such determination of this genus which are not based on investigations of spiculation; there are morphologically identical sponges having clearly hexactinosan nature of dictyonal skeleton (Pl. 11: 2).

Occurrence. — Oxfordian marls (Alfa): Plettenberg, Lochen; Oxfordian limestones (Beta): Bärenthal; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler; Kimmeridgian marls (Delta): Hochwang, Hettingen; limestones of the Kimmeridgian (Delta): Erkenbrechtsweiler.

Sporadopyle pusilla SCHRAMMEN, 1937
(Pl. 19: 7; Pl. 42: 4, 5)

1937. *Sporadopyle pusilla* n. sp.; SCHRAMMEN, p. 18, pl. 12: 4.

Material. — 58 specimens, some with siliceous spicules.

Description. — Conical to elongated conical sponge, up to 8 cm tall and 2.5 cm wide at the osculum, with a wall 3–5 mm thick.

Canal openings on the dermal surface rounded and irregularly and densely distributed over the whole surface, measuring up to 1.6 × 0.8 mm across. Dictyonal skeleton complicated near the dermal surface and slightly thickened, but regular in the interior that mostly quadrate meshes which measure from 0.16 × 0.16 mm to 0.24 × 0.24 mm, smooth.

Remarks. — This species differs from *S. obliqua* (Goldfuss) in being larger, having nearly round and irregularly distributed canal openings and smooth dictyonal skeleton, which has generally larger meshes.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian crumpled limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Bärenthal, Plettenberg; Kimmeridgian marls (Gamma): Erkenbrechtsweiler, Bärenthal; Kimmeridgian marls (Delta): Hochwang, Bärenthal; Kimmeridgian limestones (Delta): Hochwang, Erkenbrechtsweiler.

Sporadopyle sp. n.
(Pl. 19: 11)

Material. — One specimen with partly preserved siliceous skeleton.

Description. — It is a tubular sponge about 10 cm tall and 3 cm in diameter, with wall 5 mm thick around a wide paragaster. Outer surface displays canal openings which alternate and form poorly defined vertical rows; they are rounded, about 2 mm in diameter, or oval and 2.8 × 2.0 mm in size and separated by skeletal bands 1.2 mm wide. These openings are slightly sunken, resulting in a rough appearance of the sponge surface. Dictyonal skeleton with regular meshes 0.25 × 0.20 mm in size, and with poorly developed cortex.

Remarks. — This sponge resembles *Sporadopyle pusilla* Schrammen in organization of canal openings (which are, however, much larger) and in general shape, but being much larger and having a relatively thick wall. Also dictyonal skelton is less regular. All this suggests that it is a new species, but limited material precludes a formal erection of a new taxon.

Occurrence. — Kimmeridgian marls (Delta): Hochwang.

Family **Ventriculitidae** Smith, 1848, emended Zittel, 1877

Genus *Pachyteichisma* Zittel, 1877

Emended diagnosis. — Conical to double-conical, or plate-like lychniscosan sponges with thick walls that are covered on both sides with radially oriented skeletal ridges. Canal openings large, located in furrows between ridges; canals extend radially from both sides but end blindly under the opposite surface; dictyonal skeleton very regular with square meshes.

Remarks. — Contrary to Zittel's (1877) opinion, as well as to the more recent one expressed by Mehl (1992) *Pachyteichisma* displays no folded wall, and this is the main reason for emendation of the diagnosis.

Pachyteichisma lamellosa (Quenstedt, 1878)
(Pl. 3: 5; Pl. 14: 3; Pl. 16: 3–5; Pl. 43: 10, 11; Fig. 24)

non 1833. *Cnemidium lamellosum*; Goldfuss, p. 15. pl. 6: 1.
1833. *Scyphia empleura* Münster; Goldfuss, p. 87, pl. 32: 1.
1878. *Lancispongia lamellosa tumulosa*; Quenstedt, p. 92, pl. 119: 1.
1878. *Lancispongia acuminata*; Quenstedt, p. 97, pl. 119: 7.
1910. *Pachyteichisma lamellosum* Goldfuss; Kolb, pp. 198–199.
1937. *Pachyteichisma lamellosa* Goldfuss; Schrammen, pp. 3–4.
1937. *Pachyteichisma lamellosa* var. *turbinata*; Schrammen, pp. 4–5.
1972. *Pachyteichisma lamellosum* (Goldfuss); Müller, pp. 3–9, pls 1–3.
1989. *Pachyteichisma lamellosa* (Goldfuss); Trammer, p. 80, pl. 16: 1.
1992. *Pachyteichisma lamellosa* (Goldfuss); Mehl, p. 122.

Material. — 19 specimens, some with siliceous spicules preserved.

Emended diagnosis. — Low to high conical *Pachyteichisma* with thick walls and wide and deep paragaster (Fig. 24), and thick irregular, radially oriented skeletal ridges on both sides. Canalization diplorhysal.

Remarks. — Kolb (1910), and following him also Schrammen (1937), erroneously synonymized the species *Cnemidium lamellosum* Goldfuss, 1826 (see Goldfuss 1826: pl. 6: 1, the specimen reillustrated here on the Pl. 16: 2) with *Lancispongia lamellosa* Quenstedt (see Quenstedt 1878: pl. 119: 1, reillustrated here on the Pl. 16: 5). This mistake has been repeated by all subsequent authors including Müller (1972); who noted, however, that this specimen, which is very flat, is at the margin of variability of *P. lamellosa*. Müller's conclusion caused further mistakes, such as the suggestion of Mehl (1992)

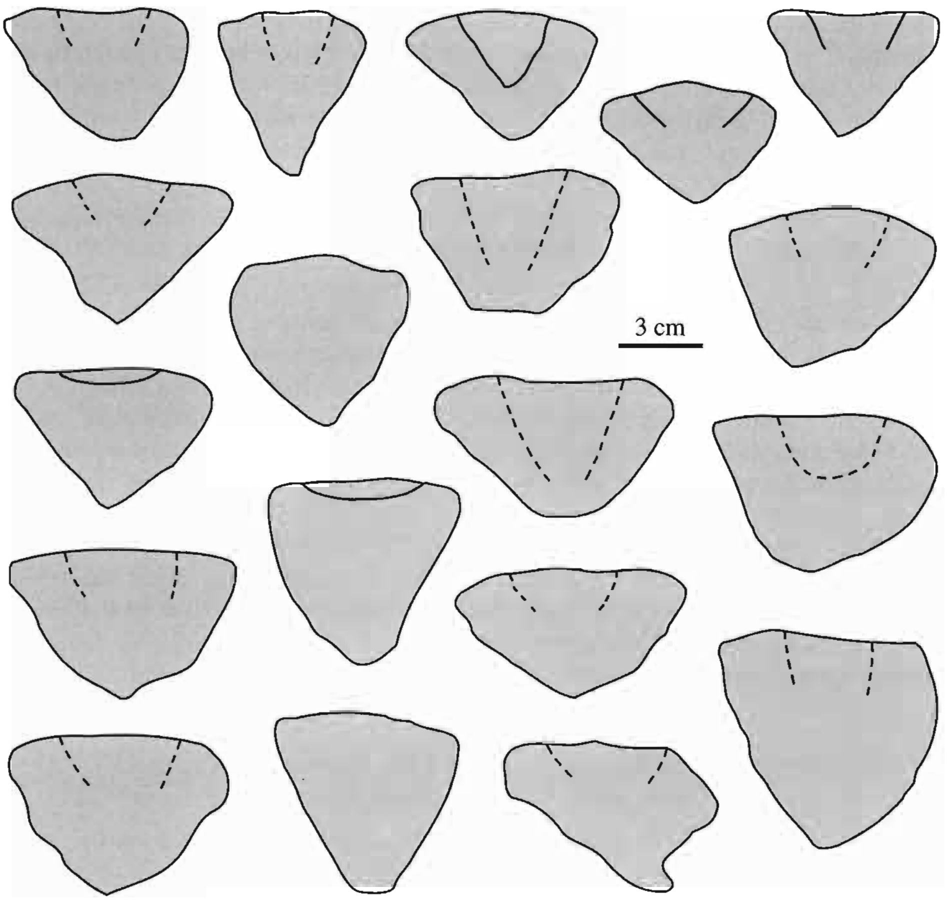


Fig. 24
Shape variability of *Pachyteichisma lamellosa* (QUENSTEDT).

that there is no difference between such species as *P. lamellosa* (GOLDFUSS), *P. lopas* (QUENSTEDT), *P. microstoma* (QUENSTEDT) and *P. gresslyi* (ETALLON). MEHL's (1992) opinion was based on an extremely simplified assumption (see MEHL 1992: fig. 31) that simple morphological measurements are sufficient for species differentiation in sponges, but that assumption is difficult to sustain. On the other hand, SCHRAMMEN (1937) indicated as a typical specimen, not the GOLDFUSS' (1826) specimen, but that of QUENSTEDT (1878: pl. 119: 1), and in effect all the latter synonymization have been done in comparisons with "*Lancispongia lamellosa tumulosa*" QUENSTEDT rather than *Cnemidium lamellosum* GOLDFUSS. I follow the practise of excluding the GOLDFUSS' specimen, which is synonymized with the species *Pachyteichisma microstoma* (QUENSTEDT) (see also remarks under *P. microstoma*). There is a great variability in the shape of this species (Fig. 24) expressed mostly in widths of paragasters (which may be narrow in young individuals) and wall thicknesses (which is smaller in large specimens); but also in the expression of radial skeletal ridges. A very detailed description of this species was given by MÜLLER (1972), but no formal diagnosis was provided to differentiate it from other species. MEHL (1992), on the other hand, defined it as having a radially folded wall, which is erroneous – these are the reasons for emending the diagnosis.

Occurrence. — Oxfordian limestones (Beta): Lochen Nordwand; Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Wilmandingen; Kimmeridgian marls (Delta): Hettingen, Hochwang, Genkingen.

Pachyteichisma lopas (QUENSTEDT, 1878)
(Pl. 5: 3; Pl. 15: 5; Fig. 25)

1878. *Lancispongia lopas*; QUENSTEDT, p. 95, pl. 119: 3, 4.
1910. *Pachyteichisma lopas* QUENSTEDT; KOLB, p. 199.
1937. *Pachyteichisma lopas* QUENSTEDT; SCHRAMMEN, p. 5.

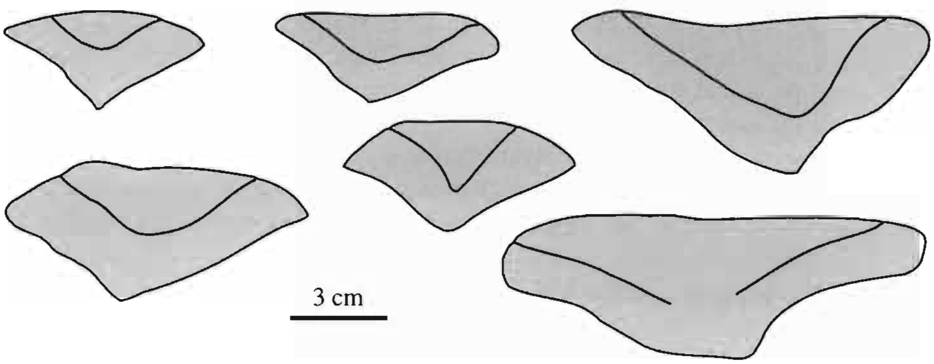


Fig. 25
Shape variability of *Pachyteichisma lopas* (QUENSTEDT).

Material. — Six specimens with calcified, but well preserved spiculation.

Emended diagnosis. — Very large, widely conical or discoidal (when young) to plate-like (when adult) *Pachyteichisma* with narrow and very regular radially oriented skeletal ridges, which may branch, on both sides.

Description. — These are large, up to 30 cm in diameter, sponges having a plate-like shape when adult but being very low discoidal when young and small (Fig. 25). Wall very thick up to 3 cm, and covered with rounded (when well preserved) radially oriented, skeletal ridges which are 3–4 mm wide, and may bifurcate. Canals openings measure 2 × 3 mm across (sometime up to 5 mm) are located in slightly more narrow furrows.

Remarks. — Small individuals of this species, which are also discoidal, slightly resemble *P. microstoma*, but they always have a wide paragaster and more regular skeletal ridges.

Occurrence. — Oxfordian crumpled limestones (Alfa): Bärenthal; Kimmeridgian marls (Gamma): Bärenthal; Kimmeridgian marls (Delta): Hettingen, Genkingen.

Pachyteichisma microstoma (QUENSTEDT, 1878)
(Pl. 15: 2–4; Pl. 16: 2; Fig. 26)

1833. *Cnemidium lamellosum*; GOLDFUSS, p. 15, pl. 6: 1.
1878. *Lancispongia microstoma*; QUENSTEDT, p. 98, pl. 119: 8.

Holotype: The specimen in QUENSTEDT (1878: pl. 119: 8).

Diagnosis. — Small discoidal *Pachyteichisma* with widely conical lower part and convex upper one, with very narrow osculum.

Material. — Twelve specimens, with calcified but very well preserved spiculation.

Description. — Relatively small discoidal sponges, up to 7 cm in diameter and 4.5 cm high, with low-conical lower part and very low conical or convex upper part (Fig. 26). Osculum very narrow, about 1 cm in diameter, walls up to 3 cm wide. Surface of the sponge covered with irregular and broken, radially oriented, narrow skeletal ridges, 2–4 mm wide, that commonly bifurcate on the upper part. Similar, but

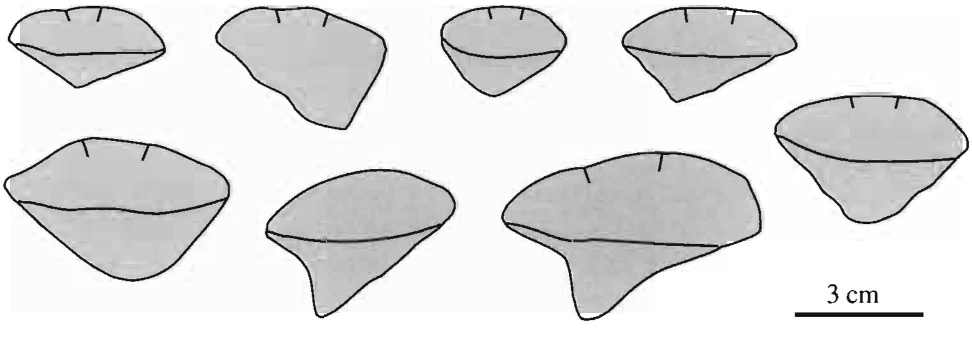


Fig. 26
Shape variability of *Pachyteichisma microstoma* (QUENSTEDT).

slightly narrower ridges occur on the paragaster surface. Narrow canals openings occur in slightly narrower furrows between ridges, and are 3 mm long and 2 mm wide. Skeleton very regular with square meshes 0.2–0.3 × 0.3 mm, which become irregular near the surface where the cortex is formed. Dictyonal strands diverge toward the outer surface.

Remarks. — There was never a formal diagnosis given by QUENSTEDT (1878) or MÜLLER (1972), who only mentioned this species more recently. *P. microstoma* differs from *P. gresslyi* (ETALLON) in having a very low upper part of the sponge, and more regular and narrower ridges, especially on the upper part of the sponge.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal; Kimmeridgian marls (Delta): Hettingen.

Pachyteichisma gresslyi (ETALLON, 1858)
(Pl. 15: 1)

1858. *Cephalocoelia gresslyi*; ETALLON, p. 536.
1860. *Cephalocoelia gresslyi*; ETALLON, p. 145, pl. 1: 11.
1907. *Pachyteichisma gresslyi* ETALLON; OPPLIGER, p. 9, pl. 4: 1.
1915. *Pachyteichisma gresslyi* ETALLON; OPPLIGER, p. 49, pl. 8: 4.
1926. *Pachyteichisma* cf. *gressly* (ETALLON); OPPLIGER, p. 31.
1972. *Pachyteichisma gresslyi;* MÜLLER, pl. 9: 1.
1972. *Pachyteichisma gresslyi* (ETALLON); GAILLARD, p. 126, pl. 2: 11–14.
1983. *Pachyteichisma gresslyi* (ETALLON); GAILLARD, p. 188, pl. 9: 1, 2.

Material. — Two specimens in my collection and several specimens from the collection of SMNS.

Diagnosis. — Small, double-conical sponge with very narrow osculum and very wide, irregular, radially organized skeletal ridges on both sides. Skeleton as in *P. microstoma* (QUENSTEDT).

Remarks. — This species is very close to *P. microstoma* and more material may prove that they are conspecific. The main difference is in morphological characters such as osculum size, width and regularity of ridges on the surface, and a more narrow shape.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Kimmeridgian marls (Delta): Genkingen.

Genus *Desmoderma* SCHRAMMEN, 1937
Desmoderma evestigata SCHRAMMEN, 1937
(Pl. 38: 9)

1937. *Desmoderma evestigata* n. sp.; SCHRAMMEN, p. 19, pl. 16: 3, 4.

Material. — Two poorly preserved specimens in author's collection and SCHRAMMEN's original (Tübingen).

Diagnosis. — Thin walled platy lychniscosan sponge with both surfaces bearing longitudinal skeletal ridges separated by furrows; canal openings in furrows, rounded on one side and oval on the opposite, canalization diplorhysal.

Description. — The investigated material is all fragmentary, represented by plates several centimeters large, which may have come from platy or widely conical sponges. The wall is thin, only 2–3 mm thick; both surfaces show longitudinal, low skeletal ridges about 1.8–2.0 mm wide, separated by furrows about 0.6–0.8 mm wide. Canal openings are situated in these furrows and are circular on one side and to oval on the other, in a craticularid pattern. Dictyonal skeleton with a cortex resulting from thickenings of rays and narrowing of meshes. Skeleton is very regular inside the wall, composed of smooth lychniscs fused into a very regular net with mostly square meshes (Pl. 38: 9) about 0.2 × 0.2 mm (up to 0.24 × 0.30 mm), with dictyonal strands nearly parallel to the surface and following the ridges on the surface.

Remarks. — Contrary to SCHRAMMEN's (1937) opinion the sponge has no radially folded wall, but a sculpture of longitudinal ridges. This, and the fact that SCHRAMMEN (1837) did not present a formal diagnosis, is the reason for presenting the diagnosis here. There are no other lychniscosan species in the Jurassic resembling *Desmoderma evestigata*; those which have some morphological similarities belong to Hexactinosa.

Occurrence. — Kimmeridgian marls (Delta): Hochwang, Bärenthal.

Family **Diapleuridae** IJIMA, 1927

Genus *Trochobolus* ZITTEL, 1877

1877. *Trochobolus* ZITTEL.
1937. *Pachyrhachis* SCHRAMMEN.

Remarks. — Both *Trochobolus* and *Pachyrhachis* have been described as having labyrinthically folded walls. The only difference between them, according to SCHRAMMEN (1937), is size (but even in his collection one can find large *Trochobolus* specimens which are well within the size range of *Pachyrhachis*) and character and size of folds on the outer surface. These are only morphological characters, not underlain by any skeletal differences. In effect, both genera are here synonymized, under *Trochobolus* ZITTEL, 1877, which has priority over *Pachyrhachis*. On the other hand, one cannot agree that this genus has a folded wall – it simply has schizorhysal canalization and large irregular outgrowths of the dictyonal skeleton on the dermal surface. Contrary to the SCHRAMMEN'S (1937) diagnosis of *Trochobolus*, which states that it has smooth lychniscs, different species of *Trochobolus* (from his original collection) have smooth or rugose lychniscs.

The genus *Trochobolus* is very close to the Recent genus *Diapleura* IJIMA, 1927, both in general structure (compare MEHL 1992), and in some peculiarities of spiculation (see remarks to *T. texatus* below), and *Trochobolus* SCHRAMMEN, 1937 may in fact be a younger synonym of *Diapleura* IJIMA, 1927.

Trochobolus texatus (GOLDFUSS, 1833)

(Pl. 17: 1, 2, 4–6; Pl. 41: 4–6; Pl. 42: 6; Fig. 27)

1962. *Trochobolus texatus* (GOLDFUSS); LAGNEAU-HÉRENGER, p. 89, fig. 13: 9.
1989. *Trochobolus texatus* (GOLDFUSS); TRAMMER, p. 81, pl. 15: 3, pl. 17: 3 (cum syn.).
1992. *Trochobolus texatus* GOLDFUSS; MEHL, p. 131.

Material. — 18 specimens, some with original skeleton preserved.

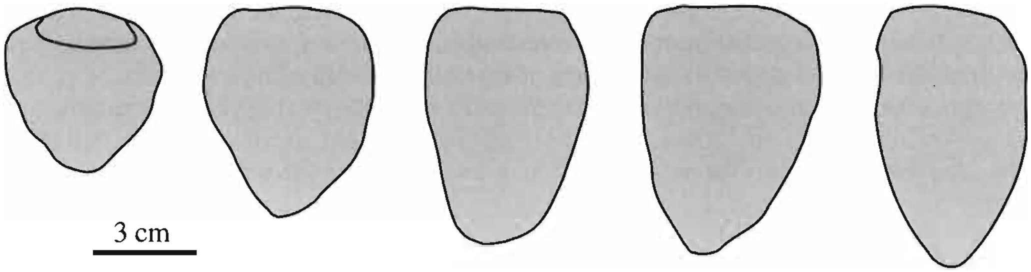


Fig. 27
Shape variability of *Trochobolus texatus* (GOLDFUSS).

Remarks. — Meshes of dictyonal skeleton are very regular, usually square and measure 0.2 mm up to 0.3 mm in size, being smaller near the surface. Canal openings on the dermal surface are elongate to oval, large and measure 1.6 to 2.0 mm in length. Dictyonal strands strongly bent toward the dermal surface from mid-wall, and nearly parallel to the gastral surface in 1/3 of the wall. Transverse rays occur at the same level producing a very regular appearance of the skeleton. Canalization schizorhysal. Portions of the skeleton near the canal surfaces are composed of genuine hexactines, not lychniscs. In some specimens, inside the choanosomal skeleton and without disrupting its course, occur small (2–3 mm in diameter) spherical skeletal bodies composed of irregularly fused hexactines with meshes much smaller than those in the main skeleton. They resemble skeletons of young buds, illustrated by IJIMA (1901) in *Rhabdocalyptus* SCHULZE and by MEHL (1992) in *Staurocalyptus* SCHULZE (see also above). Similar single true hexactines and spherical skeletal bodies composed of fused hexactines are known to occur in the Recent lychniscosan sponge *Diapleura maasi* IJIMA. Both species are nearly identical in structure and morphology, and only the time span separating them precludes me from including them in one genus. There is no doubt, however, that both genera are closely related. Dictyonal skeleton of SCHRAMMEN'S (1937) specimens (Pl. 42: 6) clearly show spine-like rugosities on the lychniscs, but they are not visible on my material (Pl. 41: 4), which is, however, strongly etched.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian crumpled limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Bärenthal; Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Erkenbrechtsweiler; Kimmeridgian limestones (Delta): Erkenbrechtsweiler; Kimmeridgian marls (Delta): Genkingen, Hochwang.

Trochobolus suevicus SCHRAMMEN, 1937
(Pl. 17: 3, 7–9; Pl. 38: 6, 7; Pl. 42: 7, 8)

1937. *Trochobolus suevicus* n. sp.; SCHRAMMEN, p. 10, pl. 24: 3.

Material. — Four specimens, all with siliceous skeletons preserved.

Remarks. — My specimens are up to 7 cm tall and 5.5 cm wide at the osculum. This species differs from *T. texatus* (GOLDFUSS) in having a completely irregular jagged surface (particular outgrowths and ridges are up to 3 mm long and 2–3 mm high) and in skeletal features. Meshes of the choanosomal skeleton are larger than in *T. texatus* (GOLDFUSS) and measure from 0.35 × 0.40 mm to 0.45 × 0.45 mm. On the dermal surface a cortex is formed by thickening of rays and addition of new spicules. Canal openings located in irregular furrows between skeletal outgrowths are elongate-oval and measure 0.6 to 2.0 mm long.

Occurrence. — Kimmeridgian marls (Gamma): Erkenbrechtsweiler; Kimmeridgian marls (Delta): Hochwang.

Trochobolus cylindratus OPPLIGER, 1915
(Pl. 18: 1, 4, 6; Fig. 28)

1915. *Trochobolus cylindratus* sp. nov; OPPLIGER, pp. 52–53, pl. 8: 5.
1937. *Pachyrhachis cylindrata* n. sp.; SCHRAMMEN, pp. 6–7.

Material. — 24 variously preserved specimens.

Remarks. — Canal openings on the dermal surface are from 1.6 to 3.0 mm long and about 2 mm wide, and are situated in furrows between irregular ridges and tooth like spines, up to 5 mm wide and 10 mm long. Canalization schizorhysal, 2–3 mm wide. Dictyonal skeleton inside the wall very regular with square meshes 0.3 × 0.3 mm. Dictyonal strands diverge toward the dermal surface. Dictyonal skeleton has developed dermal cortex produced by thickening of rays and addition of new spicules.

This species differs from other species of *Trochobolus* in its shape (Fig. 28) and large size (up to 11 cm in my collection and up to 15 cm in SCHRAMMEN's collection), in development of larger skeletal outgrowths (and their shape) on the dermal surface, as well as size of the skeletal meshes and details of canalization.

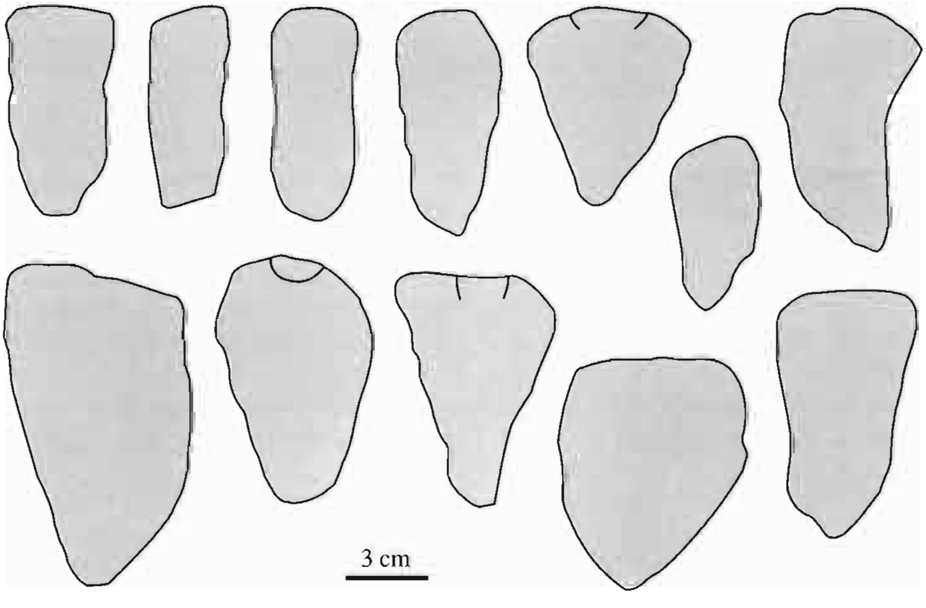


Fig. 28
Shape variability of *Trochobolus cylindratus* OPPLIGER.

Occurrence. — Oxfordian crumpled limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Bärenthal; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler; Kimmeridgian marls (Delta): Hochwang, Genkingen; Kimmerdgian limestones (Delta): Erkenbrechtsweiler.

Trochobolus dentatus KOLB, 1910
(Pl. 39: 9; Fig. 29)

1962. *Trochobolus dentatus* KOLB; LAGNEAU-HÉRENGER, p. 89, fig. 13: 8.
1989. *Trochobolus dentatus* KOLB; TRAMMER, p. 81 (cum syn.).

Material. — Two specimens.

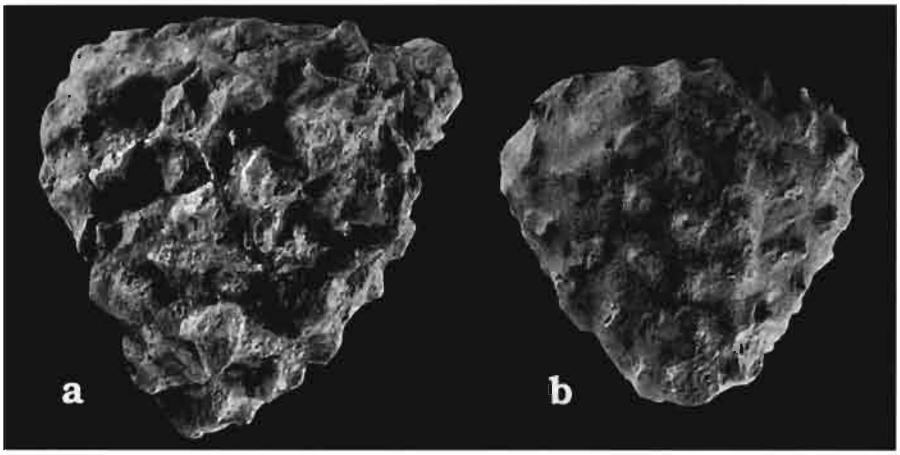


Fig. 29
Trochobolus dentatus KOLB, 1910. *a* ZPAL Pf.VIII/501, Bärenthal, Kimmeridgian marls (Gamma) × 1.5; *b* ZPAL Pf.VIII/502, Hochwang, Kimmeridgian marls (Delta) × 1.5.

Remarks. — The main difference between this species and *T. texatus* (GOLDFUSS) is the shape of skeletal ridges and outgrowths; in *T. dentatus* they are tooth-like and separate from each other, while in *T. texatus* often joined and forming connected network; dictyonal skeleton has meshes of the same size but is less regular (Pl. 39: 9) in *T. dentatus*. In my opinion, these differences are enough to consider them as separate species, contrary to MEHL's (1992) opinion. Relationship between this species and *T. tuberculatus* LAGNEAU-HÉRENGER, from the Lower Cretaceous need to be clarified for the main difference is in the more conical shape and thicker wall of the latter.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal; Kimmeridgian marls (Delta): Hochwang.

Trochobolus labyrinthicus (SCHRAMMEN, 1937)
(Pl. 13: 3, 7; Pl. 41: 1–3)

1937. *Pachyrhachis labyrinthica* n. sp.; SCHRAMMEN, p. 7, pl. 25: 3.

Material. — 21 specimens with well preserved spiculation.

Remarks. — The main difference between this species and other species of *Trochobolus* is the double-conical shape of the sponge and the very narrow paragaster. Also skeletal meshes are slightly smaller than in other species and measure 0.2 × 0.2–0.3 mm. My specimens are smaller than SCHRAMMEN's (1937) and reach only 7 cm tall.

In one of the investigated specimens, a large smooth pentactine, typical of a dermal layer, has been found incorporated into the middle of choanosomal skeleton; a similar observation was made in the case of *Cypellia rugosa* (GOLDFUSS), but there the dermal pentactines are usually fused and well preserved in most specimens. This suggests that *T. labyrinthicus* had, in fact, a dermal layer of loose pentactines, which are simply not preserved in known material.

Occurrence. — Oxfordian crumpled limestones (Beta): Bärenthal; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler, Hettingen, Wilmandingen; Kimmeridgian limestones (Delta): Hochwang, Erkenbrechtsweiler; Kimmeridgian marls (Delta): Genkingen, Hochwang.

Trochobolus cupulus (Schrammen, 1937)
(Pl. 18: 5, 8; Fig. 30)

1937. *Pachyrhachis cupula* n. sp.; Schrammen, p. 6, pl. 10: 10.

Material. — Seven specimens with well preserved skeletons.

Remarks. — The main difference between this species and *T. cylindratus* Oppliger is the cylindrical shape with a narrow paragaster in the latter, and a widely conical shape with a relatively wide paragaster and thicker wall in the former (Fig. 30). Mesh sizes of choanosmal skeleton are similar, *i.e.* 0.2–0.3 × 0.3 mm, but skeleton is less regular, and rectangular and trapezoidal meshes are common in the species here.

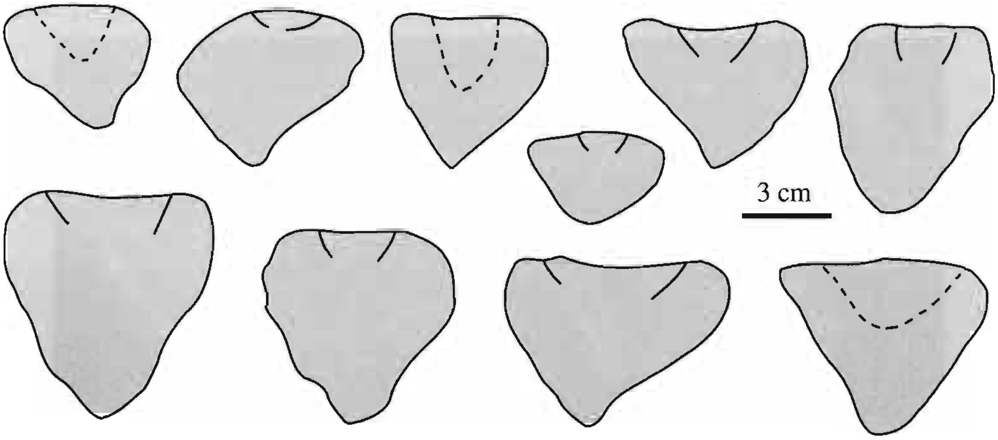


Fig. 30
Shape variability of *Trochobolus cupulus* (Schrammen).

Occurrence. — Oxfordian limestones (Beta): Plettenberg; Kimmeridgian marls (Gamma): Bärenthal; Kimmeridgian marls (Delta): Hochwang, Genkingen; Kimmeridgian limestones (Delta): Erkenbrechtsweiler.

Family **Neoaulocystidae** Zhuralvleva, 1962

Genus *Phlyctaenium* Zittel, 1877

Phlyctaenium coniforme (Quenstedt, 1878)
(Pl. 18: 2, 7)

1826. *Scyphia verrucosa* nobis; Goldfuss, p. 7, pl. 2: 11.
1937. *Phlyctaenium coniforme* Quenstedt; Schrammen, p. 8 (cum syn.).

Material. — Two specimens

Remarks. — The studied material is calcified but very well preserved, and clearly shows the presence of low tubular outgrowths with large (up to 2 mm) canal openings at the end. Meshes of the not very regular dictyonal skeleton are square to rectangular and measure 0.3 × 0.3–0.4 mm.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal.

Genus *Camerospongia* d'Orbigny, 1847

Camerospongia? sp. n.
(Pl. 32: 3)

Material. — Three specimens.

Description. — Small, up to 44 mm in diameter and 23 mm tall, hemispherical to flattened hemispherical sponges with smooth upper surface (suggesting that it was covered with a siliceous membrane) and a very irregular lower one (attachment surface). Single osculum 15 mm wide and situated at the top. Skeleton composed of lychniscs with regular meshes 0.24 × 0.30 mm to 0.3 × 0.4 mm in size.

Remarks. — In general shape the species resembles *Multiloqua fungiformis* (Goldfuss), but that species has hexactines not lychniscs. Morphologically, this sponge also resembles Cretaceous genus

Camerospongia, in which, however, the wall is composed of intermingled skeletal tubes. Because preservation of our material does not allow recognition of such details, attribution is only tentative. There are no doubts, however, that our specimens are different from any Jurassic sponges described so far.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal.

Genus *Cavispongia* QUENSTEDT, 1878

Remarks. — KOLB (1910) included here two species *C. cylindrata* and *C. porata*, which differ mostly in gross morphology and size, and number of tubes composing the sponge. Most probably they are conspecific, but my material is too limited (and the museum specimens could not be cut) for solution of this problem.

Cavispongia cylindrata QUENSTEDT, 1878
(Pl. 12: 1, 2; Pl. 14: 1)

1878. *Cavispongia cylindrata*; QUENSTEDT, p. 158, pl. 122: 19–21.

1910. *Cavispongia cylindrata* QUENSTEDT; KOLB, p. 196.

Material. — Two specimens in author's collection (several other were examined in SMNS colection).

Diagnosis. — Massive, irregularly conical lychniscosan sponge without paragaster, composed of tightly and vertically packed thin-walled (wall 2 mm thick) tubes with oscules at the top; secondary oscula on lateral surfaces.

Description. — This sponge is usually conical and composed of numerous tightly packed (vertically oriented), thin-walled tubes that have oscular openings on the flat or slightly concave upper surface. My specimens are rather small and measure only 26 mm tall and 28 mm wide, but this sponge may be two to three times larger. Numerous oscula (up to 15) are 2–4 mm wide. Lateral surface of the sponge is covered with numerous irregular outgrowths (up to 5 mm across and 3 mm high), which are separated by meandering deep and narrow (2 mm wide) furrows. Secondary oscula, about 3 mm wide are present atop some furrows.

Skeleton very regular, no cortex was present in my specimens. In one place a large and stout ?pentactine has been found attached to the dictyonal skeleton, which may be part of dermal skeleton. Meshes of the dictyonal skeleton square and 0.2 × 0.2 mm large.

Remarks. — Specimens in the museum collections, *i.e.* QUENSTEDT's originals and MÜLLER's collection in SMNS, have not been etched, so no details of spiculation were observed; but organization of this sponge is so unique among the Upper Jurassic sponges that their attribution causes no doubts.

Occurrence. — Kimmeridgian marls (Gamma): Wilmandingen; crumpled marly limestones of the Kimmeridgian (Delta): Hettingen.

Genus *Centrosia* SCHRAMMEN, 1910

Remarks. — The Jurassic genus *Ceriodictyon* OPPLIGER, 1915 is very close to *Centrosia,* and most probably should be synonymized.

Centrosia jurassica MÜLLER, 1994
(Pl. 9: 2)

1994. *Centrosia jurassica* n. sp.; MÜLLER, pp. 1–9, figs 1–4, pl. 2: 1, 2.

Material. — One specimen with calcitized but well preserved spicules.

Remarks. — The holotype is a very large sponge, with my specimen measuring only 45 × 40 mm and about 1 cm thick. It shows, however, all the features of *C. jurassica* MÜLLER. Skeleton is calcified but well preserved and displays all square meshes 0.3 × 0.3 mm large in the interior.

Occurrence. — Kimmeridgian limestones (Epsilon): Hermaringen.

Lychniscosa incertae sedis

Genus *Xenoschrammenum* DE LAUBENFELS, 1955 (= *Amphiblestrum* SCHRAMMEN, 1937)

Emended diagnosis. — Plate-like or funnel-shaped lychniscosan sponge with thin wall and canal openings densely distributed on both surface and in alternate or irregular pattern. Canalization diplorhysal.

Remarks. — This genus was included by SCHRAMMEN (1937) into Hexactinosa incertae sedis. Reinvestigation of SCHRAMMEN's specimens, as well as of the new very well preserved specimens housed in the SMNS, revealed that it is a lychniscosan sponge, but with subdermal lychniscs occluded (Pl. 37: 6, 8). Suggestion that this genus is a lychniscosan sponges was already expressed by REID (1963b), a fact overlooked by later authors. SEM pictures of their skeleton, given here, leave no doutbs, however, about their true taxonomic position.

TRAMMER (1982), who had very poorly preserved material, included the species *Tremaphorus punctatus* SCHRAMMEN into the genus *Xenoschrammenum* based on morphological characters and observations by WAGNER (1963). Because reinvestigation of SCHRAMMEN's original showed that *T. punctatus* species is a true hexactinosan sponge, the species is excluded from *Xenoschrammenum* and the genus *Tremaphorus* is revived (see above). For these reasons emendation of the diagnosis is given above.

Xenoschrammenum alternans (SCHRAMMEN, 1937)

1937. *Amphiblestrum alternans* n. sp.; SCHRAMMEN, p. 58, pl. 8: 1, 2, pl. 13: 2.
?1982. *Xenoschrammenum alternans* SCHRAMMEN; TRAMMER, p. 28, pl. 11: 7.

Material. — One fragmentary specimen in author's collection and three SCHRAMMEN's specimens (Tübingen).

Diagnosis. — Lychniscosan sponge with thin wall and plate-like shape having small, oval or rounded canal openings organized in alternating pattern and densely distributed.

Description. — The sponge is always preserved as plate-like fragments, but most probably comes from a wide-conical form. Both sides display canal openings organized in alternating patterns. These openings are oval and more obviously alternating on one side; they measure 1.4 × 2.0 mm in size, or are rounded and less regularly arranged on the other where they are also smaller (0.6–1.0 mm). Dictyonal skeleton regular inside the wall (with cortex and irregular on the surface) with regular meshes 0.4 × 0.4 mm in size.

Remarks. — TRAMMER (1982) illustrated, under this name, a sponge with very similar morphology, but having no spicules preserved, thus his attribution is uncertain. The specimen in my collection has spicules entirely calcified, but undoubted lychniscs occur in the deeper part of the wall, as is the case in the holotype. SCHRAMMEN's (1937) specimen has generally smaller canal openings, but the rest of characters are identical to my specimen.

Occurrence. — The only specimen in my collection comes from a marly intercalation in the Oxfordian limestones (Beta) from Tieringen. SCHRAMMEN's specimens are from the Kimmeridgian limestones (Epsilon) at Heuchstetten.

Xenoschrammenum venosum (SCHRAMMEN, 1937)
(Pl. 11: 1, 8; Pl. 12: 8; Pl. 37: 6–8)

1937. *Amphiblestrum venosum* sp. n.; SCHRAMMEN, p. 58, pl. 3: 12, pl. 24: 4.

Material. — Three fragmentary specimens have been investigated, only one is in my collection.

Remarks. — Both SCHRAMMEN's holotype, the specimen in SMNS, and my specimen are identical in gross morphology and canalization. In the holotype, however, most lychnisc nodes are obliterated; they are clearly visible in my specimen, which is devoid of the outer part of the choanosomal skeleton.

Occurrence. — SCHRAMMEN's specimen came from the Kimmeridgian limestones (Epsilon) from Heuchstetten; the illustrated specimen from SMNS was found in Sontheim am Brenz (an old built over quarry – Kimmeridgian limestones, Epsilon); my specimen was found in the Oxfordian limestones (Beta) at Plettenberg.

Genus *Porocypellia* ZITTEL, 1877

Remarks. — This genus has been assigned by SCHRAMMEN (1937) to Hexactinosa; reinvestigation of GOLDFUSS' specimens (1826: pl. 3: 9; here illustrated Pl. 20: 2, 3) as well as new well-preserved material prove that, in fact, it is a lychniscosan sponge, as earlier suggested by ZITTEL (1877) and KOLB (1910).

Porocypellia piriformis (GOLDFUSS, 1833)
(Pl. 20: 1–3; Pl. 21: 4)

1833. *Scyphia piriformis*; GOLDFUSS, p. 10, pl. 3: 9.
1926. *Porocypellia pyriformis* GOLDFUSS; OPPLIGER, p. 26 (cum syn.).

1937. *Porocypellia piriformis* GOLDFUSS; SCHRAMMEN, p. 49, pl. 10: 4.

Material. — Three specimens in author's collection and several original specimens of GOLDFUSS (1833) and SCHRAMMEN (1937).

Diagnosis. — Small hemispherical to club-shaped lychniscosan sponge with thickened dermal layer of dictyonal skeleton pierced by numerous circular pores; osculum single at the top.

Description. — Small hemispherical to club-shaped sponge, up to 1 cm high and 1.3 cm wide at the top, with rounded oscular margin and osculum 3 mm wide. Surfaces of well-preserved specimens display a thickened outer layer of dictyonal skeleton with reduced octahedral nodes. This layer is pierced only by small (0.10 to 0.25 mm large) circular pores, which are irregularly but evenly distributed on the whole surface. Dictyonal skeleton regular with smooth lychniscs, without synapticular net, and with meshes up to 0.3 × 0.4 mm.

Remarks. — Despite the clear statement of ZITTEL (1877) and the illustration by OPPLIGER (1897) indicating the presence of lychniscs, SCHRAMMEN (1937) attributed this species to the Hexactinosa. This happened, most probably, because the sponge has a thick siliceous membrane over the dermal surface and the choanosomal skeleton is not clearly visible on SCHRAMMEN's specimens. When uncovered at bases of the sponges, occluded lychnisc nodes are seen both in the GOLDFUSS' (1833) and SCHRAMMEN's (1937) originals. Cortex resembles the siliceous membrane of *Porospongia*. It also has no stauractines in the dermal layer. Because these, and as earlier authors never presented a formal diagnosis, it is presented here.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Kimmeridgian marls (Gamma): Bärenthal; limestones of the Kimmeridgian (Delta): Genkingen.

Genus *Rhogostomium* SCHRAMMEN, 1937

Rhogostomium corrugatum SCHRAMMEN, 1937

(Pl. 39: 10)

1937. *Rhogostomium corrugatum* sp. n.; SCHRAMMEN, p. 58, pl. 2: 9, pl. 5: 6, 9, pl. 27: 3.

?1982. *Rhogostomium corrugatum* SCHRAMMEN; TRAMMER, p. 32, pl. 13: 2.

Remarks. — This species was originally assigned by SCHRAMMEN (1937) to the Hexactinosa. But its skeleton consists of lychniscs (see Pl. 39: 10), althought commonly with occluded octahedral nodes in the subdermal region. In the SCHRAMMEN's collection in Tübingen, however, there is another specimen as well which is without doubt hexactinosan sponge (see Pl. 39: 11); this specimen represents some other hexactinosan genus. TRAMMER's specimen has no spiculation preserved well enough to be sure about its taxonomic position.

Occurrence. — Kimmeridgian limestones (Epsilon): Heuchstetten.

Genus *Coscinaulus* SCHRAMMEN, 1937

Coscinaulus micropora SCHRAMMEN, 1937

1937. *Coscinaulus micropora* n. sp.; SCHRAMMEN, p. 20, pl. 9: 1.

Material. — Two calcified specimens.

Remarks. — My two specimens are 2.5 cm long and 1.5–2.0 cm wide with walls only 2–3 mm thick. Meshes of the regular dictyonal skeleton are 0.25 × 0.30 mm in size. Canal openings on the outer side are irregularly rounded and 0.6–0.8 mm in diameter. On the surface the dictyonal skeleton is only slightly thickened and irregular.

Occurrence. — Kimmeridgian marls (Delta): Hettingen.

Genus *Lychniscaulus* SCHRAMMEN, 1937

Lychniscaulus vannus SCHRAMMEN, 1937

1937. *Lychniscaulus vannus* n. sp.; SCHRAMMEN, p. 18, pl. 2: 10, pl. 4: 10, pl. 11: 11.

Material. — Three specimens with calcified spicules.

Remarks. — My specimens agree in all characters with SCHRAMMEN's (1937) description; dictyonal skeleton is not very regular and has square meshes 0.2 × 0.2 mm in size.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal; Kimmeridgian marls (Delta): Hochwang.

Class **Demospongea** SOLLAS, 1875

Order **Haplosclerida** TOPSENT, 1928

Family **Adociidae** DE LAUBENFELS, 1936

Genus *Aka* JOHNSON, 1899

Aka muelleri REITNER *et* KEUPP, 1991

(Fig. 31)

1978. Monactinen Kieselschwamms; MÜLLER, p. 9, pl. 5.
1991. *Aka muelleri* n. sp.; REITNER and KEUPP, p. 107, figs 6–8.

Material. — Several well preserved borings in calcareous sponge mummies contain spicules; numerous other fragments have been observed in both hexactinellid and lithistid sponges.

Remarks. — The spicules in my material are identical with those presented by REITNER and KEUPP (1991), and measure 1.0–1.2 mm in length and 0.06–0.08 mm in width.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Kimmeridgian marls (Gamma): Bärenthal.

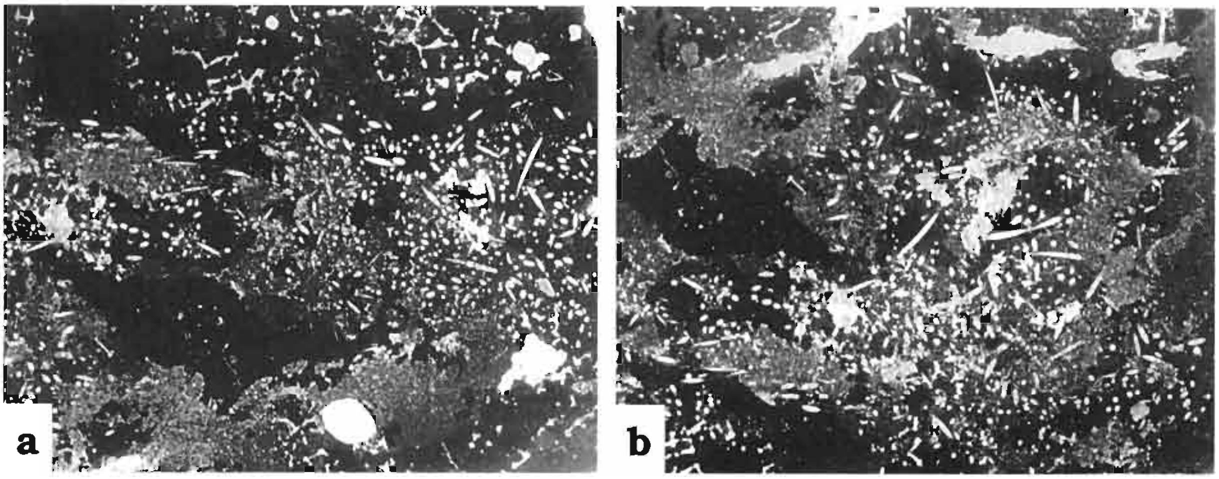


Fig. 31
Aka muelleri REITNER *et* KEUPP, ZPAL Pf.VIII/554, Plettenberg, Oxfordian, thin section. *a* × 7; *b* × 12.

Order incerate sedis

Genus *Helminthophyllum* SCHRAMMEN, 1937

Remarks. — This genus was attributed by SCHRAMMEN (1937) to Tetraxonia SCHULZE with megascleres (in opposition to Tetraxonia with desmas), Kyphorabdophora SCHRAMMEN. This is entirely informal rank, thus its position must be regarded as incertae sedis. It seems that it is of sublithistid grade.

Helminthophyllum cf. *feifeli* SCHRAMMEN, 1937

cf. 1937. *Helminthophyllum feifeli* n. sp.; SCHRAMMEN, pp. 69–70, pl. 21: 10.

Material. — One specimen.

Remarks. — This is a small platy fragment, 0.5 mm thick, of a sponge composed of loosely felted kyphorabds. No canalization has been observed. Desmas are up to 1 mm long and 0.1 mm thick. My specimen is calcified, but desmas are very characteristic allowing for determination; on the other hand, it has no dermal spicules preserved, and being a very small fragment difficult in assignment.

Occurrence. — Kimmeridgian marls (Delta): Hochwang.

"Lithistida"

Suborder **Megamorina** ZITTEL, 1878

Remarks. — Genera included here were separated by SCHRAMMEN (1937) into Megamorina ZITTEL and Helomorina SCHRAMMEN. As there are more recent suggestions (REID 1968b) that megaclones and heloclones are homologous spicules I treat them here together following WIEDENMAYER (1994) in this respect for the reason of convenience.

Genus *Pachycoton* SCHRAMMEN, 1912

Pachycoton quenstedti (KOLB, 1910)
(Pl. 47: 13)

1937. *Pachycoton Quenstedti* KOLB; SCHRAMMEN, p. 76, pl. 18: 1, 2 (cum syn.).

Material. — 19 specimens in my collection and one excellently preserved specimen from SMNS.

Remarks. — All my specimens are plate-like fragments with very variable wall thickness – from as little as 3 mm to about 1 cm. Canal openings, which are also very variable, especially in distribution density, are smaller than in SCHRAMMEN's (1937) specimens and measure 0.6–1.0 mm in diameter. Desmas are heloclones 0.14–0.16 mm thick and at least 1.6 mm long, displaying completely irregular organization, and are only slightly curved. In places of contacts there are zygomes developed on generally smooth spicules. Inside the wall the meshwork is much more loose than on the surface. In one specimen with siliceous spicules preserved, dermal dichotriaenes have been found in place (Pl. 47: 13). They have wide, massive clads with short arms and are of a type unknown in other Upper Jurassic sponges.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Erkenbrechtsweiler; Kimmeridgian marls (Delta): Hochwang; Kimmeridgian limestones (Delta): Blaubeuren; Kimmeridgian crumpled marly limestones (Delta): Hettingen; Kimmeridgian limestones (Zeta): Niederstozingen.

Genus *Heterostinia* ZITTEL, 1878

Heterostinia? sp.

Material. — 13 calcified specimens.

Description. — These are plate-like fragments of various size, the largest being 3 × 4 cm across and with variable wall thickness reaching 1 cm. Desmas are strongly curved and poorly branched, organized into a regular pattern producing meshes that are irregular in outline but very similar in shape and size, measuring 0.4–0.8 mm. No other canal openings on the surface were observed. Desmas reach to 0.8 mm in size and are 0.12–0.14 mm thick, and are fused along zygomes and at all numerous points of contact.

Remarks. — The main difference between *Pachycothon quenstedti* (KOLB) and *Heterostinia*? sp. is the shape of desmas, which are only slightly curved heloclones in *P. quenstedti,* and where they are felted into completely irregular meshwork. In *Heterostinia*? sp. they are always slightly branched, strongly arched and forming a regular meshwork; this species also lacks any visible canal openings, except meshes of the skeleton. Its desmas resemble desmas of *Doryderma* ZITTEL (Cretaceous genus) which has well developed canalization. Because all my specimens are calcified, I was not able to study details of spicules, and thus there is uncertainity in attribution.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler, Wilmandingen; Kimmeridgian marls (Delta): Hochwang; Kimmeridgian limestones (Delta): Hochwang, Blaubeuren.

Genus *Heloraphinia* SCHRAMMEN, 1937

Heloraphinia? sp.
(Fig. 32)

Material. — One fragmentary specimen.

Description. — Cylindrical sponge 8 cm high and 3.5 cm in diameter without paragaster. Canal openings on the surface are 1.2 mm in size and are irregularly but equally distributed over the whole surface. Heloclones about 0.16–0.20 mm thick and at least 2 mm long.

Remarks. — The only earlier known species of this genus, *Heloraphinia arborescens* SCHRAMMEN from the Upper Jurassic of the Swabian Alb is branched, less thick and nothing about canalization is reported, thus attribution to this genus is only tentative.

Occurrence. — Kimmeridgian crumpled marly limestones (Delta): Hettingen.

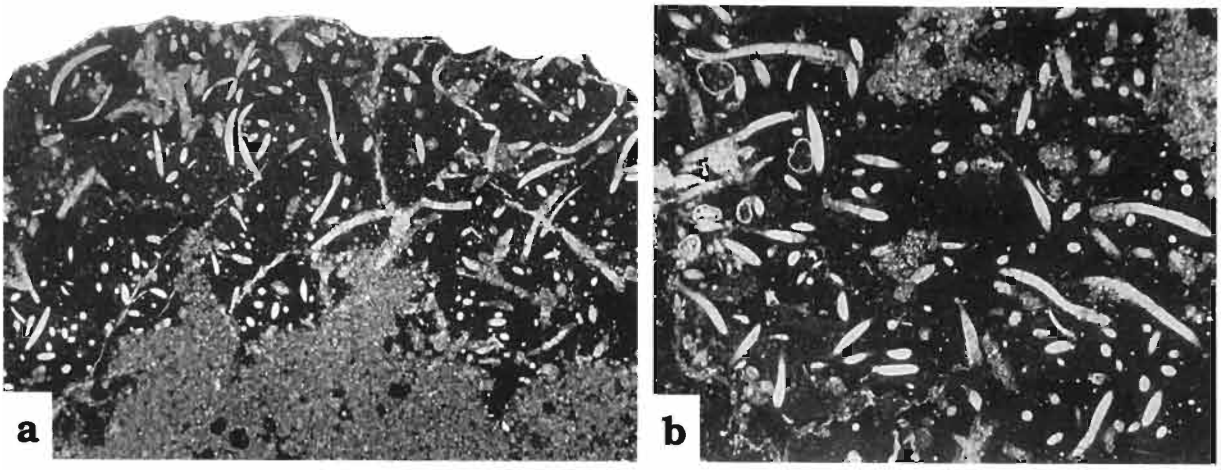


Fig. 32
Heloraphinia? sp. , ZPAL Pf.VIII/551, Hettingen, Kimmeridgian crumpled marly limestones (Delta), transverse thin section; *a* note loosely felted heloclones, × 6; *b* another enlarged fragment, × 12.

Genus *Megalithista* ZITTEL, 1878

Megalithista cf. *foraminosa* ZITTEL, 1878
(Pl. 29: 2, 3)

cf. 1937. *Megalithista foraminosa* ZITTEL; SCHRAMMEN, p. 74, pl. 18: 5, 6, pl. 25: 4 (cum syn.).

Material. — Two specimens.

Remarks. — Bodily preserved sponges have been examined only in the collection of SMNS; in my own material only loose spicules attributable to this species have been found. The SMNS specimens show radially meandering furrows running from the oscula, which were not mentioned by SCHRAMMEN (1937). The rest of characters are identical with SCHRAMMEN's description.

Occurrence. — Upper Jurassic, localities and exact age unknown.

Megalithista sp.

Material. — One calcified specimen.

Description. — Small, 3 cm in diameter, spherical sponge without any paragaster or canal openings. Desmas as large, poorly branched megaclones, up to 1 mm long and 0.10–0.12 mm thick. Skeletal meshes on the surface up to 1 mm in size.

Remarks. — Similar sponge has been described as *M. minuta* KOLB, but it displays canalization which is absent in the investigated material.

Occurrence. — Kimmeridgian marls (Gamma): Erkenbrechtsweiler.

Genus *Anomorphites* KOLB, 1910

Remarks. — There is a question of difference between the genus *Anomorphites* (which is funnel-shaped or plate-like) and *Megalithista* (which is irregularly spherical or conical with a small narrow paragaster); the difference between the two genera are difficult to assess and most probably they should be synonymized. The relation between this genus and *Heterostinia* ZITTEL is also not clear.

Anomorphites trigonus KOLB, 1910
(Pl. 32: 1)

1910. *Anomorphites trigonus* n. sp.; KOLB, p. 249, pl. 18: 21–25.

Material. — Three specimens with calcified, but well preserved spicules.

Description. — Irregularly oval plate-like sponge 3.5 cm in diameter and with about 0.5 cm thick wall displaying no canal openings, except some meshes which are slightly larger than others. Desmas as megaclones which are multibranched and measure 0.5 mm in size. Meshes of the skeleton 0.4–0.5 mm in diameter.

Remarks. — The investigated specimens resemble *Anomorphites trigonus* KOLB in being plate-like and in character of desmas; the difference is in oval shape of the studied specimens, while *A. trigonus* is triangular in outline, but such a difference is of no importance in lithistid sponges. There is another species, *A. plicatus* KOLB, which differs only in having a shape of a compressed funnel – most probably all these species should be synonymized.

Occurrence. — Kimmeridgian marls (Gamma); Kimmeridgian crumpled marly limestones (Delta): Hettingen.

Suborder **Tetracladina** ZITTEL, 1878

Genus *Kalpinella* HINDE, 1883

Kalpinella cf. *pateraeformis* HINDE, 1883

(Pl. 26: 8; Pl. 49: 1–10)

cf. 1883 *Kalpinella pateraeformis* sp. n.; HINDE, p. 71, pl. 18: 4, pl. 19: 1.
cf. 1962. *Kalpinella pateraeformis* HINDE; LAGNEAU-HÉRENGER, p. 124, fig. 203.

Material. — One specimen with siliceous spicules preserved.

Description. — Plate-like sponge fragment (clearly derived from a funnel-shaped sponge) having 0.6 cm thick wall. One surface displays round, densely spaced canal openings about 0.5 mm in diameter. Opposite side (outer one by analogy with HINDE's specimen) shows oval canal openings of the same size that are organized in poorly defined, vague rows. Desmas are slim tetraclones, with strongly branched zygomes (Pl. 49: 8), measuring 0.3–0.5 mm in size and those from near the surface bearing small rugosities or spines on the near-surface side. Skeletal meshes 0.1–0.4 mm across. Dermal spicules (not found in place, only in residue) are probably with a short shaft (Pl. 49: 10).

Remarks. — In shape, spicules and canal openings the investigated specimen resembles *Kalpinella pateraeformis* HINDE (see SCHRAMMEN 1910; LAGNEAU-HÉRENGER 1962), the species known from the Middle and Upper Cretaceous (LAGNEAU-HÉRENGER 1962).

Occurrence. — Kimmeridgian limestones (Epsilon): Heuchstetten.

Genus *Sontheimia* KOLB, 1910

Sontheimia cf. *parasitica* KOLB, 1910

(Pl. 30: 8)

cf. 1910. *Sontheimia parasitica* sp. n.; KOLB, p. 207, pl. 14: 21–28, pl. 20: 5–9.
cf. 1937. *Sontheimia parasitica* KOLB; SCHRAMMEN, pp. 71–72, pl. 19: 1, 2.

Material. — Two calcitized specimens.

Description. — Small knoby (up to 5 cm in diameter) encrusting sponge without visible paragaster or canalization. Tetraclones thick and short. Skeletal meshes on the surface 0.3–0.6 mm in size.

Remarks. — Both habit and tetraclones resemble *Sontheimia parasitica* KOLB, 1910, which may, however, show (according to SCHRAMMEN 1937) well developed paragaster lacking in the investigated specimens; on the other hand its presence was not mentioned by KOLB (1910).

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian crumpled limestones (Alfa): Bärenthal.

Sontheimia perforata KOLB, 1910

(Pl. 30: 2–5)

1937. *Sontheimia perforata* KOLB; SCHRAMMEN, p. 72, pl. 19: 3 (cum syn.).

Material. — Nine specimens with calcitized but well-preserved spicules.

Remarks. — Morphological characters fit very well with the original description by KOLB (1910) as well as the one by SCHRAMMEN (1937); thickness of the wall is greater in my specimens and may reach up to 1.5 cm. Canal openings visible on the surface are rounded to oval and measure about 0.5–0.8 mm in diameter, and are distributed without any order on the outer surface (they are situated at larger distances than indicated by SCHRAMMEN), while intraskeletal meshes are only 0.15 mm in diameter. Canals which run from the opposite sides are arched toward the oscular edge and measure 0.6 mm in height. The most characteristic feature of the skeleton is its organization into longitudinal fibres diverging toward both surfaces in a fan-like pattern; particular fibres are separated by distances of 0.25–0.30 mm. As all my specimens have calcified skeleton only general features of the spiculation may be discerned.

Occurrence. — Oxfordian crumpled limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Plettenberg; Kimmeridgian marls (Gamma): Bärenthal.

Genus *Callopegma* ZITTEL, 1878

Callopegma cf. *plana* LAGNEAU-HÉRENGER, 1962

(Pl. 25: 4)

cf. 1962. *Callopegma plana* nov. sp.; LAGNEAU-HÉRENGER, p. 127, text-pl. 20: 2.

Material. — One specimen with calcitized spicules.

Description. — Small, 2.5 cm in diameter, low conical sponge without paragaster; upper surface convex and covered with irregularly distributed large (up to 1 mm) canal openings. Desmas in the form of large and smooth tetraclones loosely organized.

Remarks. — The investigated specimen resembles closely in shape and spiculation, as well as canalization, *Callopegma plana* LAGNEAU-HÉRENGER from the Aptian of France; it differs only in the absence of paragaster. It is also very close to *Callopegma obconica* HINDE (1883: pl. 11: 3, p. 61) both in shape and spicule organization but this species comes from the Upper Chalk, being thus much younger.

Occurrence. — Oxfordian limestones (Beta): Plettenberg.

Tetracladine sponge sp.

(Pl. 43: 1–9)

Remarks. — This 0.5 cm fragment of platy sponge is without any canalization visible and composed of strongly branched smooth tetraclones. In these respects it differs from other tetracladine sponges here described.

Occurrence. — Kimmeridgian limestones (Epsilon): Heuchstetten.

Suborder **Dicranocladina** SCHRAMMEN, 1910

Genus *Kyphoclonella* KOLB, 1910

Kyphoclonella multiformis KOLB, 1910

1910. *Kyphoclonella multiformis* n. sp.; KOLB, p. 212, pl. 15: 9–11, pl. 20: 14–17.
1937. *Kyphoclonella multiformis* KOLB; SCHRAMMEN, p. 78, pl. 20: 1, 7.

Material. — Two calcified specimens.

Remarks. — My largest specimen is 7 cm high and 2.5 cm in diameter. Canal openings measure 0.35 mm in diameter running more or less radially, but not straight. Meshes on the surfaces are 0.14–0.20 mm in size and distributed sparcely on the surface. Desmas are calcified but preserved well enough for determination.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal.

Kyphoclonella? sp.

(Pl. 30: 6)

Material. — One calcified specimen.

Description. — Small conical sponge which is about 3.7 cm high and 3 cm wide, and has very narrow paragaster. Upper surface convex, with only a very small, about 2 mm wide opening at the center. Both upper and lower surfaces covered with radially organized but irregular, bifurcating and meandering furrows which are 0.5 to 1.0 mm wide; they are separated by skeletal bands 2 to 4 mm wide. Canal openings, which are 1–2 mm long and 0.5–0.7 mm wide, are situated at the bottom of these furrows. Desmas as dicranoclones.

Remarks. — The only species described to date of the genus, *Kyphoclonella multiformis* KOLB, may be of similar shape but differs in lacking furrows on the surface (see KOLB 1910), so most probably my specimen represents a new species. It is, however, too poorly preserved (calcified) for formal erection of a new taxon.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal.

Genus *Dicranoclonella* SCHRAMMEN, 1937

Remarks. — This genus is very close to the Recent *Corallistes* SCHMIDT, 1870 differing only in having modified subdermal dicranoclones which resemble rhizoclones, and most probably should be synonymized.

Dicranoclonella schmidti SCHRAMMEN, 1937
(Pl. 46: 1–10)

1937. *Dicranoclonella schmidti* n. sp.; SCHRAMMEN, pp. 79–80, pl. 20: 3–6.

Material. — One small silicified fragment with well preserved original choanosomal and dermal spicules.

Description. — Small fragment derived from plate-like sponge. Both sides are similar with skeletal meshes 0.14–0.16 mm in size; dermal layer composed of small dichotriaenes measuring 0.3 mm across. They show in some places small and round openings 0.06–0.08 mm in size, resembling canal openings, but which are places where shafts of dichotriaenes were inserted into main skeleton; they are visible only when dichotriaene is removed. Desmas are mostly tetrapodal dicranoclones with strong and large tubercles. In a near-dermal layer empty spaces between typical choanosomal dicronoclones are infillied with modified dicranoclones of two types; the first is much more slender, thinner and with less numerous tubercles, and the second is nearly flat and plate-like, but with strongly incised and branched edge, and also bearing some tubercles on the surface. All these, including dermal dichotriaenes are overlapping and situated at various levels (*i.e.* dichotriaenes are not always the most external spicules, sometimes they occur below modified dicranoclones) forming a very dense outer layer.

Remarks. — Subdermal modified dicranoclones are known also in Cretaceous dicranoclonid sponges, but in both cases they were interpreted as rhizoclonid desmas (see SCHRAMMEN 1937; MORET 1926; LAGNEAU-HÉRENGER 1962), while in fact they are simply modified dicranoclones. This mistake followed from the fact that they are very small and only SEM observations allow for their interpretation.

Occurrence. — Kimmeridgian limestones (Zeta): Gussenstadt.

Dicranoclonella sp.

Material. — One fragment with very well-preserved original choanosomal spicules.

Remarks. — This is a fragment of a platy sponge about 5 mm thick displaying no canalization; skeletal meshes are 0.1–0.2 mm in size, dicranoclones measuring about 0.4 mm and covered with numerous small tubercles. No dermal spiculation preserved.

The difference between this species and *D. schmidti* is in tuberculation of desmas – *Dicranoclonella* sp. has much more numerous and smaller tubercles on the upper side.

Occurrence. — Kimmeridgian limestones (Epsilon): Heuchstetten.

Genus *Leiocarenus* SCHRAMMEN, 1937

Leiocarenus planus SCHRAMMEN, 1937
(Pl. 24: 5)

1937. *Leiocarenus planus*, n. sp.; SCHRAMMEN, pp. 78–79, pl. 20: 11.

Material. — One specimen with calcitized spicules.

Description. — Small (2 × 3 cm) ear-shaped sponge with wall 0.3 cm thick having on the upper surface strong conical papillae (3 mm wide at the base and 3 mm high) each bearing canal openings (0.5–1.0 mm in diameter) at the top. Papillae are spread over the entire surface without any order. Lower surface finely porous, without differentiated canal openings. Desmas in the form of rather small dicranoclones.

Remarks. — The investigated material has no dermal spicules preserved, but its shape and choanosomal spicules are characteristic enough for its attribution.

Occurrence. — Kimmeridgian marls (Delta): Hochwang.

Suborder **Rhizomorina** ZITTEL, 1878

Remarks. — In zoological classifications (see SOLLAS 1888; LENDENFELD 1903, 1907; LÉVI 1973) sponges with rhizoclones are often divided between different families because of the presence or absence of specilized dermal spicules. In the present paper these families are treated together as proposed by REID (1968b) under the name Rhizomorina ZITTEL, 1878.

Genus *Platychonia* ZITTEL, 1876

1876. *Platychonia* ZITTEL.
1937. *Chonellopsis* SCHRAMMEN.

Emended diagnosis. — Rhizomorine sponge in irregular outline, ear-shaped, flat plate or vase-like and folded; rhizoclones organized in radial bands giving fine radial pattern on weathered surface and fan-like pattern in radial cross-section. Surface densely covered with small pores.

Remarks. — Change in scope of the genus is the main reason for emendation; it follows that given by TRAMMER (1982) with additional reference to skeletal features. The only differences between the genera *Platychonia* ZITTEL and *Chonellopsis* SCHRAMMEN, according to the latter author (1937), is the size of rhizoclones, which are larger in *Platychonia*, and in thickness of the wall (higher in *Platychonia*). Based on such characters, however, one cannot differentiate between genera not referring to species. At the same time, according to ZITTEL (1878b: p. 114) "Diese Gattung (i.e. *Platychonia*) ist schwer definirbar; ...in ihrem ausseren Merkmalen *Chonella* sehr anhlich". In effect, there is also no necessity to propose a new genus *Chonellopsis*, which is similar to *Chonella*, as was done by SCHRAMMEN (1937). The other difference between species in this genus is the wall thickness; this seems, however, an unreliable feature as the same specimen (see *Platychonia pruntrutana* OPPLIGER, 1926) can have portions of the wall very thin or very thick. SCHRAMMEN's collection indicates also that the wall thickness in one species can vary over a wide range, contrary to his descriptions. Also my own material is too small and/or poorly preserved to solve the entire problem of the species of the genus *Platychonia*. Many fragmentarily preserved specimens, for the reasons outlined above and below, have been determined only to the generic level for the purpose of analysis of sponge assemblage. Interesting is the question of relationships between *Platychonia* and such a very similar Cretaceous genus as *Seliscothon* ZITTEL; differences between them are very small, rather at the specific level. Most probably these genera may be synonymized, but more detailed comparative studies of both Upper Jurassic and Cretaceous genera are needed. According to my observations on QUENSTEDT'S, SCHRAMMEN's and my own material, as well as material in SMNS, the following species warrant differentiation.

Platychonia schlotheimi (MÜNSTER *in* GOLDFUSS, 1833)
(Pl. 13: 1, 2; Pl. 29: 1, 5)

1937. *Platychonia feralis* QUENSTEDT; SCHRAMMEN p. 96, pl. 22: 6–11 (cum syn.).
1982. *Platychonia schlotheimi* (MÜNSTER *in* GOLDFUSS); TRAMMER, pp. 23–24 (partly), pl. 7: 6; non 1–5 (cum syn.).

Material. — 83 specimens, variously preserved.

Remarks. — Forms included here are very variable in shape and wall thickness, as a result one cannot exclude that they belong to 2 highly variable and closely related species, but at the moment we are lacking any clear character allowing for their separation. SCHRAMMEN (1937) synonymized *Scyphia schlotheimi* MÜNSTER *in* GOLDFUSS' (1833: pl. 33: 5) with *Spongites vagans* QUENSTEDT (1878: pl. 131: 16) indicating as the holotype GOLDFUSS specimen; unfortunately GOLDFUSS' illustration is far from reality, and moreover the specimen itself is very poorly preserved. It is a plate about 5 mm thick, with one side covered with rock; other one shows striations but one cannot discern particular spicules, thus leaving some doubts about its assignment. One can even suspect its identity with the species *Platychonia striata* (SCHRAMMEN) as understood by SCHRAMMEN (1937), because of its thin wall. Much better as the holotype would be one of QUENSTEDT's specimens. On the other hand, specimens attributed to *P. schlotheimi* by SCHRAMMEN have much thicker (1.5 cm) wall and display different shapes, thus their identity with the holotype cannot be proven. Recently TRAMMER (1982) included into synonymy of the species practically all other species of that genus, especially numerous species erected by OPPLIGER (1915, 1926) but this must be treated with some caution as the only reliable feature in this multiform genus is the spiculation, which is not known in details in all mentioned species. There are also serious doubts concerning TRAMMER's specimen attributions; most of the specimens illustrated by him are ear-shaped and have a thin wall (about 5 mm) with small rhizoclones (TRAMMER 1982: pl. 7: 1–5) and clearly fall within the range of *Platychonia striata* SCHRAMMEN, where I assigned them. On the other hand, the species *P. feralis* QUENSTEDT and *P. compressa* KOLB, except for their general shapes are identical with *P. schlotheimi* (GOLDFUSS), especially in having large rhizoclones. Canal openings on the surface 0.4 mm in size, skeletal fibres 0.1 mm wide and are separated by furrows 0.3 mm wide.

Occurrence. — Oxfordian marls (Alfa): Nusplingen; Oxfordian crumpled limestones (Alfa): Bärenthal; Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Erkenbrechtsweiler, Wilmandingen.

Platychonia striata (SCHRAMMEN, 1937)
(Pl. 14: 4; Pl. 22: 5; Pl. 29: 4; Pl. 45: 1–11)

1937. *Chonellopsis striata* sp. n.; SCHRAMMEN, pp. 96–97, pl. 22: 5, pl. 23: 15, 16.
1982. *Platychonia schlotheimi* (GOLDFUSS); TRAMMER, pp. 23–24 (partly), pl. 7: 1–5.

Material. — 91 specimens, one with original spicules preserved.

Remarks. — I have included here some of the specimens illustrated by TRAMMER (1982) for the reason outlined in remarks to *P. schlotheimi*. The only difference between *P. striata* and *P. schlotheimi* is in the thickness of the wall and size of rhizoclones, which are smaller in *P. schlotheimi*. Canal openings on the surface 0.2 mm in diameter, skeletal fibres 0.1 mm separated by furrows 0.2 mm wide.

Occurrence. — Crumpled limestones of the Oxfordian (Alfa): Bärenthal; Oxfordian marls (Alfa): Nusplingen; Oxfordian limestones (Beta): Plettenberg; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler, Wilmandingen, Hochwang; Kimmeridgian marls (Delta): Hochwang, Genkingen; Kimmeridgian limestones (Delta): Bärenthal, Hochwang, and (Espilon): Heuchstetten; Kimmeridgian crumpled marly limestones (Delta): Hettingen.

Platychonia folium (SCHRAMMEN, 1937)
(Pl. 24: 3, 4)

1937. *Chonellopsis folium* n. sp.; SCHRAMMEN, p. 97, pl. 23: 17.

Material. — Eleven specimens, all with calcified spicules.

Remarks. — My specimens, which have calcified spicules, have thinner walls than given by SCHRAMMEN (1937), reaching only 5 mm in thickness. Canal openings on both surfaces are 0.4 mm in size. Slightly meandering and/or branching and 0.4 mm wide aporhysal furrows, which run from the base to the outer edge, are present on the surface. Meshes of the skeleton only 0.14 mm in size. In a cross-section spicules form fibres organized in a fan-like pattern.

Occurrence. — Kimmeridgian marls (Gamma): Erkenbrechtsweiler and (Delta): Hochwang.

Genus *Trachydictya* POMEL, 1872

Remarks. — These sponges have skeletons organized in fibres and lamellae, and as such are rather closer to *Platychonia* ZITTEL than to *Hyalotragos* ZITTEL (which has confused skeleton). The scope of this genus has been recently presented by BRIMAUD and VACHARD (1986) and I follow them in synonymizing under *Trachydictya* such genera as *Seliscothon* ZITTEL and *Proseliscothon* SIEMIRADZKI.

Trachydictya sp.
(Pl. 25: 5; Pl. 29: 7; Pl. 30: 7, 10)

Material. — Five specimens.

Description. — Plate-like sponge with often folded wall which is about 0.8–1.0 cm thick. No visible canal openings on the surface. Skeleton organized into skeletal lamellae which are 0.6 mm wide and separated with spaces 0.25–0.40 mm wide. On the surface these lamellae are connected from place to place with skeletal bridges (usually large single rhizoclones). In longitudinal section skeleton fibrous, with fibres diverging toward both surfaces.

Remarks. — All my specimens are calcified so I am unable to give the size of desmas. Very similar sponges have been described by SIEMIRADZKI (1913) as *Proseliscothon cracoviense,* no details of spiculation, however, are available and illustration is very poor.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Kimmeridgian marls (Delta): Hochwang; and Kimmeridgian limestones (Delta): Hochwang.

Genus *Cnemidiastrum* ZITTEL, 1878

Remarks. — In the formal diagnosis of this genus by ZITTEL (1878b) is mentioned the presence of smooth cortex, which is rarely observed by other authors; this feature is very well preserved in most specimens from the Lower Oxfordian marls from Zalas in Poland (personal observation), and well described and illustrated by MAŁECKI (1994). Most probably it was originally formed by a thick envelope of microscleres, which are, unfortunately, not preserved in their original forms.

Cnemidiastrum stellatum (GOLDFUSS, 1826)
(Pl. 24: 6–8)

1982. *Cnemidiastrum stellatum* (GOLDFUSS); TRAMMER, pp. 18–20, pl. 3: 1–14, pl. 5: 4.
1987. *Cnemidiastrum stellatum* (GOLDFUSS); MÜLLER, pp. 14–15, pl. 4: 1–3, pl. 8: 1 (cum. syn.).
1987. *Cnemidiastrum hoheneggeri* ZITTEL; MÜLLER, pp. 16–17, pl. 4: 4 (cum. syn.).
1987. *Cnemidiastrum goldfussi* (QUENSTEDT); MÜLLER, pp. 17–19, pl. 5: 1, 2, 4, pl. 8: 2, 3, pl. 9: 2 (cum syn.).
1987. *Cnemidiastrum stellatum* (GOLDFUSS); MEYER *et al.*, p. 69, pl. 2: 4.
1987. *Cnemidiastrum hohenegeri* ZITTEL; MEYER *et al.*, p. 69, pl. 3: 6, 7.
1987. *Cytoracea goldfussi* (QUENSTEDT); MEYER *et al.*, p. 70, pl. 2: 3.
1989. *Cnemidiastrum stellatum* (GOLDFUSS); TRAMMER, p. 62.
1993. *Cnemidiastrum stellatum* (GOLDFUSS); GRUBER, p. 54, pl. 22: 2.
1994. *Cnemidiastrum stellatum* (GOLDFUSS); MAŁECKI, p. 288, pl. 1: 1–4.
1994. *Cnemidiastrum tuberosum* (GOLDFUSS); MAŁECKI, pp. 294–295, pl. 4: 1, pl. 5: 1.
1994. *Cnemidiastrum goldfussi* (QUENSTEDT); MAŁECKI, pp. 296–297, pl. 4: 2.

Material. — Twelve specimens.

Remarks. — This species has been carefully studied recently by TRAMMER (1981, 1982, 1989) and MÜLLER (1987), as well as by MAŁECKI (1994). In the present paper I follow TRAMMER's approach lumping such forms as *hohenegeri* (see discussion in TRAMMER 1982) and *goldfussi* for these forms show no differences in skeletal structures, but only difference of shape and present in this respect continuity; I follow in this a more general approach, concluding slight differences in form alone, without underlying difference of skeletal elements or structure, cannot be the base of distinguishing a species. Considering this, MAŁECKI's (1994) paper is rarely seen extreme – no skeletal differences are found but any morphological deviation from the type (only idealized drawings are presented!) is a base of erecting a new species. Considering variability of both fossil and especially Recent lithistid sponges (in which species can be delimited with the help of spicules) the latter approach is rejected and most forms described by MAŁECKI (1994) are synonymized with earlier established species.

Occurrence. — Oxfordian crumpled limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Plettenberg; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler.

Cnemidiastrum rimulosum (GOLDFUSS, 1833)
(Pl. 23: 2–6)

1987. *Cnemidiastrum rimulosum* (GOLDFUSS); MÜLLER, pp. 7–8, pl. 1: 1–5, pl. 8: 4, pl. 10: 3 (cum syn.).
1987. *Cnemidiastrum granulosum* (QUENSTEDT); MÜLLER, p. 12, pl. 8: 2, 3 (cum syn.).
1989. *Cnemidiastrum rimulosum* (GOLDFUSS); TRAMMER, p. 63.
1993. *Cnemidiastrum rimulosum* (GOLDFUSS); GRUBER, pp. 54–55, pl. 22: 3.
1994. *Cnemidiastrum rimulosum* (GOLDFUSS); MAŁECKI, pp. 290–291, pl. 2: 1.
1994. *Cnemidiastrum calixum* n. sp.; MAŁECKI, pp. 288–289, pl. 1: 5.
1994. *Cnemidiastrum catinum* n. sp.; MAŁECKI, p. 294, pl. 3: 3.
1994. *Cnemidiastrum fungoides* n. sp.; MAŁECKI, p. 300, pl. 6: 2.

Material. — 103 specimens with calcified spicules.

Remarks. — Also this species has been thoroughly described recently by TRAMMER (1982) and MÜLLER (1987), with whom I agree entirely. Most of my specimens are fan-shaped, and regular vase-shaped forms are very rare. There is a large variability in canal courses on the sponge surface, which are even enlarged by weathering effects – in the wall interior they are nearly straight. The same problem concerns the difference between *C. rimulosum* (GOLDFUSS) and *C. granulosum* (QUENSTEDT); especially when comparing specimens with preserved dermal smooth layer with those in which it is not preserved. For discussion of the problem of synonymization of MAŁECKI's (1994) species see remarks to *C. stellatum* (GOLDFUSS).

Occurrence. — Oxfordian crumpled limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Bärenthal; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler, Hochwang, Wilmandingen;

Kimmeridgian crumpled marly limestones (Delta): Hettingen; Kimmeridgian limestones (Delta): Erkenbrechtsweiler, Blaubeuren, Hochwang; Kimmeridgian marls (Delta): Genkingen, Hochwang.

Cnemidiastrum pluristellatum ZITTEL, 1878
(Pl. 23: 1)

1987. *Cnemidiastrum pluristellatum* ZITTEL; MÜLLER, pp. 12–14, pl. 3: 1–4 (cum syn.).

Material. — Five specimens.

Remarks. — According to TRAMMER (1982) this species has shape that ranges from plate, vase or bowl to fan, while some of specimens from the Swabian Alb have shape of massive cones (Pl. 23: 1); as there are no other differences I regard them conspecific with *C. pluristellatum*, in agreement with MÜLLER (1987).

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler; Kimmeridgian marls (Hochwang).

Genus *Cytoracea* POMEL, 1872
Cytoracea variabilis (KOLB, 1910)
(Pl. 24: 1)

1937. *Cytoracea variabilis* KOLB; SCHRAMMEN, pp. 88–89, pl. 24: 2, 7, 8.
1937. *Cytoracea pusilla* n. sp.; SCHRAMMEN, p. 89, pl. 17: 7.

Material. — 20 specimens.

Remarks. — All my specimens are smaller than SCHRAMMEN's *C. variabilis*, but otherwise identical with his material; *C. pusilla* has been synonymized, as it differs only slightly in morphology, but fits well into the continous morphological spectrum. My specimens are also older, and occur as early as in the White Jurassic Gamma.

Occurrence. — Kimmeridgian marls (Gamma) and (Delta): Hochwang.

Genus *Hyalotragos* ZITTEL, 1878
Hyalotragos patella (GOLDFUSS, 1826)
(Pl. 25: 1, 2)

1913. *Hyalotragos patelloides* n. nom.; SIEMIRADZKI, p. 178, pl. 3: 40.
1989. *Hyalotragos patella* (GOLDFUSS); TRAMMER, p. 63 (cum syn.).
1993. *Hyalotragos patella* (GOLDFUSS); GRUBER, pp. 55–56, pl. 22: 4.

Material. — 48 specimens.

Remarks. — This species has been revised by TRAMMER (1989) and MÜLLER (1988), I follow here TRAMMER's approach regarding *H. patelloides* SIEMIRADZKI as including within the variability range of *H. patella* (GOLDFUSS).

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal, Wilmandingen, Hochwang, Erkenbrechtsweiler; Kimmeridgian crumpled limestones (Delta): Hettingen; Kimmeridgian limestones (Delta): Hochwang; Kimmeridgian marls (Delta): Hochwang, Genkingen.

Hyalotragos pezizoides (GOLDFUSS, 1826)
(Pl. 26: 1–7; Pl. 44: 1–9)

1989. *Hyalotragos pezizoides* (GOLDFUSS); TRAMMER, p. 63 (cum syn.).
1993. *Hyalotragos pezizoides* (GOLDFUSS); GRUBER, p. 56, pl. 22: 5.

Material. — 99 specimens.

Remarks. — This species has been recently revised by TRAMMER (1989) and MÜLLER (1988). I entirely agree with their observations.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Erkenbrechtsweiler, Wilmandingen; Kimmeridgian crumpled marly limestones (Delta): Hettingen; Kimmeridgian limestones (Delta): Bärenthal, Blaubeuren, Genkingen, Erkenbrechtsweiler, Hochwang; Kimmeridgian marls (Delta): Hochwang, Genkingen; Kimmeridgian limestones (Zeta): Niederstozingen.

Hyalotragos rugosum (MÜNSTER *in* GOLDFUSS, 1833)
(Pl. 27: 2–4; Pl. 28: 3, 4)

1833. *Agaricia rotata*; GOLDFUSS, pl. 12: 10.
1982. *Hyalospongia rugosa* (MÜNSTER *in* GOLDFUSS); TRAMMER, p. 26, pl. 10: 3.
1988. *Hyalotragos rugosum* (MÜNSTER *in* GOLDFUSS); MÜLLER, pp. 10–12, pl. 2: 1, fig. 4b, 5c (cum syn.).
1989. *Hyalospongia rugosa* (MÜNSTER *in* GOLDFUSS); TRAMMER, p. 65.

Emended diagnosis. — *Hyalotragos* with multiple oscula and associated radially arranged aporhysal furrows on the upper side.

Material. — 15 specimens.

Remarks. — Investigations of the original GOLDFUSS' collection, partly housed in the Bonn Univeristy, revealed that the fossil described as the coral *Agaricia rotata* represents, in fact, the sponge *H. rugosum* deprived only of the outer crust in which usually clear oscular openings are developed. Of special interest is the problem of the crust which is developed on its upper (inner) surface. In thin section it becomes clear that it is not a siliceous structures, but thick encrustion (up to 1 mm) of micritic calcium carbonate; as a result it is not clear if it should be regarded as a part of the sponge or, some other unknown organism product, and often the sponge may be devoid of it. Large, round openings are formed in this crust above regions where on the sponge surface are located ?oscula into which run aporhysal canals (structure very similar to that in *Cnemidiastrym pluristellatum*) – that is the reason for emendation. TRAMMER (1982) assigned it to the genus *Hyalospongia* SIEMIRADZKI, 1913, which was erected based on the presence of a smooth "cortex"; as this is not a siliceous structure, and thus probably not a part of a sponge, that genus should be regarded as invalid. The difference between this species and *Hyalotragos pezizoides* is analogous to that between well established species of the genus *Cnemidiastrum*: *C. rimulosum* (GOLDFUSS) and *C. pluristellatum* ZITTEL, for example, thus there is also no necessity for a new genus.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Erkenbrechtsweiler, Wilmandingen; Kimmeridgian marls (Delta): Hochwang, Genkingen; Kimmeridgian crumpled marly limestones (Delta): Hettingen.

Genus *Pyrgochonia* ZITTEL, 1878
Pyrgochonia radiata (MÜNSTER *in* GOLDFUSS, 1833)
(Pl. 22: 3, 4; Pl. 24: 2; Pl. 29: 6)

1988. *Hyalotragos radiatus* (MÜNSTER *in* GOLDFUSS); MÜLLER, p. 9, pl. 1: 3, 5, pl. 2: 5 (cum syn.).
1989. *Hyalotragos radiatum* (MÜNSTER *in* GOLDFUSS); TRAMMER, p. 64, pl. 7: 2.

Material. — Eleven specimens.

Remarks. — Recently, this species has been described in details by MÜLLER (1988) and my specimens conform entirely with his description. Because he had only very few specimens no investigations of the skeletal structure have been done. My observations show that it is clearly fibrous, with meshes of the skeleton rounded to irregular on the surface and 0.1–0.3 mm in size, while in vertical section skeletal fibres diverge toward both surfaces and are 0.3 mm apart. This structure is identical with that of *Pyrgochonia*, in effect I follow here SCHRAMMEN (1937) and attribute this species to *Pyrgochonia*.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler; Kimmeridgian limestones (Delta): Genkingen, Blaubeuren; Kimmeridgian crumpled marly limestones (Delta): Hettingen.

Pyrgochonia acetabulum (GOLDFUSS, 1829)
(Pl. 28: 1, 2)

1988. *Pyrgochonia acetabulum* (GOLDFUSS), MÜLLER, pp. 13–14 (cum syn.).
1993. *Pyrgochonia acetabulum* (GOLDFUSS); GRUBER, pp. 56–57, pl. 22: 6.

Material. — Twelve specimens.

Remarks. — When outer surface damaged or covered with rock it is impossible to separate it from *Hyalotragos*; only the structure of the skeleton allows for determination; in *Hyalotragos* rhizoclones are confused while the skeleton in *Pyrgochonia* is organized in a clear fibrous fan-like pattern (in this respect *Pyrgochonia* is close to *Platychonia*), where fibres are 0.2–0.3 mm apart. There is also some concentric banding of spicules. Cavities on the upper surface in my specimens are only 0.8–1.2 mm wide and irregularly distributed over the surface at the distance about 3 mm. Meshes of the skeleton on the outer surface are only 0.1 mm in size.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal, Wilmandingen; Kimmeridgian marls (Delta): Hochwang, Genkingen; Kimmeridgian crumpled marly limestones (Delta): Hettingen.

Genus *Discostroma* KOLB, 1910
Discostroma intricatum (QUENSTEDT, 1878)
(Pl. 27: 1)

1910. *Discostroma intricatum* QUENSTEDT; KOLB, p. 234 (cum syn.).

1926. *Discostroma intricatum* (QUENSTEDT); OPPLIGER, p. 5.

Material. — Two specimens with calcitized spicules.

Description. — Plate-like or very wide and shallow conical sponge up to 4 cm in diameter and 2 cm high, with wall 0.5 cm thick. Upper (inner) surface with irregularly rounded, 0.8–1.0 cm in diameter depressions or shallow cavities with canal openings at the bottom, from which extend irregularly but generally radially oriented aporhysal furrows; in the middle there is a bundle of vertical canals 0.8–1.0 mm in diameter. Lower (outer) side with intraskeletal meshes only. Skeleton fibrous organized in fan-like pattern; particular fibres 0.10–0.15 mm apart. There is also some concentric banding (parallel to the growing edge) of spicules in which particular bands are 0.2–0.3 mm apart.

Remarks. — Specimens described by KOLB (1910) are much larger and he reported nothing about their skeletal organization. Skeletal structure of this species closely resembles *Pyrgochonia acetabulum* (GOLDFUSS) and, in fact, it may be a *Pyrgochonia* species, but both my material of *Discostroma* and *Pyrgochonia* is too limited for any conclusive decision.

Occurrence. — Kimmeridgian marls (Delta): Genkingen.

Genus *Amphibleptula* SCHMIDT, 1879
(= *Microsleroderma* KIRKPATRICK, 1903)
Amphibleptula jurassica sp. n.
(Pl. 22: 6; Fig. 33)

1986. Algenproblematikum Ladwien (1976); BRACHERT, p. 242, pl. 40: 2.

1990. Lithistider Demospongier (*Platychonia*); KEUPP *et al.*, pl. 21: 1.

Holotype: Fig. 33, specimen ZPAL Pf.VIII/552.

Type horizon: Kimmeridgian marls (Delta).

Type locality: Genkingen, Swabia, Germany.

Derivation of the name: Referring to the age of specimens.

Material. — Six specimens with calcified spicules.

Diagnosis. — Plate-like rhizomorine sponge with thick dermal layer composed of long oxeas and ectosomal desmas more branched than the inner ones.

Description. — These are plate-like fragments of a sponge from 0.5 to 1.5 mm thick, with skeletons composed of large rhizoclones organized in poorly developed fibres (fan-like arrangement in longitudinal section). Intraskeletal meshes measure about 0.4–0.6 mm in size. Ectosomal desmas more branched and densely packed than the inner ones. There is the dermal zone, composed of oxeas protruding from the main desma-composed skeleton, which is up to 3 mm thick (at the edge, but usually thinner over the surface). These oxeas are 0.04–0.06 mm thick and up to 3 mm long, and are densely packed and organized into bush-like patterns. Small, about 0.7 mm wide and irregularly distributed ostia visible on the upper side of specimens devoid of dermal oxeas.

Remarks. — Recent sponges with rhizoclone desmas more branched on the surface, and long protruding bundles of oxeas are included into the genus *Amphibleptula* SCHMIDT (= *Microscleroderma* KIRKPATRICK). Formally, however, this genus was defined as "Scleritodermidae with special ectosomal desmas, more intricately branched than those of the choanosome, without ectosomal microstrongyles" (VAN SOEST and STENTOFT 1988). The absence of microstrongyles in the fossils cannot be proved, thus I was left with macrosclere associations to asses its taxonomic position. On the other hand, also Leiodermatidae LENDENFELD in addition to rhizoclones, contains oxeas, but never in such specialized arrangement, thus assignment to *Amphibleptula* seems obvious. This sponge resembles slightly those included in *Platychonia* in fibrous organization of the skeleton (but this feature is much less developed) as well as in larger size of rhizoclones and specialized rhizoclones near the surface, and finally in the presence of the protruding bundles of oxeas.

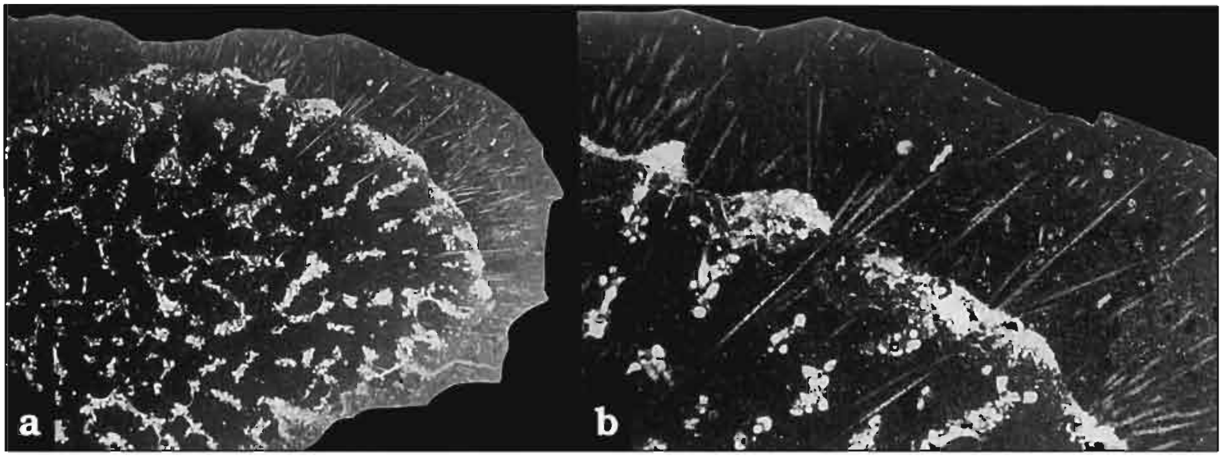


Fig. 33
Amphibleptula jurassica sp. n., ZPAL Pf.VIII/552, holotype, Genkingen, Kimmeridgian marls (Delta), thin section; marginal zone of a sponge in cross section, showing choanosomal skeleton and bundles of oxeas protruding from within, × 5; *b* details of a previous fragment, × 20.

Occurrence. — Kimmeridgian marls (Delta): Genkingen, Hochwang; Kimmeridgian limestones (Delta): Hochwang.

Genus *Reiswigia* TRAMMER, 1979
Reiswigia sp.
(Pl. 25: 3)

Material. — Four specimens.

Remarks. — TRAMMER (1979) described only one new species *Reiswigia ramosa*, but MAŁECKI (1991) in an attempted revision synonymized it with two various species from different genera, indicating, however, the same TRAMMER's specimens as belonging to both his taxa, thus complicating the whole situation. My material is limited and too poorly preserved to solve the problem, but fits well enough with TRAMMER's specimens for generic identification.

Occurrence. — Kimmeridgian marls (Gamma): Erkenbrechtsweiler, Bärenthal.

Genus *Epistomella* ZITTEL 1878
Epistomella sp.
(Pl. 31: 1, 2)

Material. — Two specimens.

Description. — Platy to very low vase-like sponges with walls up to 0.5 mm thick and up to 3 cm in diameter. Lower surface only with concentric growth lines; upper surface covered with numerous, irregularly distributed low crater-like outgrowths which are 2.0–2.5 mm wide at the base and 1.5 mm at the top, and separated by a distance of 1.5 to 3.0 mm. Desmas are rhizoclones forming the skeleton with meshes about 0.15 mm in size.

Remarks. — Poor preservation precludes more precise determination.

Occurrence. — Kimmeridgian marls (Gamma): Erkenbrechtsweiler; Kimmeridgian limestones (Delta): Genkingen.

Suborder **Didymmorina** ZITTEL, 1878

Genus *Cylindrophyma* ZITTEL, 1878
Cylindrophyma milleporata (GOLDFUSS, 1833)
(Pl. 31: 5–8; Pl. 48: 5–12; Fig. 34)

1989. *Cylindrophyma milleporata* (GOLDFUSS); TRAMMER, p. 66 (cum syn.).

Material. — 106 specimens, among them one with original siliceous spicules preserved.

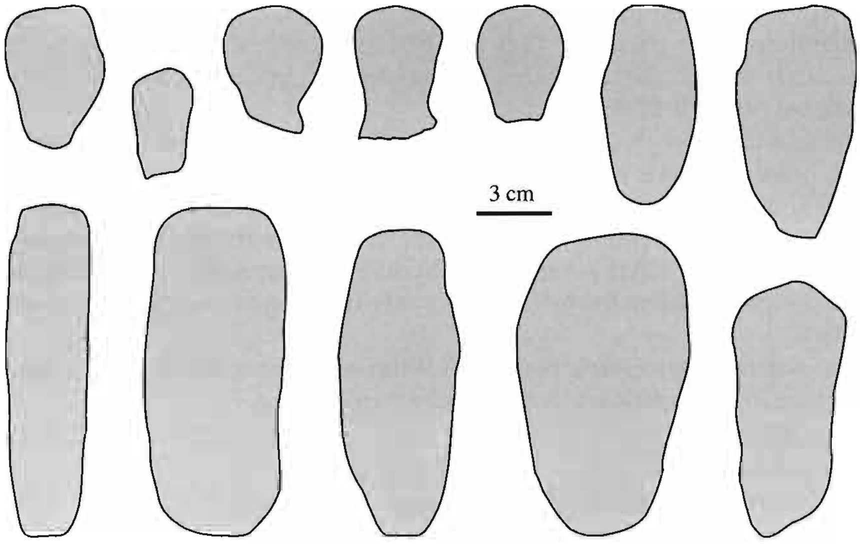


Fig. 34
Shape variability of *Cylindrophyma milleporata* (GOLDFUSS).

Remarks. — This species shows a high shape variability – from elongated oval or spherical to nearly straight cylindrical (Fig. 34). Canal openings on the surface are 0.6–0.8 mm in size, while meshes of the skeleton on the surface only 0.16–0.20 mm in size. Two swollen centers of the spicule are usually 0.2–0.3 mm apart. It is worth to mention that, in addition to typical didymoclones there are desmas, interpreted here as perhaps young (having however the same size as typical didymoclones) didymoclones, which differ from them considerably. They have smooth shafts connecting only slightly swollen centers from which radiate in all directions smooth long branches, while typical didymoclones have strongly swollen centers with tuberculated one side and long smooth branches which extend from the opposite side. These strange spicules resemble some anthaspidellid sponges desma. *C. milleporata* is one of the few lithistid sponges which occurs through all the investigated stratigraphical interval; it is very common, however, only in the Upper Kimmeridgian strata.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian crumpled limestones (Alfa): Bärenthal; Oxfordian limestones (Beta): Plettenberg, Beuron; Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler, Hochwang, Wilmandingen; Kimmeridgian crumpled marly limestones (Delta): Hettingen; Kimmeridgian limestones (Delta): Hochwang, Erkenbrechtsweiler; Kimmeridgian marls (Delta): Hochwang, Genkingen; Kimmeridgian limestones (Zeta): Niederstozingen, Arnegg, Asselfingen, Gussenstadt.

Genus *Linochone* SCHRAMMEN, 1937
Linochone rimosa SCHRAMMEN, 1937
(Pl. 31: 3, 4)

1937. *Linochone rimosa* n. sp.; SCHRAMMEN, pp. 103–104, pl. 17: 8.

Material. — One specimen with calcitized spicules.

Description. — Thin walled (up to 2 mm thick) cylinder (flattened by compaction) which is 8 cm high and 3 cm in diameter. Outer surface displays densely spaced but irregularly spread ostia of small (0.5–1.0 mm wide) canals. Desmas are small didymoclones.

Remarks. — The investigated specimen from my collection differs from the SCHRAMMEN's (1937) one in being cylindrical while the holotype is clearly funnel-shaped (Pl. 31: 4).

Occurrence. — Kimmeridgian marls (Gamma): Wilmandingen.

Genus *Melonella* ZITTEL, 1878
Melonella radiata (QUENSTEDT, 1878)
(Pl. 32: 6)

1989. *Melonella radiata* (QUENSTEDT); TRAMMER, p. 66 (cum syn.).

Material. — Three specimens in my collection and numerous in SMNS.

Remarks. — My largest specimens are up to 6 cm in diameter and 5 cm high. Conical paragaster is about 1 cm in diameter at the osculum. Two sets of canals, described in details by KOLB (1910), are 0.6–0.8 mm wide, and end with the same size openings on the surface that are 1.0–1.5 mm apart. Meshes of the skeleton are only 0.10–0.15 mm in size.

This species is sometimes regarded as a more spherical morphotype of *Cylindrophyma milleporata*. There is no doubt, however, that it is a separate species, while its assignment to a different genus may be a matter of debate. It differs in having larger and more loosely spaced canal openings on the surface, in having radial to sinous channels running down from the osculum on the outer surface, as well as in having smaller and slightly different didymoclones. The Middle Jurassic species *M. ovata* SOLLAS, 1883, as illustrated by HINDE (1893), differs from *M. radiata* only in being ovate and smaller, and most probably is conspecific with it.

Occurrence. — Kimmeridgian marls (Gamma): Wilmandingen; Kimmeridgian crumpled marly limestones (Delta): Hettingen; Kimmeridgian marls (Delta): Hochwang.

Suborder **Sphaerocladina** SCHRAMMEN, 1910

Genus *Coscinodiscus* SCHRAMMEN, 1937

Coscinodiscus suevicus SCHRAMMEN, 1937

(Pl. 32: 5)

1937. *Coscinodiscus suevicus* n. sp.; SCHRAMMEN, p. 105, pl. 21: 6.

Material. — Holotype (SCHRAMMEN original housed in Tübingen), here designated.

Remarks. — SCHRAMMEN (1937) has never illustrated his new species, except desmas; for this reason original SCHRAMMEN's specimen housed in Tübingen is here illustrated.

Occurrence. — Kimmeridgian (Gamma/Delta), Schwabtal.

Coscinodiscus sp.

Material. — Nine specimens.

Remarks. — These are plate-like fragments with walls up to 1 cm thick displaying openings of canals 0.4–0.8 mm in diameter, separated by skeletal bands 0.2–1.0 mm on one side, and large depressions, very variable in size, measuring from 0.5 to 4.0 mm in diamater, and irregular in outline occur over the whole surface on the other side. These specimens are thinner than *C. suevicus* SCHRAMMEN, have smaller canal openings, and have large depressions developed only on one side.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Kimmeridgian marls (Gamma): Erkenbrechtsweiler, Hochwang, Bärenthal; Kimmeridgian marls (Delta): Hochwang; Kimmeridgian limestones (Zeta): Asselfingen.

Order incertae sedis

Genus *Lecanella* ZITTEL, 1878

1878. *Lecanella* ZITTEL.

1937. *Sphaeropegma* SCHRAMMEN.

Emended diagnosis. — Plate-like, vase-like to clumpy sponge composed of astrochones; canal openings very small and distributed without order over both surfaces; dermalia are dichotriaenes.

Remarks. — The only difference between *Lecanella* ZITTEL and *Sphaeropegma* SCHRAMMEN is that the former is plate-like to funnel shaped, while the latter is irregularly spherical with a deep and narrow paragaster but there is no difference whatsoever in spiculation. According to the criteria used in classification of Recent lithistid sponges, and accepted here, such differences cannot be used as the base for generic differentiation. Therefore it seems that they should be synonymized for the distinction seems to be rather one of specific level. So far the genus *Lecanella* has been included into Sphaerocladina SCHRAMMEN (REID 1968b; RIGBY 1983; WIEDENMAYER 1994), relaying on interpretation of choanosomal spiculation which was interpreted as sphaeroclonal. The present finding dichotriaenes as dermal spicules indicates that it must be either excluded from the Sphaerocladina or the Sphaerocladina redefined. Having no more data about other genera I treat *Lecanella* as incerate sedis.

Lecanella pateraeformis ZITTEL, 1878
(Pl. 32: 2, 7; Pl. 45: 12–16; Fig. 35)

1937. *Lecanella pateraeformis* ZITTEL; SCHRAMMEN, pp. 108–109, pl. 21: 1, 2 (cum syn.).

Material. — 40 specimens with calcitized spicules and one (from Heuchstetten) with original siliceous spicules preserved.

Diagnosis. — Funnel to plate-like *Lecanella* with dermal spicules as small dichotriaenes.

Description. — This is a highly variable species, generally having plate-like or ear-like to funnel shapes and wall thicknesses from a few milimeters to 1 centimeter. My specimens have strongly varying wall thicknesses, and desmas measuring 0.4–0.9 mm in size. Both surfaces display small, that range from 0.4 to 0.8 mm large, meshes. Skeleton shows no organization and is confused. In one specimen in situ dermalia, developed as small dichotriaenes with slender clads and 0.20–0.25 mm in diameter, are preserved (Fig. 35).

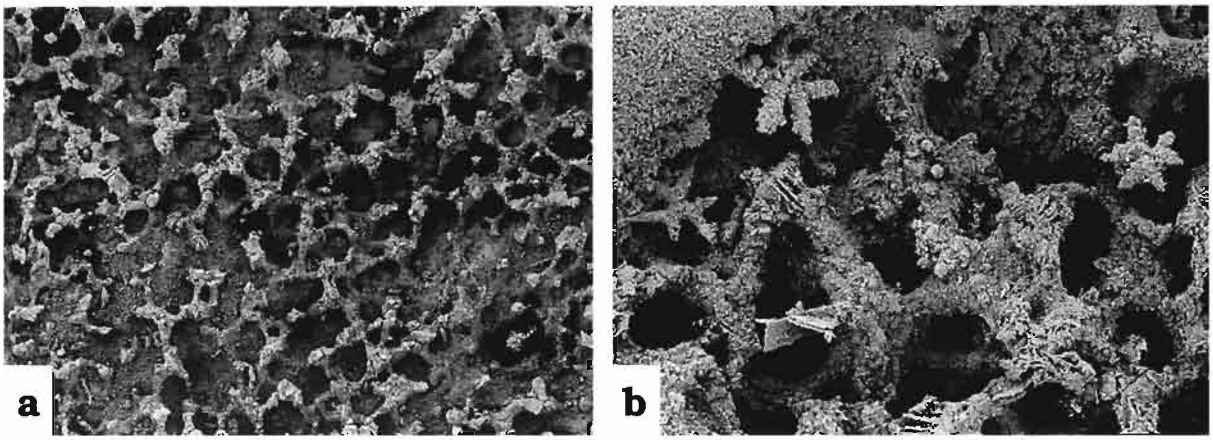


Fig. 35
Lecanella pateraeformis ZITTEL, SEM, ZPAL Pf.VIII/553, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); *a* view of choanosomal skeleton × 22; *b* choanosomal skeleton and few dermal dichotriaenes preserved in situ, × 65.

Remarks. — The other species of this genus, *L. flabellum* KOLB, 1910, probably should be synonymized here also. HINDE (1883) assigned to this species loose spicules from the Upper Cretaceous of Germany, but without knowing the bodily preserved sponge such assignment must be treated with caution.

Occurrence. — Oxfordian crumpled limestones (Alfa): Bärenthal; Kimmeridgian marls (Gamma): Bärenthal, Hochwang, Erkenbrechtsweiler, Wilmandingen; Kimmeridgian crumpled limestones (Delta): Hettingen; Kimmeridgian limestones (Delta): Hochwang; Kimmeridgian marls (Delta): Hochwang, Genkingen; Kimmeridgian limestones (Epsilon): Heuchstetten; Kimmeridgian limestones (Zeta): Gerstetten.

Lecanella cf. *nuda* (SCHRAMMEN, 1937)
(Pl. 30: 1, 9)

cf. 1937. *Spheropegma nuda* n. sp; SCHRAMMEN, p. 109, pl. 21: 3.

Material. — Four specimens with calcitized spicules.

Description. — Cylindrical to conical, thick-walled sponge which is from 5 to 9 cm high and from 2 to 4 cm wide. Paragaster narrow, 0.5 to 1.5 cm in diameter. Outer surface smooth except with irregular large canal openings, 0.5–2.0 mm in diameter, which are rather distantly and irregularly distributed. Desmas are large about 0.5 mm in size, smooth and poorly branched astroclones; skeletal meshes about 0.2–0.4 mm in diameter.

Remarks. — The investigated specimens resemble rather closely the only known specimen described by SCHRAMMEN (1937) in desmas character as well as features of canalization; they differ in shape – SCHRAMMEN's specimen is spherical.

Occurrence. — Oxfordian marls (Alfa): Plettenberg; Oxfordian limestones (Beta): Plettenberg; Kimmeridgian marls (Gamma): Bärenthal.

Lecanella sp. A

Material. — Three specimens.

Remarks. — These are plate-like sponge fragments generally conforming with *Lecanella pateraeformis* ZITTEL, but which differ in having smaller and more strongly branched spicules; skeletal meshes rounded and measure 0.2–0.3 mm in diameter. Such differences are usually regarded as specific characters.

Occurrence. — Kimmeridgian marls (Gamma): Erkenbrechtsweiler; Kimmeridgian crumpled limestones (Delta): Hettingen; Kimmeridgian limestones (Delta): Genkingen.

Lecanella sp. B

(Pl. 11: 7)

Material. — Three specimens.

Description. — Small, 1.5 cm wide hemispherical sponge encrusting a hexactinellid sponge, with entirely calcitized but well-preserved astroclones. No paragaster or canalization.

Remarks. — The only species described by SCHRAMMEN (1937) which is similar is *Lecanella* (= *Sphaeropegma) nuda*, but it has a well developed paragaster. The investigated specimens lack any trace of it and their spicules are also smaller.

Occurrence. — Kimmeridgian marls (Gamma): Bärenthal, Erkenbrechtsweiler.

LOOSE SPICULES

Loose disassociated spicules have been obtained by dissolving rocks in a weak hydrochloric or formic acid solution. They are present only in samples from Gussenstadt, Heuchstetten and Gerstetten. At least 75% of spicules, by number, are selenaster (= rhaxes) of placospongids (Hadromerida). Various oxeas and microxeas are also very common spicules. Among desmas the most common are tetraclones and megaclones, kyphorabds, and ophirabds. Less common are astroclones of *Lecanella* ZITTEL, didymoclones (*Cylindrophyma* ZITTEL), prodichotriaenes and phyllotriaenes. Rhizomorine desmas, as well as hexactinosan and lychniscosan spicules are very rare. Such frequency of rigid-skeleton derived spicules agrees very well with what we know from bodily preserved sponges, which are dominantly various lithistid species, while hexactinosan and lychniscosan sponges are very rare. Most of the loose spicule types illustrated herein have already been noted from the Upper Jurassic of the Swabian Alb by SCHRAMMEN (1937), and REIF (1967) who reported similar frequency of particular types of spicules. Numerous of these spicules types have been reported already from the Lower Jurassic of Austria by DUNIKOWSKI (1882), and by WIŚNIOWSKI (1889, 1891) from the Middle and Upper Jurassic of Poland.

Summing up, among loose spicules are represented those which belong to bodily preserved lithistid sponges, but common are also spicules from sponges which had unfused skeletons, both demosponges and hexactinellids. Among the demosponges the most common non-lithistids are placospongids (Hadromerida), pachastrellid and geodiid sponges (Astrophorida), among those which I was able to recognize. Representatives of Haplosclerida were most probably also present.

DEMOSPONGE SPICULES

Selenasters (= Rhax of HINDE 1880) (Pl. 53: 18–20). — These demosponge spicules are the most common spicules (numbering in thousands) in the Upper Kimmeridgian samples with corals from Gussenstadt and Heuchstetten. They have the bean-shape form and ragged (corroded) surface, and are 0.12–0.17 mm long. Fossil ones, both from the Upper Jurassic (REIF 1967; TRAMMER 1982) and the Cretaceous (GRUBER and REITNER 1991) were interpreted as sterrasters which occur in Recent Geodidae (Astrophorida). As it was nicely shown by RÜTZLER and MACINTYRE (1978), the Jurassic material most probably represents corroded selenasters [spicules of Recent *Placospongia* GRAY – see VOSMAER and VERNHOUT 1902, but similar spicules are also known from *Timea spiniglobata* (CARTER) as reported by REID (1968b)]; those reported from the Cretaceous, are better preserved and practically identical with selenasters of *Placospongia carinata* (BOWERBANK) illustrated by RÜTZLER and MACINTYRE (1978).

Selenasters of *Placospongia* (Hadromerida) and sterrasters of the Geodidae slightly resemble each other, however, sterrasters always have a spherical form and develop from multiaxial centres, while selenasters are monaxon-based (also in the case of *Timea* GRAY), and receive their characteristic shape only late in ontogeny (VOSMAER and VERNHOUT 1902).

Oxyspherasters (Pl. 53: 15–17). — They measure 0.17–0.18 mm in diameter and oxyasters (Pl. 53: 13, 14), which represent euasters, measure about 0.2 mm, and occur in various groups of Recent sponges. Such spicules are common among Recent Geodidae where they compose a thick outer zone (see for example SOLLAS 1888: pl. 16: 11; LENDENFELD 1907: pl. 31: 45, pl. 37: 17; and DENDY: 1924: pl. 7: 10) and most probably the investigated specimens belong also to Geodidae. One must admit, however, that morphologically very similar spicules are known in the hadromerid *Timea* (see TOPSENT 1928: pl. 6: 7c) and halichondrid *Vibulinus* GRAY (TOPSENT 1928: pl. 6: 20), and *Halicnemia* BOWERBANK (TOPSENT 1928: pl. 6: 22c). There, however, they are covered with tiny rugosities. Occasionally such spicules also occur in the lithistid theonellids (WIEDENMAYER 1994, and my own unpublished data). Similar spicules are known also from the late Triassic (MOSTLER 1976) and Liassic (MOSTLER 1990a). Generally they have rather doubtful diagnostic value as fossils (WIEDENMAYER 1994).

Dermal dichotriaenes, phyllotriaenes and discotriaenes (Pl. 45: 17; Pl. 50: 8, 11; Pl. 52: 1–16). — These spicules have cladomes from about 0.40 to 0.75 mm in diameter and shafts of various lengths.

There is morphological continuity between these types of spicules, so they are treated here together. Phyllo- to discotriaenes occur in Recent tetractinellid sponges (genera *Discodermia* DU BOCAGE, *Racodiscula* ZITTEL and *Theonella* GRAY – see LENDENFELD 1903; LÉVI and LÉVI 1989; VACELET and VASSEUR 1971), thus it is difficult to attribute all my material more precisely. The presence of discotriaenes and phyllotriaenes is indicative, however, of the lithistids with tetractine desmas. On the other hand, extreme variability of these spicules makes estimation of number of species which they represent in the investigated material a precarious matter. Such spicules may differ strongly, for example, between inhalant and exhalant surfaces, even in the same specimen (see SOLLAS 1888; LÉVI and LÉVI 1989, and my own unpublished data). The group encompassing phyllotriaenes to discotriaenes with a smooth convex surface and a very short shaft (Pl. 52: 8, 11–14) most probably represents one species of tetractinellid sponges. Another group is represented by simple phyllotriaenes with a short conical shaft (Pl. 52: 3, 7, 10). Phyllotriaenes with thick and long shafts and smooth surfaces belong to a different species. A third still different species may be represented by the peculiar irregular phyllotriaenes (Pl. 52: 4, 5) with very long shafts and clade laying in various planes, as well as having irregular clades tips indicating articulation with other dermal phyllotriaenes. This last type is very close to those illustrated by REIF (1967: pl. 15: 23) from Nattheim. Also discotriaenes from Nattheim (REIF 1967: pl. 15: 1, 5) are very close to my material. The fourth species is represented by a peculiar phyllotriaene which has a short shaft in the form of a cross (Pl. 52: 2). Massive dichotriaenes (Pl. 50: 8, 11) measuring 0.28 to 0.35 mm in cladome diameter, also belong, most probably, to lithistid sponges for similar dermal spicules are known in the Recent Corallistidae SOLLAS (see SOLLAS 1888: pl. 15: 40, 41). Similar spicules are known already from the Upper Triassic–Lower Jurassic deposits (MOSTLER 1989b). Sponges bearing dermal layers of phyllo- and/or discotriaenes are known from shallow depths (coral reefs – VACELET and VASSEUR 1971) down to 180 meters on the shelf slopes of the New Caledonia region (LÉVI and LÉVI 1989), and down to 234–270 meters on the shelf off Barbados (VAN SOEST and STENTOFT 1988), where they are common between 100 and 180 meters.

Various prodichotriaenes (Pl. 47: 5; Pl. 50: 1, 3–5, 7, 10) **and orthodichotriaenes** (Pl. 50: 2, 6). — With cladomes measuring 0.50–0.75 mm in diameter, and various lenght and shape of shaft reaching 4.4 mm in length represent, without doubt, several different species of non-lithistid (astrophorid) sponges.

Massive mesotriaen (Pl. 50: 9). — With a cladome measuring 0.62 mm in diameter also occur. Similar spicules were reported by MOSTLER (1986a) from the Triassic, and today occur in pachastrellid sponges (WIEDENMAYER 1994).

Procricotriaens (Pl. 51: 28, 29). — Ones in the collection measure 1.1–1.3 mm in lenght and can have poorly to well developed clads. There are 4–5 rings on the shaft and up to 4 on the clads.

Cricostyles (Pl. 51: 19, 20). — These may be straight or slightly curved and bear from 1 to 4 rings and measure up to 2.5 mm in length. They were earlier described from Nattheim (White Jurassic Zeta = Uppermost Kimmeridgian) by SCHRAMMEN (1937) and REIF (1967), the oldest known spicules of this type are from the late Triassic (MOSTLER 1976; WIEDENMAYER 1994). In my material they are present in the uppermost Kimmeridgian samples (coral limestones) from Gerstetten. Some authors (see REIF 1967; MOCZYDŁOWSKA and PARUCH-KULCZYCKA 1978) have suggested there is an evolutionary trend expressed in increase of numbers of rings, which are more numerous in Cretaceous specimens; but that may be doubted for Triassic cricostyles have from 4 to 42 rings (WIEDENMAYER 1994). This type of spicule cannot be assigned to any particular group for they occur neither in Recent sponges nor in bodily preserved fossil sponges.

Massive ?orthotriaene (Pl. 51: 16). — Such spicules measure at least 1.8 mm in length in the collection. Nearly identical spicules from the Upper Cretaceous were illustrated by HINDE (1880: pl. 2: 9) and were attributed to the Geodidae. Today similar triaenes occur generally in astrophorids.

Calthrops (Pl. 48: 1–4). — Variously sized calthrops (0.25 to 1.75 mm) having equal (Pl. 48: 3) or unequal rays (Pl. 48: 2), or one ray reduced into knob (Pl. 48: 4) occur in the collection. They are typical of Recent pachastrellids and Calthropellidae LENDENFELD (WIEDENMAYER 1994). Very similar triaenes have been reported from rocks as old as the Cambrian (KEMPEN 1990; WIEDENMAYER 1994).

Criccalthrop (Pl. 47: 4). — Measuring about 0.2 mm in diameter; this type of spicule has been reported from the Triassic of Alps (MOSTLER 1990a). According to WIEDENMAYER (1994) they have affinities with the Recent genus *Sphinctrella* SCHMIDT.

Acanthocalthrop (Pl. 47: 3). — Measuring about 0.27 mm in diameter. Similar spicules are known from the Permian (FINKS 1960), but some may be as old as Carboniferous (see REID 1970). They are common in the Triassic and Lower Jurassic, as well as younger deposits (MOSTLER 1976, 1990a; WIEDENMAYER 1994). According to WIEDENMAYER (1994) they are related to the sphinctrellids.

Trachelotriaenes (from trachelotriaenes to trachelodichotriaenes) of various character (Pl. 51: 10, 11, 17, 18, 25, 26). — They measure 1.1–2.1 mm in length. The oldest spicules of this type are known from the Triassic (MOSTLER 1976). Spicules of trachelodichotriaene (Pl. 51: 10, 11) type had been described from the Upper Cretaceous by HINDE (1880: pl. 2: 6–8) and SCHRAMMEN (1924). Today they occur in some astrophorids (WIEDENMAYER 1994).

Microxeas (Pl. 53: 4, 5). — These are the common demosponge spicules in my samples. Unfortunately today they occur in such different groups as tetractinellid lithistids, haplosclerid and poecilosclerid sponges, and thus have no diagnostic value.

Simple oxeas (Pl. 51: 3–8). — Of various size are very common spicules in all the samples, unfortunately they also occur in various groups of demosponges and as such cannot be ascribed to any smaller group.

Long sinuous oxeas (Pl. 51: 1, 2). — Measuring up to 3.75 mm in length and 0.10–0.15 mm in thickness; they are known, for example, in the Recent rhizomorine sponge *Leiodermatium* SCHMIDT and tetracladine *Theonella* GRAY (see VAN SOEST and STENTOFT 1988). Very similar spicules can be also found in other non-lithistid demosponges (see SOLLAS 1888). Other spicules from the same sample indicate that both of these groups were present in the investigated material.

Small strongyles (Pl. 53: 1–3, 6, 7). — Measuring from 0.20 × 0.08 mm to 0.36 × 0.06 mm are relatively common in most samples. Strongyles of similar type and size are known to occur in the Recent hadromerid genus *Strongylophora* DENDY (see VAN SOEST and STENTOFT 1988: pp. 128–129). They occur also in the fossil record as early as the Carboniferous (WIEDENMAYER 1994).

Tylostyles. — Mostly of two types: one with a large part of the proximal tip swollen (Pl. 51: 12–14) and measuring about 1.1 and 1.2 mm in length, and the second with only the proximal tip swollen (Pl. 51: 21–24, 27) and measuring 1.1–2.6 mm. Most probably they belong to the Hadromerida and Poëcilosclerida (REIF 1967). Among the rare types of unknown affinity is an exotylostyle (Pl. 51: 9) measuring over 2 mm long, and a peculiar massive and irregular tylostyle (Pl. 47: 13) measuring 0.6 mm long.

Cricorhabds (Pl. 53: 8–12). — These differ in numbers of rings (from 3 to 6) and general outline, and measure 0.22–0.27 mm in length and 0.07–0.09 mm in thickness. According to WIEDENMAYER (1994) they most probably belong to the clionids (Hadromerida).

Desmas. — Megaclones (Pl. 47: 10–12); these spicules which are up to 1.1 mm long, are identical with spicules of *Megalithista foraminosa* SCHRAMMEN known from bodily preserved specimens from the same deposits. They are very close to the spicules of the Recent species *Pleroma turbinatum* SOLLAS (see SOLLAS 1888: pl. 33: 7, 8; LÉVI and LÉVI 1983: pl. 2: 5–7) and thus belong without doubt to the Megamorina (perhaps the Pleromidae). The oldest known spicules of this type (not very different from the investigated ones) are known from the Lower Permian (KOZUR and MOSTLER 1989).

— Rhizoclones (Pl. 50: 12–16) measuring 0.45–0.60 mm in size from the sponge infesting *Dicranoclonella schmidti* SCHRAMMEN. These spicules resemble rhizoclones of *Platychonia schlotheimi* (MÜNSTER *in* GOLDFUSS, 1833) but are usually tri- to tetrapodial, while those of *Platychonia schlotheimi* are usually linear (see Pl. 45: 1–11). Other type is represented by strongly branched and ornamented rhizoclones? (Pl. 44: 10–13; Pl. 50: 18) measuring up to 0.48 mm in lenght. They differ in morphology from the spicules of any bodily preserved rhizomorine species investigated and probably belong to a new genus.

— Dicranoclones (Pl. 47: 9) measuring 0.62 mm in size. It is very close to dicranoclones composing the outer part of *Dicranoclonella schmidti* (see Pl. 46: 2, 3).

— Sphaeroclones (Pl. 50: 17) measuring about 0.35 mm in size is a spicule characteristic for sphaerocladine *Coscinodiscus* SCHRAMMEN, which occurs as bodily preserved sponges in the same horizons.

— Kyphorabds (Pl. 49: 11) measuring 0.8 mm in length are spicules typical of bodily preserved *Helminthophyllum* SCHRAMMEN. There are also desmas measuring 0.5–0.9 mm in length and resembling kyphorabds (Pl. 49: 15, 16), but sculptured with knobs and spines rather than rings. I am not able to attribute them with certainty to any genus.

— Heloclones (Pl. 49: 12–14) measuring up to 1.7 mm in length are identical with spicules occurring in bodily preserved *Pachycothon* SCHRAMMEN.

HEXACTINELLID SPICULES

Smooth or ornamented pentactines, hexactines and stauractines (Pl. 54: 1–12) occur in various hexactinosan, lychniscosan (usually as dermalia), and lyssacinosan sponges (both dermalia and choanosomalia), and as such are of low diagnostic value. On the other hand, anadiaenes (Pl. 47: 6) measuring over 1.7 mm in length, and anatetraenes (pentactine) (Pl. 47: 2) measuring over 0.8 mm in length, are common as anchoring spicules among hexactinellids with loose skeletons. Massive oxyhexactines (Pl. 54: 13–16) measuring up to 1 mm in diameter, occur in some euplectellids as oscularia (IJIMA 1927: pl. 7: 5).

REFERENCES

ALLOUC, J. 1986. Les encroûtemants sous-marins de Méditérranée Orientale: une explication génétique. — *Revue de l'Institut Français du Pétrole* **41**, 351–376.

ALLOUC, J. 1987. Les paléocommunautés profondes sur les fonds rocheaux du Pleistocène Méditérranéen. Description et essai d'interpretation paléoécologiques. — *Geobios* **20**, 241–263.

ALLOUC, J. 1990. Quarternary crusts on slopes of the Mediterranean Sea: A tentative explanation for their genesis. — *Marine Geology* **94**, 205–238.

ANTONESCU, C.S. 1929. Spongieri jurasici din Dobrogea. — *Memorille Sectiunii Stiintifice Academia Romana, Ser. 3*, **5**, 482–490.

AURELL, M. 1990. *El Jurasico Superior de la Cordiliera Iberica Central (Provincias de Zaragoza y Teruel) Analisis de Cuenca.* 389 pp. Departamento de Ciencias de la Tierra, Universidad de Zaragoza, Zaragoza.

AURELL, M. 1991. Identification of system tracts in low angle carbonate ramps: examples from the Upper Jurassic of Iberian Chain (Spain). — *Sedimentary Geology* **74**, 101–115.

AURELL, M. and MELENDEZ, A. 1993. Sedimentary evolution and sequence stratigraphy of the Upper Jurassic in the Central Iberian Chain, northeast Spain. — *Special Publication of International Association of Sedimentologists* **18**, 343–368.

AURELL, M. and MELENDEZ, G. 1990. Upper Jurassic of the Northeastern Iberian Chain (E. Spain); A synthesis. — *Seminarios de Paleontologia de la Universidad de Zaragoza* **2**, 5–31.

BARBULESCU, A. 1974. *Stratigraphie du Jurassique dans le partie Ouest de la Dobrogea Centrale.* 173 pp. Editurea Academiei Bucuresti, Bucuresti.

BARIA, L.R., STOUDT, D.L., HARRIS, P.M. and CREVELLO, P.D. 1982. Upper Jurassic reefs of Smackover Formation, United States Gulf Coast. — *American Association of Petroleum Geologists Bulletin* **66**, 1449–1482.

BUAMGARTNER, P.O. 1987. Age and genesis of Tethyan Jurassic radiolarites. — *Eclogae Geologicae Helvetiae* **80**, 831–879.

BECKER, E. and MILASCHEWITSCH, C. 1875–1876. Die Korallen der Natheimer Schichten. — *Palaeontographica* **21**, 120–243.

BEHMEL, H. 1970. Beiträge zur Stratigraphie und paläontologie des Juras von Ostspanien. V. Stratigraphie und Fazies im präbetischen Jura von Albacette und Nord-Murcia. — *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* **137**, 1–102.

BERQUIST, P.R. 1978. *Sponges*. 260 pp. Hutchinson. London.

BOURY-ESNAULT, N. and VACELET, J. 1994. Preliminary studies on the organization and development of a hexactinellid sponge from a Mediterranean cave, *Oopsacas minuta*. *In:* R.W.M. van Soest, Th.M.G. van Kempen, and J.C. Braekman (eds), *Sponges in Time and Space*, 407–415. Balkema, Rotterdam.

BRACHERT, T.C. 1986. Kontinuerliche und diskontinuerliche Sedimentation süddeutschen Oberjura (unteres Kimmeridge; Ludwag/Oberfranken, Nördliche Frankenalb). — *Facies* **15**, 233–284.

BRACHERT, T.C., DULLO, W-Ch. and STOFFERS, P. 1987. Diagenesis of siliceous sponge limestones from the Pleistocene of the Tyrrhenian Sea (Mediterranean Sea). — *Facies* **17**, 41–50.

BRIMAUD, C. and VACHARD, D. 1986. Les Spongiaires siliceux du Tortonien des Betiques (Miocène de l'Espange du Sud): espèces nouvelles ou peu connues I. Choristides et Lithistides. — *Bulletin Musée national d'Histoire naturelle, Paris sér., 8, sect. C* **3**, 293–341.

BROGLIO LORIGA, C., MASETI, D., FORASTIERI, S. and TREVISANI, E. 1991. Comunita a Poriferi nei Calcari Grigi delle Vette Feltrine. — *Annali dell'Universita di Ferara (Nuova Serie), Scienze della Terra* **3**, 51–81.

BRUNTON, F.R. and DIXON, O.A. 1994. Siliceous sponge-microbe associations and their recurrence through the Phanerozoic as reef mound constructors. — *Palaios* **9**, 370–387.

BUSQUETS, P., PISERA, A., REGUANT, S. and SERRA-KIEL, J. 1995. Biofacies with siliceous sponges, corals, bryozoa and large foraminifera of the outer continental shelf in the Bartonian of the eastern part of Ebro basin in Vic area (Barcelona, Spain). *VII International Symposium on Fossil Cnidaria and Porifera, Abstract*, 14–15. Madrid.

CONWAY, K.W., BARRIE, J.V., AUSTIN, W.C. and LUTERNAUER, J.L. 1991. Holocene sponge bioherms on the western Canadian continental shelf. — *Continental Shelf Research* **11**, 771–790.

CORSELLI, C., BASSO, D. and GARZANTI, E. 1994. Paleobiological and sedimentological evidence of Pleistocene/Holocene hiatuses and ironstone formation at the Pontian island shelfbreak (Italy). — *Marine Geology* **117**, 317–328.

CREVELLO, P.D. and HARRIS, P.M. 1984. Depositional models for Jurassic reefal buildups. *GCSEPM Foundation Third Annual Research Conference Proceedings*, 57–102.

DAYTON, P.K., ROBILLIARD, G.A., PAINE, R.T. and DAYTON, L.B. 1974. Biological accommodation in the benthic community at McMurdo Sound, Antarctica. — *Ecological Monographs* **44**, 105–128.

DENDY, A. 1921. The tetraxonic sponge spicules: a study in evolution. — *Acta Zoologica* **2**, 95–152.

DENDY, A. 1924. Porifera. Part I. Non-antarctic sponges. — *British Antarctic (Terra Nova) Expedition, 1910. Natural History Report, Zoology* **6**, 269–392.

DONOFRIO, D.A. 1984. Microfaune triassiche e giurassiche dalla serie calcareo-silico-marnosa della Lucania, facies S. Fele (Apennino Campano-Lucano, Italia Meridionale). — *Geologische-Paläontologische Mitteilungen Innsbruck* **13**, 177–199.

DUNIKOWSKI, E. 1882. Die Spongien, Radiolarien und Foraminiferen der unterliassischen Schichten vom Schafberg bei Salzburg. — *Denkschriften der Kaiserlichen Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Klasse* **1**, 162–194.

ETALLON, A. 1858. Études paléontologiques sur le Haut-Jura. Monographie du Coralliens Rayonnés. — *Mémoires Société Emulations Doubs* **3**, 1–153.

ETALLON, A. 1860. Sur la classification des Spongiaires du Haut-Jura et leur distribution dans les étages. — *Actes Société Jurassienne Emulation* **1858**, 129–160.

FERNANDEZ-LOPEZ, S. and MELENDEZ, G. 1994. Abrasion surfaces on internal moulds of ammonites as paleobathymetric indicators. — *Palaeogeography, Palaeoclimatology, Palaeoecology* **110**, 29–42.

FERNANDEZ-LOPEZ, S. and MELENDEZ, G. 1995. Taphonomic gradients in Middle Jurassic ammonites of the Iberian Range (Spain). — *Geobios, M.S.* **18**, 155–165.

FINKS, R.M. 1960. Late Paleozoic sponge faunas of the Texas region. — *Bulletin of the American Museum of Natural History* **120**, 1–160.

FINKS, R.M. 1983. Fossil Hexactinellida. *In:* J.K. Rigby and C.W. Stearn (eds), Sponges and Spongiomorphs. Notes for a Short Course. — *University of Tennessee Department of Geological Sciences Studies in Geology* **7**, 101–115.

FLÜGEL, E. and STEIGER, T. 1981. An Upper Jurassic sponge-algal buildup from the northern Frankenalb, W. Germany. *In:* D.F. Toomey (ed.), European Fossil Reef Models. — *Special Publication of the Society of Economic Paleontologists and Mineralogists* **30**, 371–398.

FRAKES, L.A., FRANCIS, J.E. and SYKTUS, J.I. 1992. *Climate Modes of the Phanerozoic*, 1–274. Cambridge University Press, Cambridge.

FRANZ, M. and MÜLLER, W. 1988. Kieselschwämme aus dem Parkinsonien-Oolith von Sengenthal b. Neumarkt/Opf. (Frankische Alb). — *Jahresberichte und Mitteilungen der Oberrheinischen Geologischen Vereins*, N.F. **70**, 215–227.

FREYBERG, B. 1928. *Casearia* sp., ein Schwamm aus dem Muschelkalk von Sonderhausen. — *Beiträge zur Geologie der Thüringen* **1**, 24–27.

FRIEBE, A. 1995. Die Schwammfazies im Mitteljura des nordostlischen Keltibericum (Spanien). — *Profil* **8**, 239–279.

FRITZ, G.K. 1958. Schwammstozen, Tuberolithe und Schuttbreccien im Weissen Jura der Schwäbischen Alb. — *Arbeiten aus dem Geologisch-Paläontologischen Institut Technische Hochschule Stuttgart N.F.* **13**, 1–118.

FROMENTAL, E. 1859. Introduction à l'étude des éponges fossiles. — *Mémoire de la Société Linnéenne de Normandie* **2**, 1–50.

FÜRSICH, F.T., OSCHMANN, W., JAITLY, A.K. and SINGH, I.B. 1991. Faunal response to transgressive-regressive cycles: example from the Jurassic of western India. — *Palaeogeography, Palaeoclimatology, Palaeoecology* **85**, 149–159.

FÜRSICH, F.T., OSCHMANN, W., SINGH, I.B. and JAITLY, A.K. 1992. Hardgrounds, reworked concretion levels and condensed horizons in the Jurassic of western India: their significance for basin analysis. — *Journal of the Geological Society of London* **149**, 3–13.

FÜRSICH, F.T. and WERNER, W. 1991. Palaeoecology of coralline sponge-coral meadows from the Upper Jurassic of Portugal. — *Paläontologische Zeitschrift* **65**, 35–69.

GAILLARD, C. 1971. La formation à spongiaires des Calcaires lités (Oxfordien supérieur) du Jura méridional. — *Documents des Laboratoires de Géologie de Faculté des Sciences Lyon* **45**, 19–130.

GAILLARD, C. 1972. Les éponges siliceuses des Calcaires Lités du Jura méridional (Oxfordien supérieur). — *Documents des Laboratoires de Géologie de Faculté des Sciences Lyon* **50**, 103–141.

GAILLARD, C. 1983. Les bioherms à spongiaires et leur environment dans l'Oxfordien du Jura méridional. — *Documents des Laboratoires de Géologie Lyon* **90**, 1–515.

GEYER, O. and GWINNER, M.P. 1984. Die Schwäbische Alb und ihr Vorland. — *Sammlung Geologischer Führer* **67**, 1–275.

GLAUB, I. 1994. Mikrobohrspuren in ausgewahlten Ablagerungsraumen des europeischen Jura und der Unterkreide (Klassifikation und Palökologie). — *Courier Forschungsinstitut Senckenberg* **174**, 1–300.

GOLDFUSS, A. 1826–1833. *Petrefacta Germaniae.* Teil 1–4. 252 pp. List and Franke. Leipzig.

GRADSTEIN, F.M., GIBLING, M.R., SARTI, M., RAD, U. VON, THUROW, J.W., OGG, J.G., JANSA, L.F., KAMINSKI, M.A. and WESTERMANN, G.E.G. 1991. Mesozoic Tethyan strata of Thakkhola, Nepal: evidence for the drift and breakup of Gondwana. — *Palaeogeography, Palaeoclimatology, Palaeoecology* **88**, 193–218.

GRADSTEIN, F.M. and RAD, U. VON 1991. Stratigraphic evolution of Mesozoic continental margin and oceanic sequences: Northwest Australia and Northern Himalayas. — *Marine Geology* **102** (1–4), 131–173.

GRADSTEIN, F.M., RAD, U. VON, GIBLING, R.M., JANSA, L.F., KAMINSKI, M.A., KRISTIANSEN, I-R., OGG, J.G., ROHL, U., SARTI, M., THURROW, J.W., WESTERMANN, G.E.G. and WIEDEMANN, J. 1992. Stratigraphy and depositional history of the Mesozoic continental margin of Central Nepal. — *Geologisches Jahrbuch, B* **77**, 3–141.

GRUBER, G. 1993. Mesozoische und rezente desmentragende Demospongiae (Porifera, "Lithistidae") (Paläobiologie, Phylogenie und Taxonomie). — *Berliner Geowissenschaftliche Abhandlungen, E* **10**, 1–73.

GRUBER, G. and REITNER, J. 1991. Isolierte Mikro- und Megaskleren von Porifera aus dem Untercampan von Hover (Norddeutschland) und Bemerkungen zur Phylogenie der Geodiidae (Demospongiae). — *Berliner Geowissenschaftliche Abhandlungen, A* **134**, 107–117.

GWINNER, M.P. 1976. Origin of the Upper Jurassic Limestones of the Swabian Alb (Southwest Germany). — *Contribution to Sedimentology* **5**, 1–75.

GYGI, R.A. 1981. Oolitic iron formations: marine or not marine? — *Eclogae Geologicae Helvetiae* **74**, 233–254.

GYGI, R.A. 1986. Eustatic sea level changes of the Oxfordian (Late Jurassic) and their effect documented in sediments and fossil assemblages of an epicontinental sea. — *Eclogae Geologicae Helvetiae* **79**, 455–491.

GYGI, R.A. and MARCHAND, D. 1982. Les Cardioceratinae (Ammonoidea) du Callovien terminal et l'Oxfordien inférieure et moyen (Jurassique) de la Suisse Septerionale: stratigraphie, paléoécologie, taxonomie préliminaire. — *Geobios* **15**, 517–571.

GYGI, R.A. and PERSOZ, F. 1987. The epicontinental sea of Swabia (southern Germany) in the Late Jurassic – factors controlling sedimentation. — *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* **176**, 49–65.

HALLAM, A. 1988. A re-evaluation of Jurassic eustasy in the light of new data and the revised Exxon curve. *In:* C.K. Wilgus, B.S. Hastings, C.G.St.C. Kendall, H.W. Posamentier, C.A. Ross and J.C. van Wagoner (eds), Sea-level Change: An integrated approach. — *SEPM Special Publication* **42**, 261–273.

HALLAM, A. 1992. *Phanerozoic Sea-level Changes.* 266 pp. Columbia Univeristy Press, New York.

HALLAM, A. 1993. Sequence stratigraphic test of alternative Jurassic sea-level curves. *Carboniferous to Jurassic Pangea. Calgary, Alberta, Canada August 15–19, 1993. Program and Abstracts*, 127. Calgary.

HAQ, B.U. 1988. Paleoceanography: A synoptic overview of 200 million years of ocean history. *In:* B.U. Haq and J.D. Milliman (eds), *Marine Geology and Oceanography of Arabian Sea and Coastal Pakistan*, 201–231. Van Nostrand Reinhold Company, New York.

HAQ, B.V., HARDENBOL, J. and VAIL, P.R. 1988. Mesozoic and Cenozoic chronostratigraphy and cycles of sea-level change. *In:* C.K. Wilgus, B.S. Hastings, Ch.G.St.C. Kendall, H.W. Posamentier, C.A. Ross and J.C. van Wagoner (eds), Sea-level changes: an integrated approach. — *SEPM Special Publication* **42**, 71–108.

HARTMAN, W.D., WENDT, J.W. and WIEDENMAYER, F. 1980. Living and fossil sponges (Notes for a short course). — *Sedimenta* **8**, *Comparative Sedimentology Laboratory University of Miami.* 274 pp. Miami.

HASKELL, B. 1986. *The sedimentary processes involved in the formation of Oxfordian sponge-algal bioherm mounds on Plettenberg, Southwest Germany.* 77 pp. Diplomarbeit, Tübingen Universität.

HILLER, K. 1964. Über die Bank- und Schwammfazies des Weissen Jura der Schwäbischen Alb (Würtemeberg). — *Arbeiten aus dem Institut für Geologie und Paläontologie der Technische Hochschule Stuttgart, N.F* **40**, 1–190.

HINDE, G.J. 1880. Fossil sponge spicules from the Upper Chalk found in the interior of a single flint-stone from Horstead in Norfolk. *Inaugural-Dissertation Erlangung der akademischen Doctorwurde bei der philosophischen Facultät der Ludwig-Maximilians-Universität.* 83 pp. München.

HINDE, G.J. 1883. *Catalogue of the fossil sponges in the geological department of the British Museum.* 248 pp. London.

HINDE, G.J. 1893. A monograph of the British Fossil Sponges. Part III. Sponges of the Jurassic strata. — *Palaeontographical Society Monograph*, 189–254. London

HINE, A.C., HARRIS, M.W., LOCKER, S.D., HALLOCK, P., PEEBLES, M., TEDESCO, L., MULLINS, H.T., SNYDER, S.W., BELKNAP, D.F., GONZALES, J.L., NEUMANN, A.C. and MARTINEZ, J. 1994. Sedimentary infilling of an open seaway: Bawihka Channel, Nicaraguan Rise. — *Journal of Sedimentary Research, B* **64**, 2–25.

IJIMA, I. 1901. Studies on the Hexactinellida. Contribution I. — *Journal of the College of Science, Imperial University, Tokyo, Japan* **15**, 1–299.

IJIMA, I. 1904. Studies on the Hexactinellida. Contribution IV. — *Journal of the College of Science, Imperial University, Tokyo, Japan* **18**, 1–307.

IJIMA, I. 1927. The Hexactinellida of the Siboga Expedition. — *Siboga-Expeditie* **6**, 1–383. Leiden.

IVANY, L.C., NEWTON, C.R. and MULLINS, H.T. 1994. Benthic invertebrates of a modern carbonate ramp: a preliminary survey. — *Journal of Paleontology* **63**, 417–433.

JAMES, N.P. and GINSBURG, R.N. 1979. The seaward margin of Belize barrier and atoll reefs. — *International Association of Sedimentologists Special Publication* **3**, 1–191.

JANSA, C.F. 1991. Processes affecting paleogeography, with examples from the Tethys. — *Palaeogeography, Palaeoclimatology, Palaeoecology* **87**, 345–371.

KAPITZKE, M. and LAUXMAN, U. 1988. *Tiaradendron giganteum* n. sp., eine neue Koralleneart aus dem hoheren Oberjura der Schwäbische Alb. — *Stuttgarter Beiträge zur Naturkunden, B* **145**, 1–5.

KAŹMIERCZAK, J., ITTEKKOT, V. and DEGENS, E.T. 1985. Biocalcification through time: environmental challenge and cellular response. — *Paläontologische Zeitschrift* **59**, 15–33.

KEMPEN, T.M.G. VAN 1990. On the oldest tetraxon megascleres. *In:* K. Rützler (ed.), *New Perspectives in Sponge Biology*, 9–16. Smithsonian Institution Press, Washington, D.C.

KEUPP, H., KOCH, R. and LEINFELDER, R. 1990. Steuerungsprozesse der Entwicklung von Oberjura-Spongiolithen Süddeutschlands: Kenntnisstand, Probleme und Paerspectiven. — *Facies* **23**, 141–174.

KEUPP, H., REITNER, J. and SALOMON, D. 1989. Kieselschwämme (Hexactinellida und "Lithistida") aus den Cipit-Kalken der Cassianer Schichten (Karn, Südturol). — *Berliner Geowissenschaftliche Abhandlungen, A* **106**, 221–241.

KHOUDARY, R.H. EL 1974. Beiträge zur Stratigraphie und paläontologie des Juras von Ostspanien. VI. Untersuchungen im Oberjura der südwestlischen Iberischen Kordillere unter besonderer Berücksichtigung der Mikrofauna (Provinz Teruel und Ricon de Ademuz). — *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* **144**, 296–341.

KOCH, R., SENOWBARI-DARYAN, B. and STRAUSS, H. 1994. The late Jurassic "Massenkalk Fazies" of southern Germany: calcareous sand piles rather than organic reefs. — *Facies* **31**, 179–208.

KOLB, R. 1910. Die Kieselspongien des schwäbisches weissen Jura. — *Palaeontographica* **57**, 141–256.

KOZUR, H. and MOSTLER, H. 1989. Radiolarien und Schwammskleren aus dem Unterperm des Vorurals. — *Geologische und Paläontologische Mitteilungen Insbruck, Sonderband* **2**, 147–275.

KRAUTTER, M. 1995. Kieselschwämme als potentielle Indikatoren für Sedimentationsrate und Nährstoffangebot am Beispiel der Oxford-Schwammkalke von Spanien. — *Profil* **8**, 281–304.

KUTEK, J., MATYJA, B.A. and WIERZBOWSKI, A. 1984. Late Jurassic biogeography in Poland and its stratigraphical implications. *In:* O. Michelsen and A. Zeiss (eds), *International Symposium on Jurassic Stratigraphy, Copenhagen*, 743–754. Geological Survey of Denmark, Copenhagen.

KUTEK, J., WIERZBOWSKI, A., BEDNAREK, J., MATYJA, B.A. and ZAPAŚNIK, T. 1977. Notes on the Upper Jurassic in the Polish Jura Chain. — *Przegląd Geologiczny* **8/9**, 438–445.

LAGNEAU-HÉRENGER, L. 1962. Contribution à l'Etude des Spongiaires Siliceux du Crétacé Infériuere. — *Mémoires de la Société Géologique de France, Nouvelle Série* 41, *Mémoire* **95**, 1–252.

LANG, B. and STEIGER, T. 1984. Paleontology and diagenesis of Upper Jurassic siliceous sponges from the Mazagan Escarpment. — *Oceanologica Acta SP*, 93–100.

LAUXMAN, U. 1991. Revision der oberjurassischen Korallen von Württemberg (SW-Deutschland), exclusive Fungina. — *Palaeontographica, A* **219**,107–175.

LEFELD, J. 1988. Radiolarites and associated rocks along the northern marigin of Tethys. *In:* M. Rakus, J. Dercourt and A.E.M. Nairn (eds), Evolution of the Northern Margin of Tethys I. — *Mémoires de la Société Géologique de France* **154**, 154–164.

LEGARRETA, L. 1991. Evolution of a Callovian-Oxfordian carbonate margin in the Neuquén basin of west-central Argentina: facies, architecture depositional sequence and global sea-level changes. — *Sedimentary Geology* **70**, 209–240.

LEINFELDER, R.R. 1993. Upper Jurassic reef types and controlling factors. A preliminary report. — *Profil* **5**, 1–45.

LEINFELDER, R.R., KRAUTTER, M., LATERNSER, R., NOSE, M., SCHMID, D.U., SCHWEIGERT, G., WERNER, W., KEUPP, H., BRUGGER, H., HERMANN, R., REHFELD-KIEFER, U., SCHROEDER, J.H., REINHOLD, C., KOCH, R., ZEISS, A., SCHWEIZER, V., CHRISTMANN, H., MENGES, G. and LUTERBACHER, H. 1994. The origin of Jurassic reefs: current research developments and results. — *Facies* **31**, 1–56.

LEINFELDER, R.R., KRAUTTER, M., NOSE, M., RAMALHO, M.M. and WERNER, W. 1993. Siliceous sponge facies from the Upper Jurassic of Portugal. — *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* **189**, 199–254.

LENDENFELD, R. VON 1903. Tetraxonia. *In:* F.E. Schulze (ed.), *Das Tierreich 19*, 1–168. Verlag von R. Friedländer und Shon, Berlin.

LENDENFELD, R. VON 1907. Die Tetraxonia. *In:* C. Cun (ed.), *Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition auf dem Dampfer Valdivia 1898–1899* **11**, 59–374.

LÉVI, C. 1973. Systématique de la classe des Demospongiaria (Démosponges) *In:* P.P. Grasse (ed.), *Traité de Zoologie, III (Spongiaires)*, 577–631. Paris.

LÉVI, C. 1986. *Laocoetis perion* nov. sp. , Spongiaire Hexactinellide Craticulariidae de l'océan Indien. — *Bulletin Muséum National d'Histoire Naturelle Paris*, 4 sér., **8**(A3), 437–442.

LÉVI, C. 1991. Lithistid sponges from the Norfolk Rise. Recent and Mesozoic Genera. *In:* J. Reitner and H. Keupp (eds), *Fossil and Recent Sponges*, 72–82. Springer Verlag, Berlin.

LÉVI, C. and LÉVI, P. 1983. Eponges tetractinellides et Lithistides bathyaux à affinités crétacées de la Nouvelle Calédonie. — *Bulletin Muséum National d'Histoire Naturelle Paris* **4**, 5(A1), 101–168.

LÉVI, C. and LÉVI, P. 1988. Nouveaux Spongiaires Lithistides bathyaux à affinités crétacées de la Nouvelle Calédonie. — *Bulletin Muséum National d'Histoire Naturelle Paris* **4**, 10(A2), 241–263.

LÉVI, C. and LÉVI, P. 1989. Spongiaires (MUSORSTOM 1 & 2). *In:* J. Forest (ed.), Resultats des compagnes MUSORSTOM, Volume 4. — *Mémoire du Muséum National d'Histoire Naturelle, A* **143**, 25–103.

LI XIAOCHI and GRANT-MACKIE, J.A. 1993. Jurassic sedimentary cycles and eustatic sea-level changes in southern Tibet. — *Palaeogeography, Palaeoclimatology, Palaeoecology* **101**, 27–48.

MAGEL, R. and LAUXMAN, U. 1990. Zur Verkieselung der oberjurassichen Korallen von Würtemberg. — *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte* **10**, 622–638.

MALIVA, R.G., KNOLL, A.H. and SEIVER, A. 1989. Secular change in chert distribution: A reflection of evolving biological participation in the silica cycle. — *Palaios* **4**, 519–532.

MAŁECKI, J. 1991. Kieselspongien der Gattung *Reiswigia* in den Ablagerungen des Unter Oxfords in der Umgebung von Krakau. — *Bulletin of the Polish Academy of Sciences, Earth Sciences* **38**, 39–43.

MAŁECKI, J. 1994. Gattung *Cnemidiastrum* (Demospongia, Rhizomorina) nach dem material aus dem Weissen Jura von Zalas. — *Bulletin of the Polish Academy of Sciences, Earth Sciences* **42**, 285–301.

MATYJA, B.A. 1976. *Oksford południowo-zachodniego obrzeżenia Gór Świętokrzyskich*, 85 pp. Unpublished Ph.D. Thesis. University of Warsaw.

MATYJA, B.A. 1978. Struktury wczesnodiagenetyczne w wapiennych utworach oksfordu. — *Przegląd Geologiczny* **3**, 156–158.

MATYJA, B.A. and GIŻEJEWSKA, M. 1979. Distribution of Callovian and Lower Oxfordian ammonite faunas in Poland. — *Acta Geologica Polonica* **29**, 177–185.

MATYJA, B.A. and PISERA, A. 1991. Late Jurassic European sponge megafacies: general perspective. *3rd International Symposium on Jurassic Stratigraphy*, 81. Poitiers.

MATYJA, B.A. and TARKOWSKI, R. 1981. Lower and Middle Oxfordian ammonite biostratigraphy at Zalas in the Cracow Upland. — *Acta Geologica Polonica* **31**, 1–14.

MATYJA, B.A. and WIERZBOWSKI, A. 1985. Rozwój sedymentacji i zróżnicowanie facjalne w jurze górnej struktury Zalesia. *Utwory jurajskie struktury Zalesia na Kujawach i ich znaczenie surowcowe*, 30–35. Wydawnictwa Geologiczne, Warszawa.

MATYJA, B.A. and WIERZBOWSKI, A. 1994. Bathymetry of late Jurassic sponge megafacies. *4th International Congress on Jurassic Stratigraphy and Geology, Abstracts*, 30–31. Mendoza.

MATYSZKIEWICZ, J. 1989. Early diagenetic environment of the Upper Oxfordian massive limestones in the Kraków region (south Poland). — *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte* **5**, 308–320.

MATYSZKIEWICZ, J. and FELISIAK, I. 1992. Microfacies and diagenesis of an Upper Oxfordian carbonate buildup in Mydlniki (Cracow Area, Southern Poland). — *Facies* **27**, 179–190.

MEHL, D. 1992. Die Entwicklung der Hexactinellida seit dem Mesozoikum. Paläobiologie, Phylogenie und Evolutionsökologie. — *Berliner Geowissenschaftliche Abhandlungen, E* **2**, 1–164.

MEHL, D. and REISWIG, H. 1993. New aspects on the living lychniscid sponge *Neoaulocystis grayi* (Bowerbank, 1863) and the Lychniscosa (Hexactinellida). *4th International Porifera Congress. Sponges in Time and Space. Book of Abstracts. Amsterdam* (without pagination). Institute of Taxonomic Zoology, University of Amsterdam, Amsterdam.

MENIN, A. 1972. Silicisponge nell'Eocene medio della Valle del Chaimpo (M. Lessini, Vincenza). — *Annali dell'Univerista di Ferrara, Sezione IX, Scienze Geologiche e Paleontologiche* **5**, 63–69.

MESSING, C.G., NEUMANN, A.C. and LANG, J.C. 1990. Biozonation of deep-water lithoherm and associated hardgrounds in the Northeastern straits of Florida. — *Palaios* **5**, 15–33.

MEYER, R.F.K., MÜLLER, W. and ÜBERLACKER, L. 1987. Die Schwamm- und Begleitfauna eines Schwammriffes des Unteren Malm der Oberpfalz. — *Geologische Blatter für NO-Bayern* **37**, 63–88.

MEYER, R.K.F. and SCHMIDT-KALER, H. 1990. Paläogeographie und Schwammriffentwicklung des süddeutschland Malm – ein Überblick. — *Facies* **23**, 175–184.

MOCK, S.E. and PALMER, T.J. 1991. Preservation of siliceous sponges in the Jurassic of southern England and northern France. — *Journal of the Geological Society, London* **148**, 681–689.

MOCZYDŁOWSKA, W. and PARUCH-KULCZYCKA, J. 1978. An analysis of siliceous sponge spicules from the Oxfordian of Wrzosowa and Zawodzie, and the Campanian of Bonarka. — *Kwartalnik Geologiczny* **22**, 83–103.

MORET, L. 1924. Contribution à l'étude des spongiaires siliceux du Miocène de l'Algérie. — *Mémoires de la Société Géologique de France (Nouvelle Série)* **1**, 1–27.

MORET, L. 1926. Contribution à l'étude des spongiaires siliceux du Crétacé supérieur français. — *Mémoires de la Société Géologique de France, Série 4*, **3**, 121–334.

MOSTLER, H. 1976. Poriferenspiculae der alpinen Trias. — *Geologisch-Paläontologische Mitteilungen Innsbruck* **6**, 1–42.

MOSTLER, H. 1978. Ein Beitrag zur Mikrofauna der Potschenkalke an der Typlokalität unter besonderer Berücksichtigung der Poriferenspiculae. — *Geologisch-Paläontologische Mitteilungen Innsbruck* **7**, 1–28.

MOSTLER, H. 1986a. Neue Kieselschwamme aus den Zlambachschichten (Obertrias, Nordliche Kalkalpen). — *Geologisch-Paläontologische Mitteilungen Innsbruck* **13**, 331–361.

MOSTLER, H. 1986b. Beitrag zur stratigraphischen verbreitung und phylogentischen Stellung der Amphidiscophora und Hexasterophora (Hexactinellid, Porifera). — *Mitteilungen Österreichischen Geologischen Gesselschaft* **78**, 319–359.

MOSTLER, H. 1989a. Mikroskleren hexactinellider Schwamme aus dem Lias der Nordlischen Kalkalpen. — *Jahrbuch Geologischer Bundes-Anstalt* **132**, 687–700.

MOSTLER, H. 1989b. Mit "Zygomen" ausgestattete Dermalia von Kieselschwammen (Demospongiae) aus pelagischen Sedimenten der Obertrias und unteren Jura (Nordlische Kalkalpen). — *Jahrbuch Geologischer Bundes-Anstalt* **132**, 701–726.

MOSTLER, H. 1990a. Mikroskleren von Demospongien (Porifera) aus dem basalen Jura der nordlichen Kalkalpen. — *Geologisch-Paläontologische Mitteilungen Innsbruck* **17**, 119–142.

MOSTLER, H. 1990b. Hexactinellide Poriferen aus pelagischen Kieselkalken (Unterlias, nordliche Kalkalpen). — *Geologisch-Paläontologische Mitteilungen Innsbruck* **17**, 143–178.

MÜLLER, W. 1972. Beobachtungen an der hexactinelliden Juraspongie *Pachyteichisma lamellossum* (Goldf.). — *Stuttgarter Beiträge zur Naturkunde, B* **2**, 1–13.

MÜLLER, W. 1974. Beobachtungen an der hexactinelliden Juraspongie *Casearia articulata* (Schmidel). — *Stuttgarter Beiträge zur Naturkunde, B* **12**, 1–19.

MÜLLER, W., 1978. Beobachtungen zur Ökologie von Kieselspongien aus dem Weissan Jura der Schwäbische Alb. — *Stuttgarter Beiträge zur Naturkunde, B* **37**, 1–15.

MÜLLER, W. 1984. Die Kalkschwämme der Unterordnung Inozoa Steinmann aus dem Oberen Jura von Würtemberg (SW-Deutschland). — *Stuttgarter Beiträge zur Naturkunde, B* **100**, 1–85.

MÜLLER, W. 1987. Revision der Gattung *Cnemidiastrum* (Demospongia, Rhizomorina) nach Material aus dem Weissen Jura der Schwäbische Alb. — *Stuttgarter Beiträge zur Naturkunde, B* **129**, 1–51.

MÜLLER, W. 1988. Revision der Gattungen *Hyalotragos* und *Pyrgochonia* (Demospongia, Rhizomorina) nach Material aus dem Weissen Jura der Schwäbische Alb. — *Stuttgarter Beiträge zur Naturkunde, B* **143**, 1–31.

MÜLLER, W. 1990. *Casearia depressa* Kolb, eine hexactinellidae Kieselspongie aus dem Weissjura Schwabens. — *Stuttgarter Beiträge zur Naturkunde, B* **162**, 1–7.

MÜLLER, W. 1991. Observation on the Jurassic Hexactinellid sponge *Tremadictyon radicatum* (QUENSTEDT). *In:* J. Reitner and H. Keupp (eds), *Fossil and Recent Sponges*, 36–42. Springer Verlag, Berlin.

MÜLLER, W. 1994. *Centrosia jurassica* n. sp. - ein neuer Kieselschwamm aus dem oberen Weiss-jura der Schwäbischen Alb. — *Stuttgarter Beiträge zur Naturkunde, B* **209**, 1–9.

MULLINS, H.T., GARDULSKI, A.F., HINCHEY, E.J. and HINE, A.C. 1988. The modern carbonate ramp slope of central west Florida. — *Journal of Sedimentary Petrology* **58**, 273–290.

NEUMANN, A.C., KOFOED, J.W. and KELLER, G.H. 1977. Lithoherms in the Straits of Florida. — *Geology* **5**, 4–10.

NITZOPOULOS, G. 1974. Faunistisch-ökologische, stratigraphische und sedimentologische Untersuchungen am Schwammstozen-Komplex bei Spielberg am Hahnenkamm (Ob. Oxfordien, Südliche Frankenalb). — *Stuttgarter Beiträge zur Naturkunde, B* **16**, 1–143.

NORRIS, M.S. and HALLAM, A. 1995. Facies variations across the Middle-Upper Jurassic boundary in Western Europe and the relationship to sea level changes. — *Palaeogeography, Palaeoclimatology, Palaeoecology* **116**, 189–245.

NUTSUBIDZE, K. Sh. 1965. Liassic sponges of the Dzirulski Massif [in Russian]. — *Trudy Geologitsheskovo Instututa, serija Gelogitscheskaja* **14** (19) 1964, 5–35.

OPPLIGER, F. 1897. Die Juraspongien von Baden. — *Abhandlungen Schweizerische Paläontologische Gesselschaft* **24**, 1–58.

OPPLIGER, F. 1907. Spongien aus dem Argovien I (Birmestorferschichten) des Departement du Jura, Frankreich. — *Abhandlungen Schweizerische Paläontologische Gesselschaft* **34**, 1–19.

OPPLIGER, F. 1915. Die spongien der Birmensdorfenschichten des schweizerischen Jura. — *Abhandlungen Schweizerische Paläontologische Gesselschaft* **40**, 1–84.

OPPLIGER, F. 1926. Kieselspongien des schweizerischen weissen Jura. — *Abhandlungen Schweizerische Paläontologische Gesselschaft* **46**, 1–76.

PAULSEN, S. 1964. Aufbau und Petrographie des Riffkomplexes von Arnegg im höheren Weissen Jura der Schwäbischen Alb (Würtemeberg). — *Arbeiten aus dem Institut für Geologie und Paläontologie der Technische Hochschule Stuttgart, NF* **42**, 1–72.

PÉ, J. 1973. Etude quantitative de la régulation du squelette chez une éponge d'eau douce. — *Archives Biologiques, Bruxelles* **84**, 147–173.

PISERA, A. 1991. Upper Jurassic sponge megafacies in Spain: Preliminary report. *In:* J. Reitner and H. Keupp (eds), *Fossil and Recent Sponges*, 486–497. Springer Verlag, Berlin.

PISERA, A. 1993. Siliceous sponges from the Middle Jurassic of the Mečsek Mountains (southern Hungary). *4th International Porifera Congress. Sponges in Time and Space. Book of Abstracts* (without pagination). Institute of Taxonomic Zoology, University of Amsterdam, Amsterdam.

PISERA, A. and BODZIOCH, A. 1991. Middle Triassic lyssacinosan sponges from Silesia (southern Poland), and history of hexactinosan and lychniscosan sponges. — *Acta Geologica Polonica* **41**, 193–207.

PISERA, A., SATIR, M., GRUSZCZYŃSKI, M., HOFFMAN, A. and MAŁKOWSKI, K. 1992. Variation in $\delta^{13}C$ and $\delta^{18}O$ in Late Jurassic carbonates, Submediterranean Province, Europe. — *Annales Societas Geologorum Poloniae* **62**, 141–147.

POČTA, P. 1886. Über einige Spongien aus dem Dogger des Funfkirchner Gebirges. — *Mitteilungen aus dem Jahrbuche der Königliche Ungarische Geologischen Anstalt* **8**, 109–121.

POMEL, A. 1872. *Paléontologie ou Description des Animaux Fossiles de la Province d'Oran. Zoophytes. 5 Fascicule. Spongiaires.* 256 pp. Typographie et lithographie A.D. Perrier, Oran.

QUENSTEDT, F.A. 1878. *Petrefactenkunde Deutschlands.* 448 pp. Fues' Verlag, Leipzig.

RAMALHO, M.M. 1988. Sur la decouverte des biohermes stromatolithiques à spongiaires siliceux dans le Kimmeridgien de l'Algarve (Portugal). — *Communicaçoes dos Serviços Geologicos de Portugal* **74**, 41–55.

REID, R.E.H. 1957. Notes on the hexactinellid sponges. II. *Dactylocalyx* Stutchbury and the family Dactylocalycidae Gray. — *Annals and Magazine of Natural History* (12) **10**, 821–826.

REID, R.E.H. 1958–1964. A monograph of the Upper Cretaceous Hexactinellida of Great Britain and Northern Ireland. — *Palaeontographical Society Monograph*, Part I and IV, i-cliv.

REID, R.E.H. 1963a. Dictyonal structure in Hexactinosa and Lychniscosa. — *Journal of Paleontology* **37**, 212–217.

REID, R.E.H. 1963b. Notes on a classification of the Hexactinosa. — *Journal of Paleontology* **37**, 218–231.

REID, R.E.H. 1963c. Hexactinellida or Hyalospongea. — *Journal of Paleontology* **37**, 232–243.

REID, R.E.H. 1968a. Bathymetric distribution of Calcarea and Hexactinellida in the present and in the past. — *Geological Magazine* **105**, 546–559.

REID, R.E.H. 1968b. Microscleres in demosponge classification. — *The University of Kansas Paleontological Contributions, Paper* **35**, 1–37.

REID, R.E.H. 1969. Notes on hexactinellid sponges: 5, *Verrucocoeloidea* gen. nov., with a discussion of the genera *Verrucolia* Etallon and *Periphragella* Marshall. — *Journal of Natural History* **3**, 485–492.

REID, R.E.H. 1970. Tetraxons and demosponge phylogeny. *In:* W.G. Fry (ed.), *The Biology of Porifera*, 63–89. Symposium of the Zoological Society of London 25. Academic Press, London.

REIF, W.-E. 1967. Schwammspicula aus dem Weissen Jura Zeta von Nattheim (Schwäbische Alb). — *Palaeontographica A* **127**, 85–102.

REIF, W.-E. and ROBINSON, J.A. 1976. On functional morphology of the skeleton in lychniscs sponges (Porifera, Hexactinellida). — *Paläontologische Zeitschrift* **50**, 57–69.

REIFF, W. 1988. Die Korallenvorkommen von Gerstetten. Faziele und stratigraphische Zuordnung im Oberen Jura der ostlischen Schwäbischen Alb. — *Jahreshefte des Geologischen Landesamt Baden-Württemeberg* **30**, 357–371.

REISWIG, H.M. 1990. In situ feeding in two shallow-water hexactinellid sponges. *In:* K. Rützler (ed), *New Perspectives in Sponge Biology*, 504–510. Washington.

REISWIG, H.M. 1991. New perspectives on the hexactinellid genus *Dactylocalyx* Stuchbury. *In:* J. Reitner and H. Keupp (eds), *Fossil and Recent Sponges*, 7–20. Springer Verlag. Berlin.

REITNER, J. and KEUPP, H. 1991. The fossil Record of the Haplosclerid excavating sponge *Aka* de Laubenfels. *In:* J. Reitner and H. Keupp (eds), *Fossil and Recent Sponges*, 102–120. Springer Verlag. Berlin.

RHEINHEIMER, G. 1980. *Aquatic Microbiology*. 235 pp. John Wiley & Sons, New York.

RIBA, A.O. 1959. Estudio geologico de la Sierra de Albarracin. — *Monografias del Cientific Instituto "Lucas Mallada" Madrid* **16**, 283.

RIGBY, J.K. 1983. Fossil Demospongia. *In:* J.K. Rigby and C.W. Stearns (eds), *Sponges and Spongiomorphs*, 12–39.

RIGBY, J.K., BUDD, G.E., WOOD, R.A. and DEBRENNE, F. 1993. Polifera. *In:* M.J. Benton (ed.), *The Fossil Record 2*, 71–99. Chapman & Hall, London.

RIGBY, J.K., RACKI, G. and WRZOŁEK, T. 1981. Occurrence of dictyid hexactinellid sponges in the Upper Devonian of the Holy Cross Mts. — *Acta Geologica Polonica* **31**, 163–168.

RIO, M., ROUX, M., GUERRIN, H. and l'équipe de CALSUB 1991. Les substrat géologique et les processus sédimentaires sur les pentes bathyales. *In:* B. Lambert and M. Roux (eds), L'environnements carbonate bathyal en Nouvelle-Calédonie. — *Documents et Travaux Institut Géologique Albert-de-Lapparent* **15**, 57–74.

ROLL, A. 1934. Form, Bau und Entstehung der Schwammstotzen im süddeutschen Malm. — *Paläontologische Zeitschrift* **16**, 197–246.

ROUX, M., BOUCHET, P., BOURSEAU, J-P., GAILLARD, C., GRANDPERRIN, R., GUILLE, A. Q., LAURIN, B., MONNIOT, C., RICHER DE FORGES, B., RIO, M., SEGOZNAC, M., VACELET, J. and ZIBROWIUS, H. 1991. L'étagement du benthos bathyal observe à l'aide de la soucoupe CYANA. *In:* B. Lambert and M. Roux (eds), L'environements carbonate bathyal en Nouvelle-Calédonie. — *Documents et Travaux Institut Géologique Albert-de-Lapparent* **15**, 151–165.

RÜTZLER, K. and MACINTYRE, I.G. 1978. Siliceous sponge spicules in coral reef sediments. — *Marine Biology* **49**, 147–159.

SALOMON, D. 1990. Nomenklatur und taxonomischer Status der fossilen Gattung *Cribrospongia* d'Orbigny, 1849 (= *Tremadictyon* Zittel, 1877) (Hexactinosa, Hexactinellida). — *Berliner geowissenschaftliche Abhandlungen, A* **124**, 35–41.

SCHEER, U. 1988. Influence of the paleogeographic position and sea-level changes on spongiolitic limestones in the Lower Bajocian (*discites*-to *humphresianum*-zone; Middle Jurasic) in Northern Spain. — *Berliner Geowissenschaftliche Abhandlungen A* **100**, 36.

SCHMALZRIEDT, A. 1991. Die mikrofauna in Schwämmen, Schwammriff- und "Normal" – fazies des unteren und mittelern Malm (Oxfordium und Kimmeridgium, Ober-Jura) der westlichen Schwäbische Alb (Württemberg). — *Tübinger Mikropaläontologische Mitteilungen* **10**, 1–120.

SCHORR, M. and KOCH, R. 1985. Fazieszonierung eines oberjurassichen Algen-Schwamm-Bioherms (Herrlingen Schwäbische Alb). — *Facies* **13**, 227–270.

SCHRAMMEN, A. 1910–1912. Die Kieselspongien der oberen Kreide von Nordwestdeutschland. I Teil. Tetraxonia, Monaxonia und Silicea incertae sedis. II Teil. Triaxonia (Hexactinellida). — *Palaeontographica Supplement* **5**, 1–385.

SCHRAMMEN, A. 1924. Zur Revision der Jura-Spongien von Süddeutschlands. — *Jahresberichte und Mitteilungen Oberrheinischen Geologischen Vereins*, 125–154.

SCHRAMMEN, A. 1936. Die Kieselspongien des Oberen Jura von Süddeutschland. — *Palaeontographica* **84**, 149–194.

SCHRAMMEN, A. 1937. Die Kieselspongien des Oberen Jura von Süddeutschland. B. Besonderer Teil. — *Palaeontographica* **85**, 1–114.

SCHULZE, F.E. 1887. Report on the Hexactinellida collected during the years 1873–1876. — *Report of Scientific Results of H.M.S. Challenger* **21**. 513 pp. Eyre and Spottiswoode.

SCHULZE, F.E. 1899. *Amerikanische Hexactinelliden nach dem Material der Albatros-Expedition*. 126 pp. Verlag von Gustaw Fischer, Jena.

SCHULZE, F.E. 1900. Hexactinelliden des Rothen Meeres. — *Berichte der Commission für Oceanographische Forschung. Zoologische Ergebnisse* **16**, 311–324. Wien.

SCHWEIGERT, G. 1993. Die Ammonitengattungen *Gravesia* Salfeld und *Tolvericeras* Hantzpergue und ihre Bedeutung für den Grenzbereich Oberkimmeridgium/Untertithonium im Schwäbischen Jura. — *Geologische Bl. NO-Bayern* **43**, 167–186.

SCHWEIGERT, G. 1994. Über einige berkenswerte Ammoniten im Oberkimmeridgium der Schwäbischen Alb (Südwestdeutschland). — *Stuttgarter Beiträge zur Naturkunde B* **203**, 1–15.

SCOTESE, C.R. 1992. *Paleomap project. Progress Report No. 36.* University of Texas, Arlington, Texas.

SEYFRIED, H. 1978. Der subbetische Jura von Murcia (Südost-Spanien). — *Geologisches Jahrbuch B* **29**, 1–204.

SIEMIRADZKI, J. 1913. Les spongiaire Jurassiques de la Pologne. — *Paléontologie de Pologne* **1**, 1–50.

SOEST, R.W.M. VAN 1990. Shallow-water reef sponges of Eastern Indonesia. *In:* K. Rützler (ed.), *New Perspectives in Sponge Biology*, 302–308. Smithsonian Institution Press, Washington.

SOEST, R.W.M. VAN 1991. Demosponge higher taxa classification re-examined. *In:* J. Reitner and H. Keupp (eds), *Fossil and Recent Sponges*, 53–71. Springer Verlag, Berlin.

SOEST, R.W.M. VAN and STENTOFT, N. 1988. Barbados deep-water sponges. — *Studies on the Fauna of Curaçao and other Caribbean Islands* **70**, 1–175.

SOLLAS, W.J. 1883. Description of fossil sponges from the Inferior Oolite, with notice on some from the Great Oolite. — *Quarterly Journal of Geological Society* **34**, 541–554.

SOLLAS, W.J. 1888. Report on the Tetractinellida collected by H.M.S. Challenger, during the years 1873–1876. — *Report of the Scientific Results, Voyage of the HMS Challenger, Zoology* **5**, i-clxvi, 1–458.

STENTOFT, N. 1994. Early submarine cementation in fore-reef carbonate sediments, Barbados, West Indies. — *Sedimentology* **41**, 585–604.

TABACHNICK, K.R. 1991. Adaptation of the Hexactinnellid sponges to deep-sea. *In:* J. Reitner and H. Keupp (eds), *Fossil and Recent Sponges*, 378–386. Springer Verlag.

TOPSENT, E. 1928. Spongiaires de l'Atlantic et de la Méditerranée provenant des croisiere du Prince Albert Ier de Monaco. — *Résultats de Campagne Scientifique Prince Albert I* **74**, 376p.

TRAMMER, J. 1979. Some aspects of the biology of fossil solid-branching demosponges, exemplified by *Reiswigia ramosa* gen. n., sp. n., from the Lower Oxfordian of Poland. — *Acta Geologica Polonica* **29**, 39–49.

TRAMMER, J. 1981. Morphological variation and relative growth in two Jurassic demosponges. — *Neues Jahrbuch für Geologie und Paläontologie, Monatshefete* **1**, 54–64.

TRAMMER, J. 1982. Lower to Middle Oxfordian sponges of the Polish Jura. — *Acta Geologica Polonica* **32**, 1–39.

TRAMMER J. 1983. The relation of the morphological type of a sponge to water turbulence. — *Speculation in Science and Technology* **6**, 143–146.

TRAMMER, J. 1989. Middle to Upper Oxfordian sponges of the Polish Jura. — *Acta Geologica Polonica*, **39**, 49–91.

TRAMMER, J. 1991. Ecologic history of the Oxfordian sponge assemblage in the Polish Jura Chain. *In:* J. Reitner and H. Keupp (eds), *Fossil and Recent Sponges*, 506–515. Springer Verlag.

TRIFFLEMAN, N.J., HALLOCK, P. and HINE, A.C. 1992. Morphology, sediments, and depositional environments of a small carbonate platform: Serranilla Bank, Nicaraguan Rise, Southwest Carribean Sea. — *Journal of Sedimentary Geology* **62**, 591–606.

VACELET, J. 1988. Indications de profondeur données par les Spongiaires dans les milieux benthiques actuels. — *Géologie Méditerranéenne* **15**, 13–26.

VACELET, J., BOURY-ESNAULT, N. and ZIBROWIUS, H. 1989. Unexpected deep-water records of calcareous sponges (Calcarea). — *Deep-Sea Newsletter* **15**, 24–25.

VACELET, J. and VASSEUR, P. 1971. Eponges des récifs coralliens de Tulear (Madagascar). — *Tethys, Supplement* **1**, 51–126.

VINASSA DE REGNY, P. 1901. Neu Schwämme, Tabulaten und Hydrozoen aus dem Bakony. — *Resultate Wissenschaftlichen Erforschung Balatonsee* **1**, 1–17.

VOSMAER, G.C.J. and VERNHOUT, J.H. 1902. The Porifera of the Siboga-Expedition. I. The genus Placospongia. — *Siboga-Expeditie* **6a**, 1–17.

WAGENPLAST, P. 1972. Ökologische Untersuchung der Fauna aus Bank- und Schwammfazies des Weissen Jura. — *Arbeiten aus dem Institut für Geologie und Paläontologie der Universität Stuttgart, N.F.* **67**, 1–99.

WAGNER, W. 1963. Kieselschwämme und Schwammökologie im Korallenkalk des oberen Malm von Laisacker bei Neuburg an der Donau. — *Mitteilungen der Bayerischen Staatssamlung für Paläontologie und historische Geologie* **3**, 1–20.

WENDT, J., WU XI-CHUN and REINHARDT, J.W. 1989. Deep water hexactinellid sponge mounds from the Upper Triassic of northern Sichuan (China). — *Palaeogeography, Palaeoclimatology, Palaeoecology* **76**, 17–29.

WEVER, P.O. DE 1989. Radiolarians, Radiolarites, and Mesozoic Paleogeography of the Circum-Mediterranean Alpine belts. *In:* J.R. Hein and J. Obradovic (eds), *Siliceous Deposits of the Tethyan and Pacific Regions*, 31–49. Springer Verlag, Berlin.

WIEDENMAYER, F. 1994. Contribution to the knowledge of post-Paleozoic neritic and archibenthal sponges (Porifera). — *Schweizerische Paläontologische Abhandlungen* **116**, 1–147.

WILDE, S. 1988. The Upper Bajocian-Lower Bathonian (Middle Jurassic) of northwest Iberian Range (Spain) - a spongiotuberolitic environment. — *Berliner Geowissenschaftliche Abhandlungen A* **100**, 52.

WILSON, J.L. 1975. *Carbonate Facies in Geologic History.* 471 pp. Springer Verlag, New York.

WIRSING, G. 1988. Mikrofazielle und diagenetische Entwicklung einer oberjurassichen Karbonatabfolge (Weissejura beta bis delta 4, Mittlere Schwäbische Alb) mit Berücksichtigung der chemischen Diagenese ausgewahlter karbonatischer Bestandteile. — *Heidelberger Geowissenschaftliche Abhandlungen* **15**, 1–337.

WIŚNIOWSKI, T. 1889. Beitrag zur Kenntniss der Mikrofauna aus den oberjurassischen Feursteinknollen der Umgegend von Krakau. — *Jahrbuch der Kaiserlichen-Königlichen Geologischen Reichsanstalt* **38**, 657–699.

WIŚNIOWSKI, T. 1891. Mikrofauna iłów ornatowych okolic Krakowa. Część II. Gąbki górnego Kelloweyu w Grójcu oraz nowe otwornice tych samych warstw. — *Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności w Krakowie* **30**, 317–331.

WU XI-CHUN 1990. Late Triassic lychniscose fauna in northwestern Sichuan. — *Acta Palaeontologica Sinica* **29**, 357–363.

ZIEGLER, B. 1962. Beobachtungen an hexactinelliden Spongien. — *Eclogae Geologie Helvetiae* **55**, 573–585.

ZIEGLER, B. 1967. Ammoniten-Ökologie am Biespiel des Oberjura. — *Geologische Rundschau* **56**, 439–464.

ZIEGLER, B. 1977. The "White" (Upper) Jurassic in Southern Germany. — *Stuttgarter Beiträge zur Naturkunde, B* **26**, 1–79.

ZIEGLER, B. 1987. Der Weisse Jura der Schwäbischen Alb. — *Stuttgarter Beiträge zur Naturkunde, C* **23**, 1–71.

ZIEGLER, P.A. 1990. *Geological Atlas of Western Europe.* Shell Internationale Petroleum Maatschappij B.V.

ZITTEL, K.A. 1876. *Handbuch der Palaeontologie. Band I. Abteilung I. Protozoa, Coelenterata, Echinodermata und Molluscoidea.* 765 pp. Oldenburg, München-Leipzig.

ZITTEL, K.A. 1877. Studies on Fossil sponges, I, Hexactinellida. — *Annals and Magazine of Natural History 4*, **20** 257–273, 405–424, 501–517.

ZITTEL, K.A. 1878a. Bemerkungen zu Taf. 119–124 der Petrefactenkunde Deutschlands von Quenstedt. Bd. V. Schwämme. — *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, 61–65.

ZITTEL, K.A. 1878b. Studien über fossile Spongien. Zweite Abteilung: Lithistidae. — *Abhandlungen der Königliche bayerischen Akademie der Wissenschaften, Mathematisch-Physische Klasse* **13**, 66–153.

PLATES

PLATE EXPLANATIONS

Abbreviations used: ZPAL – Institute of Paleobiology, Warsaw; IGPTU – Institut und Museum für Geologie und Paläontologie, Tübingen Universität; IPUB – Institut für Paläontologie, Universität Bonn; BSPHGM – Bayerische Staatssamlung für Paläontologie und Historische Geologie, München; SMNS – Staatliche Museum für Naturkunde, Stuttgart.

PLATE 1

Cribrospongia reticulata (GOLDFUSS, 1826) 47

1. Holotype (GOLDFUSS 1826: pl. 4: 1c – in fact most probably it is *Stauroderma lochense* as understood since QUENSTEDT 1878), Streitberg, IPUB; *a* side view, *b* upper surface view, *c* lower side view; × 0.66.

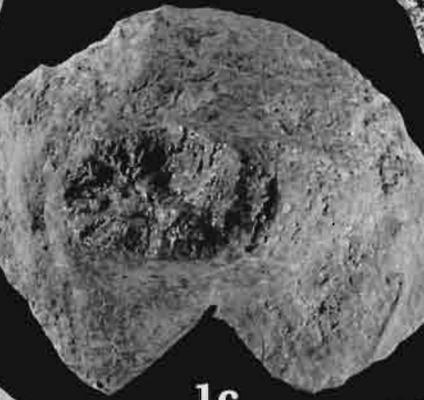
Cribrospongia cucullata (QUENSTEDT, 1878) 49

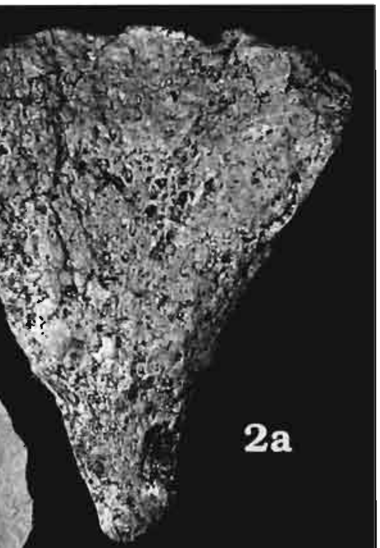
2. GOLDFUSS' specimen (1826: pl. 2: 16) described as *Scyphia polyommata* nobis, Switzerland, IPUB; *a, b* lateral views; × 0.66.
3. Specimen from SMNS collection, Obernheim, Kimmeridgian (Gamma); × 0.66.

Cribrospongia? *rugata* (QUENSTEDT, 1878) 48

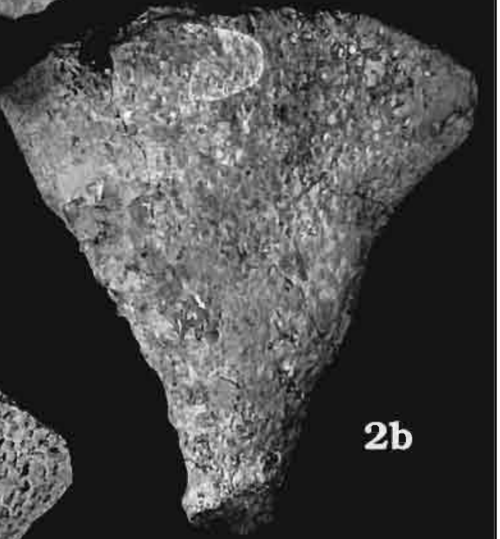
4. Holotype (QUENSTEDT 1878: pl. 116: 4), Hossingen, Oxfordian (Beta), IGPTU; outer surface view; × 0.66.
5. Specimen ZPAL Pf.VIII/6a, Plettenberg, Oxfordian limestones (Beta); outer surface view; × 0.66.

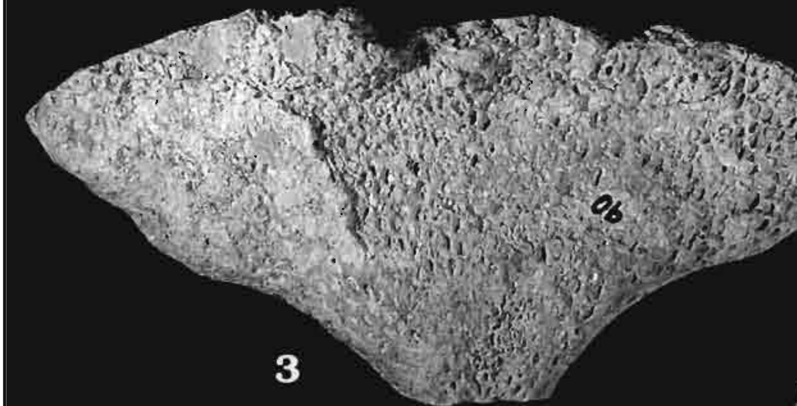

1a

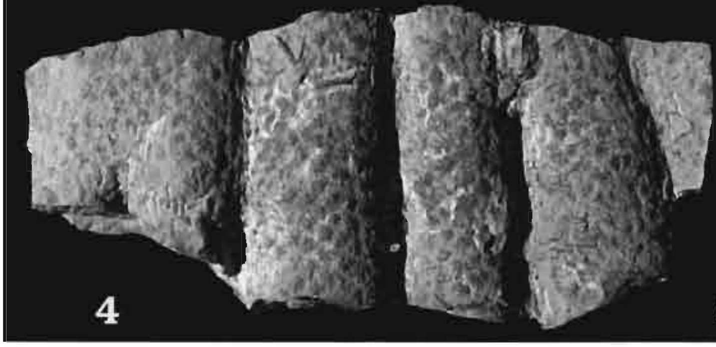

1c


2a


1b


2b


3


4


5

PLATE 2

Cribrospongia? *tesselata* (QUENSTEDT, 1878) 48

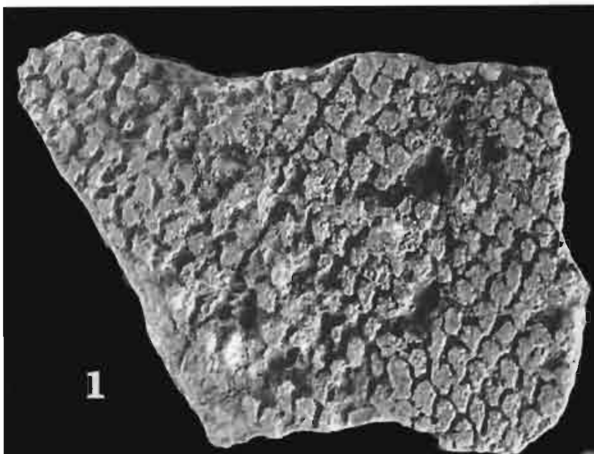
1. Specimen ZPAL Pf.VIII/271, outer (lower) surface view, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); × 1.
2. Holotype (QUENSTEDT 1878: pl. 116: 7), outer (lower) surface view, Hossingen, Kimmeridgian (Gamma), IGPTU; × 1.

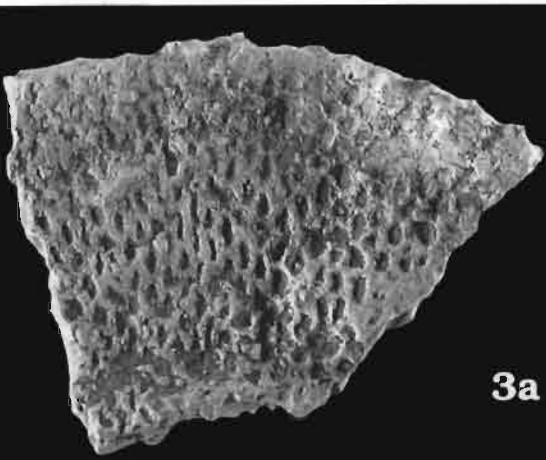
Cribrospongia elegans (SCHRAMMEN, 1937) 49

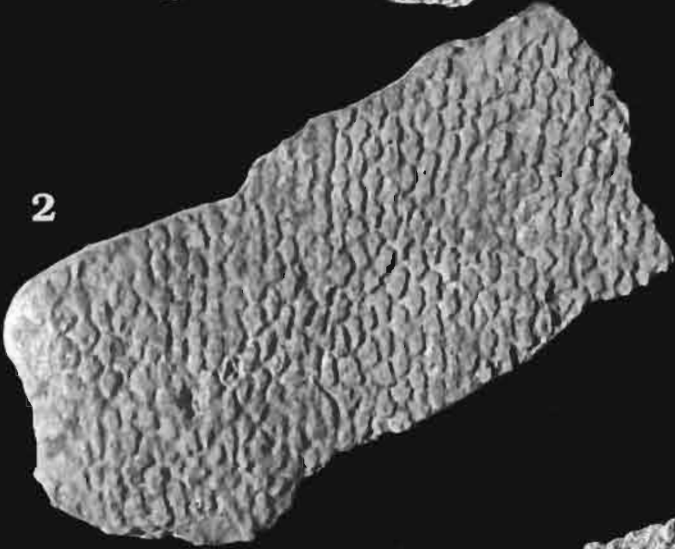
3. Specimen ZPAL Pf.VIII/300, Bärenthal, Kimmeridgian marls (Gamma); *a* lower (outer) surface view, *b* upper (inner) surface view; × 1.
5. Specimen ZPAL Pf.VIII/310, Bärenthal, Kimmeridgian marls (Gamma); × 1.

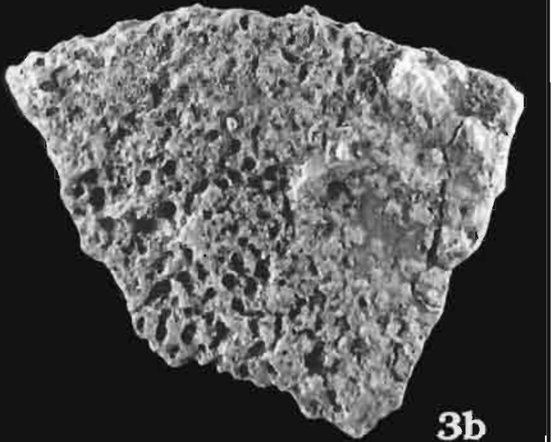
Cribrospongia cucullata (QUENSTEDT, 1878) 49

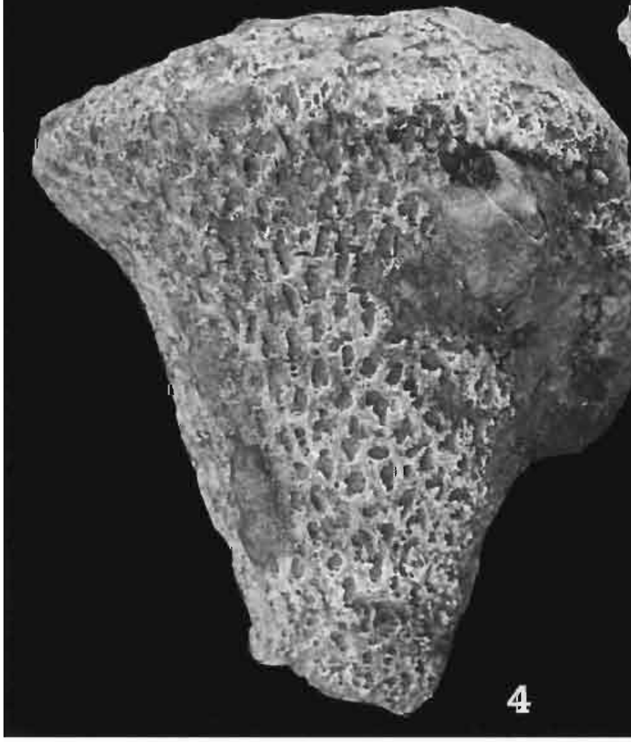
4. SCHRAMMEN's collection, Streitberg IGPTU; × 1.33.


1


3a


2


3b


4

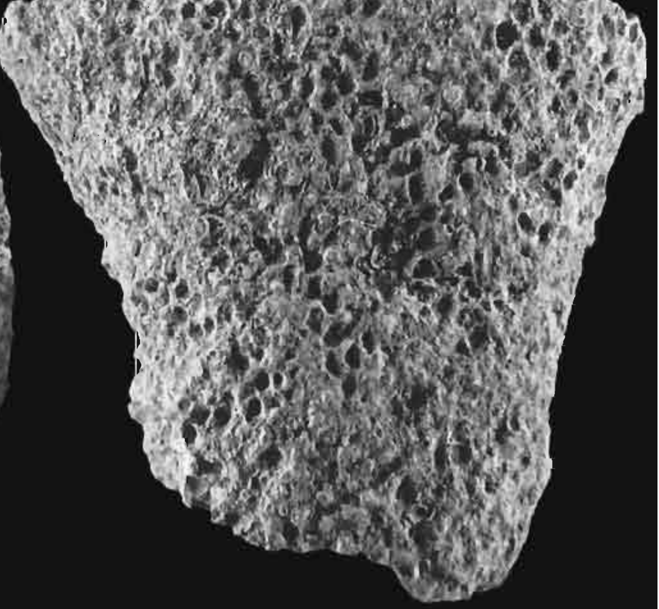

5

PLATE 3

Cribrospongia reticulata (GOLDFUSS, 1826) 47

1–3. Silicified specimens, SCHRAMMEN's collection, IGPTU; × 0.66; *1* basal part of large specimen with irregular basal skeleton visible, Natheim, (?uppermost Kimmeridgian); *2–3* wall fragments, Heuchstetten, Kimmeridgian (Epsilon).

6. Specimen ZPAL Pf.VIII/13, Bärenthal, crumpled limestones of the Oxfordian (Alfa); × 0.66.

Stauroderma lochense (QUENSTEDT, 1858) 54

4. Specimen ZPAL Pf.VIII/2, Hochwang, Kimmeridgian marls (Delta); × 1.

Pachyteichisma lamellosa (QUENSTEDT, 1878) 67

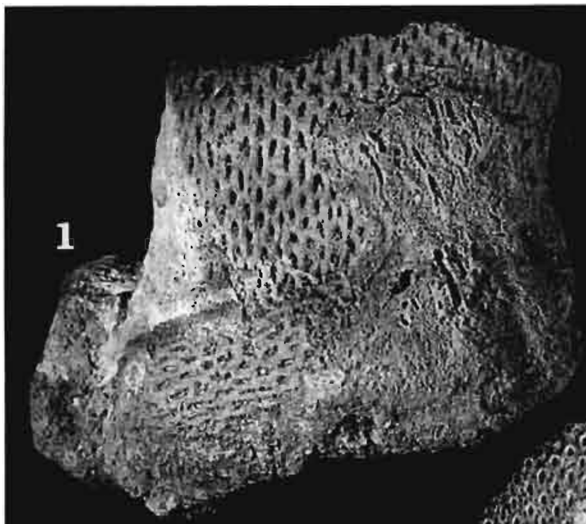
5. Specimen ZPAL Pf.VIII/266, Bärenthal, Kimmeridgian marls (Gamma); outer surface view; × 0.5.

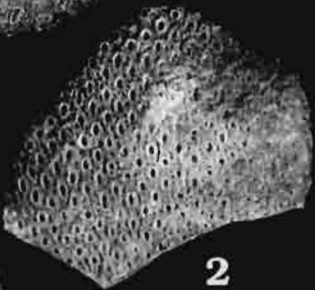
Ramispongia ramosa QUENSTEDT, 1878 53

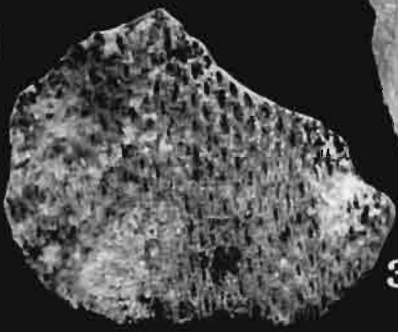
7. Specimen ZPAL Pf.VIII/206, Bärenthal, Kimmeridgian marls (Gamma); × 0.66.

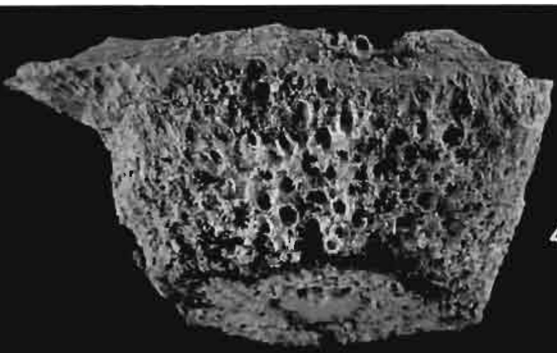
Cypellia caliciformis OPPLIGER, 1907 62

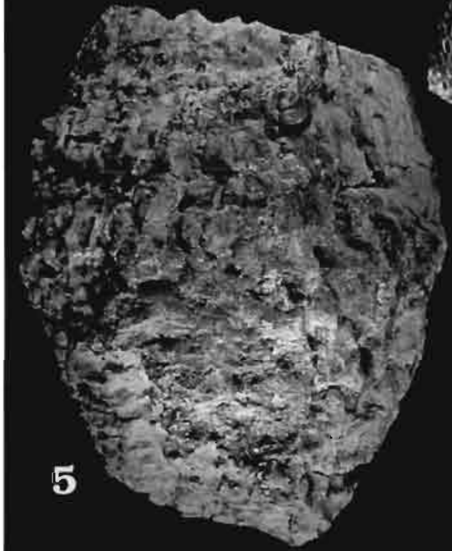
8. Specimen ZPAL Pf.VIII/280, Plettenberg, Oxfordian limestones (Beta); outer surface view; × 0.66.


1


2


3


4


5


6


7


8

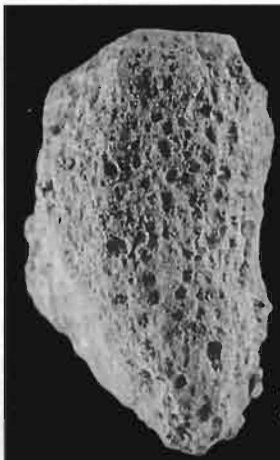
PLATE 4

Walcotella pertusa (Goldfuss, 1833) 52

1. Specimen ZPAL Pf.VIII/41, Bärenthal, crumpled marly limestones of the Oxfordian (Alfa); × 2.
2. Specimen ZPAL Pf.VIII/61, Bärenthal, Kimmeridgian marls (Gamma); × 1.4.
3. Goldfuss' specimen (1833: pl. 8a), Streitberg, Oxfordian, IPUB; × 1.
4. Quenstedt's specimen (1878: pl. 120: 61), Kimmeridgian (Gamma), IGPTU; × 1.5.
5. Quenstedt's specimen (1878: pl. 120: 65), Oberdigisheim, Kimmeridgian (Gamma), IGPTU; × 1.
7. Goldfuss' specimen (1833: pl. 2: 8c), Steitberg, IPUB; × 1.
8. Specimen ZPAL Pf.VIII/42, Bärenthal, crumpled marly limestones of the Oxfordian (Alfa); *a* oscular view, *b* lateral view; × 2.

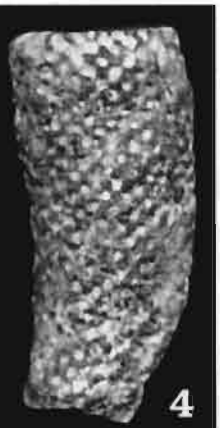
Ordinatus texturatus (v. Schlotheim, 1820) 53

6. Holotype (Goldfuss 1833: pl. 2: 9), Giengen, IPUB; × 1.5.
9. Specimen ZPAL Pf.VIII/269, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); × 1.
10. Specimen ZPAL Pf.VIII/34, Bärenthal, Kimmeridgian marls (Gamma); × 1.


1


3


2


4

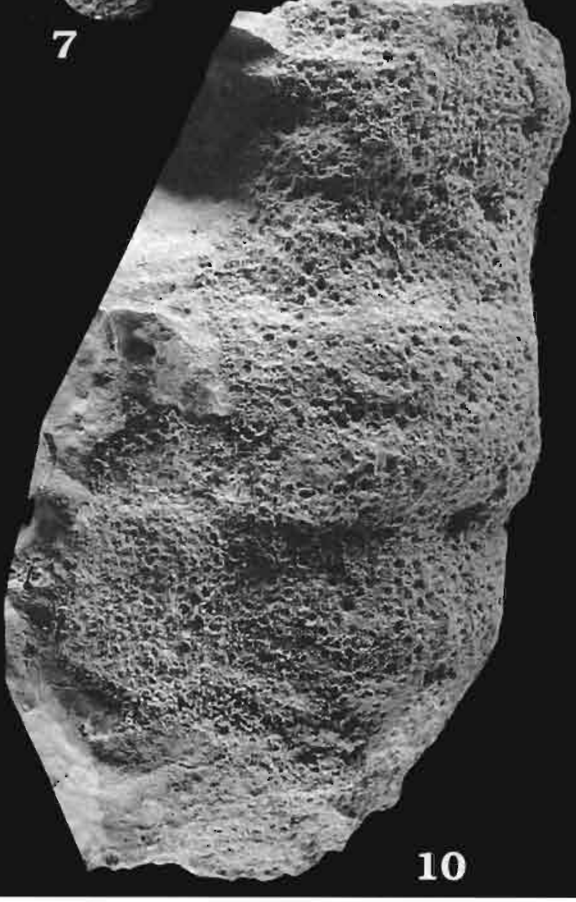

5


7


6


8a


9


10

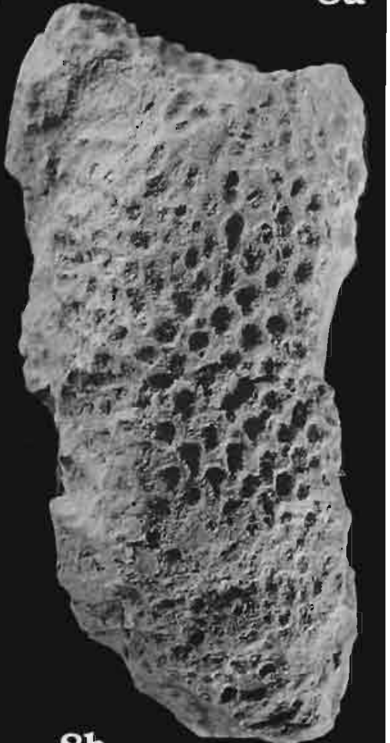

8b

PLATE 5

Cypellia caliciformis Oppliger, 1907 62

1. Specimen ZPAL Pf.VIII/60, Bärenthal, Oxfordian limestones (Beta); *a* lower surface view, *b* upper surface view, *c* lateral view; × 0.66.

Stauroderma lochense (Quenstedt, 1858) 54

2. Specimen ZPAL Pf.VIII/14, Plettenberg, Oxfordian limestones (Beta); upper surface view; × 0.66.
6. Specimen ZPAL Pf.VIII/17, Plettenberg, Oxfordian marls (Alfa); × 0.7.

Pachyteichisma lopas (Quenstedt, 1878) 68

3. Specimen ZPAL Pf.VIII/65, Bärenthal, Kimmeridgian marls (Gamma); lower surface view; × 0.66.

Placotelia laciniata (Oppliger, 1926) 64

4. Specimen ZPAL Pf.VIII/22; Bärenthal, Oxfordian limestones (Beta); × 0.7.

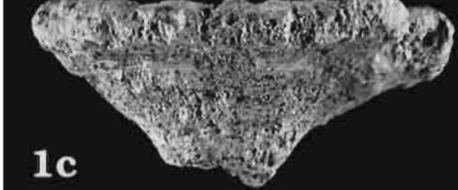
Placotelia marcoui (Etallon, 1860) 64

5. Specimen ZPAL Pf.VIII/28, Plettenberg, Oxfordian limestones (Beta); upper surface view; × 0.7.


1a


2


1b


1c


3


4


6a


5

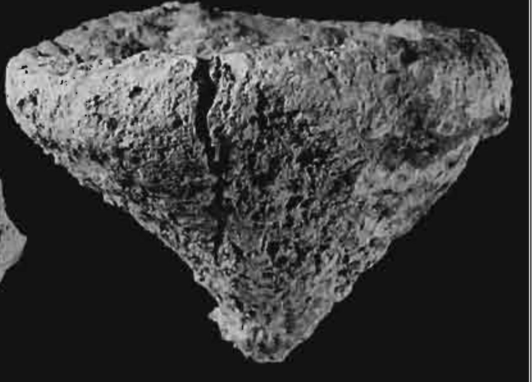

6b

PLATE 6

Laocoetis schweiggeri (GOLDFUSS, 1833) 43

1. SCHRAMMEN's collection, Lochen Nordwand, Oxfordian limestones (Beta), IGPTU; × 0.66.
6. Specimen illustrated by QUENSTEDT (1878: pl. 117: 2) as *Textispongia gigas*, Hossingen, IGPTU; × 0.66.
7. QUENSTEDT's specimen (1878: pl. 117: 1), Bollert, IGPTU; × 0.66.

Verrucocoelia verrucosa (GOLDFUSS, 1829) 37

2. SCHRAMMEN's collection, IGPTU, Geisingen, Kimmeridgian (Delta); × 0.66.

Cypellia prolifera (ZITTEL, 1878) 62

3. Specimen ZPAL Pf.VIII/275, Genkingen, Kimmeridgian limestones (Delta); × 0.66.

Laocoetis procumbens (GOLDFUSS, 1826) 40

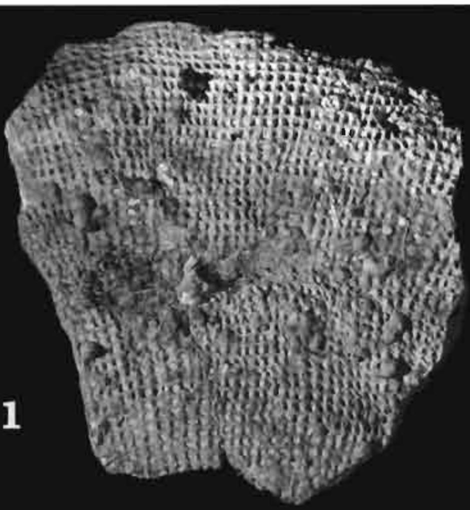
4. Holotype (GOLDFUSS 1833: pl. 4: 3), Baireutischen, IPUB; × 0.5.

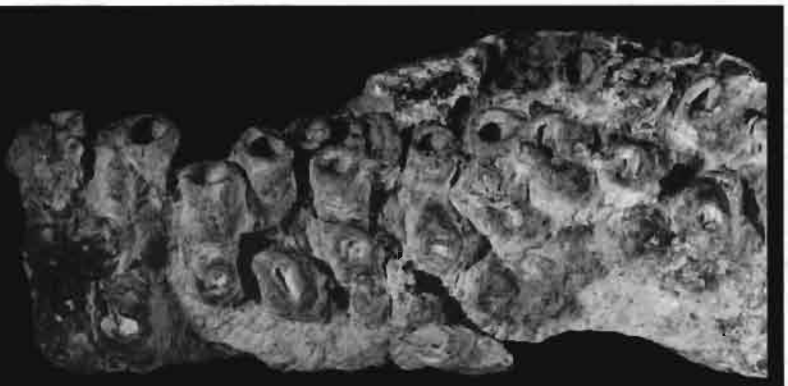
Laocoetis clathrata (GOLDFUSS, 1833) 42

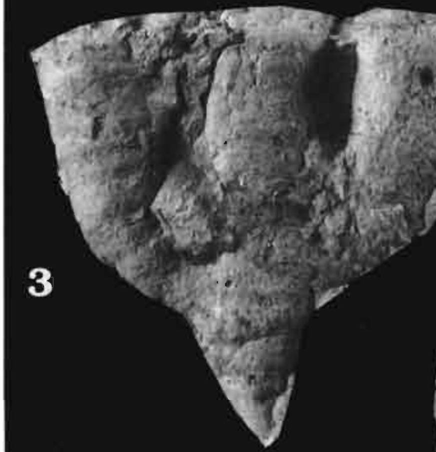
5. Holotype (GOLDFUSS 1833: pl. 3: 1), Streitberg, IPUB; × 0.66.

Laocoetis paradoxa (MÜNSTER *in* GOLDFUSS, 1833) 41

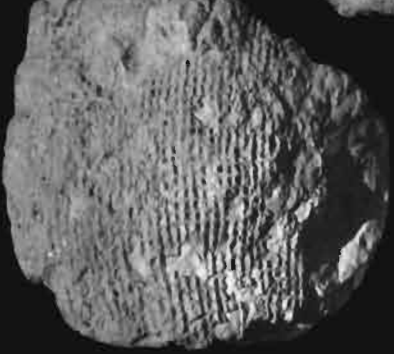
8. Holotype (GOLDFUSS 1833: pl. 31: 6a), Streitberg, BSPHGM; × 0.5.

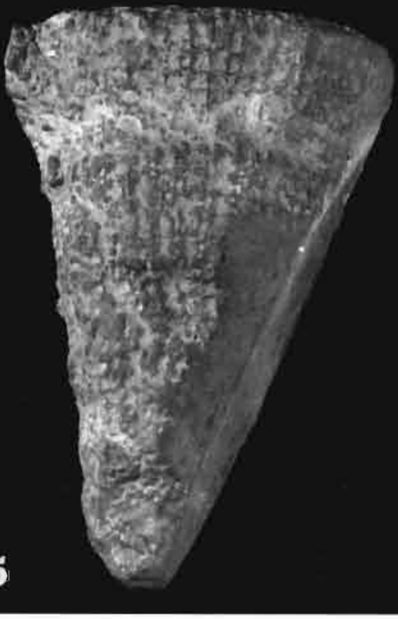

1


2


3


4


6


5


7


8

PLATE 7

Laocoetis parallela (GOLDFUSS, 1826) 38

1. Specimen ZPAL Pf.VIII/18, Plettenberg, Oxfordian marls (Alfa); *a* oscular view, *b* lateral view; × 1.
2. Specimen ZPAL Pf.VIII/88, Plettenberg, Oxfordian limestones (Beta); × 0.9.
3. Specimen ZPAL Pf.VIII/83, Plettenberg, Oxfordian marls (Alfa); × 1.

Laocoetis arborescens (SCHRAMMEN, 1937) 42

4. Specimen ZPAL Pf.VIII/86, Plettenberg, Oxfordian marls (Alfa); × 0.8.
5. Specimen ZPAL Pf.VIII/20, Bärenthal, Oxfordian limestones (Beta); × 1.5.
6. Specimen ZPAL Pf.VIII/84, Bärenthal, Kimmeridgian marls (Gamma); × 1.7.

Laocoetis paradoxa (MÜNSTER *in* GOLDFUSS, 1833) 41

7. Specimen ZPAL Pf.VIII/19, Asselfingen, Kimmeridgian limestones (Zeta); × 1.

Laocoetis clathrata (GOLDFUSS, 1826) 42

8. Specimen ZPAL Pf.VIII/76, Bärenthal, Kimmeridgian marls (Gamma); × 0.75.


1a


1b

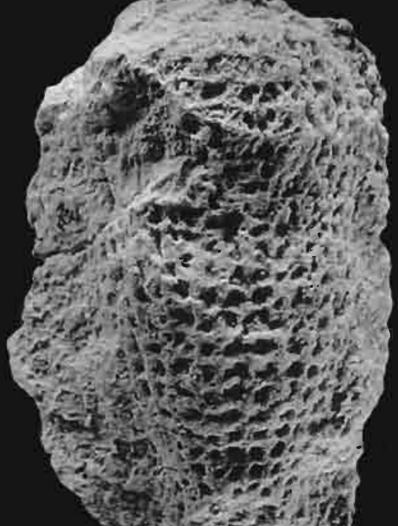

2


4

5


3


6


7

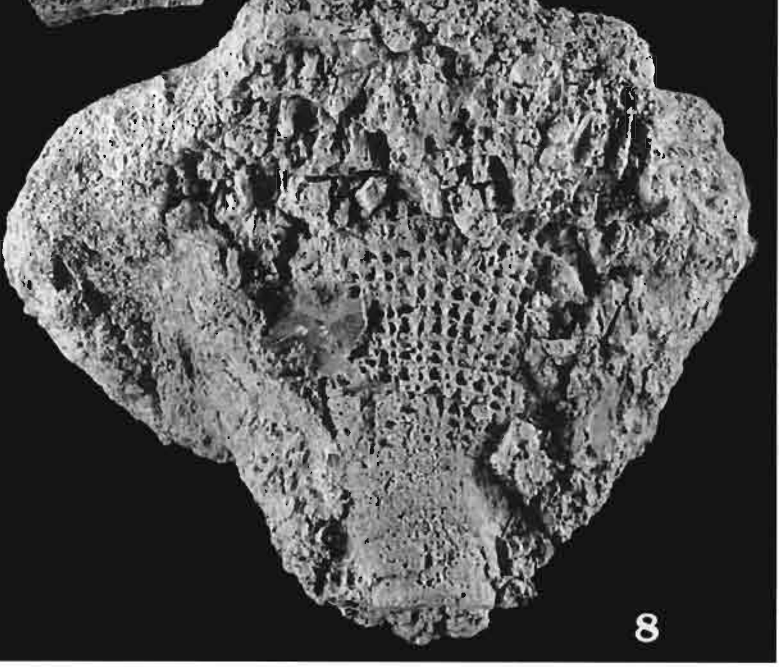

8

PLATE 8

Laocoetis parallela (GOLDFUSS, 1826) 38

1. Holotype (GOLDFUSS 1826: pl. 3: 3), Streitberg, IPUB, *a* and *b* opposite lateral views; × 1.
4. Specimen ZPAL Pf.VIII/296, Bärenthal, Kimmeridgian marls (Gamma); × 0.95.
8. Specimen ZPAL Pf.VIII/295, Bärenthal, Kimmeridgian marls (Gamma); canal openings on the gastral side of dictyonal skeleton; × 1.

Laocoetis tubifera (SCHRAMMEN, 1937) 42

2. Specimen ZPAL Pf.VIII/285, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); × 1.6.
3. Specimen ZPAL Pf.VIII/286, Hochwang, Kimmeridgian marls (Delta); × 1.6.

Laocoetis striatopunctata (SCHRAMMEN, 1937) 41

5. Specimen ZPAL Pf.VIII/312, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); × 1.

Tremaphorus favrei (OPPLIGER, 1907) 51

6. Specimen ZPAL Pf.VIII/294, Plettenberg, Oxfordian marls (Alfa); × 1.5.

Laocoetis procumbens (GOLDFUSS, 1826) 40

7. Specimen ZPAL Pf.VIII/314, Bärenthal, Kimmeridgian marls (Gamma); × 0.95.

Laocoetis schweiggeri (GOLDFUSS, 1833) 43

9. Specimen ZPAL Pf.VIII/278, fragment of a widely tubular specimen, Bärenthal, Kimmeridgian marls (Gamma); × 1.

Stauroderma lochense (QUENSTEDT, 1858) 54

10. Specimen ZPAL Pf.VIII/289, Bärenthal, Kimmeridgian marls (Gamma); × 1.
11. Lower, tubular part of plate-like specimen, ZPAL Pf.VIII/290, Bärenthal, Kimmeridgian marls (Gamma); × 1.


1a


1b

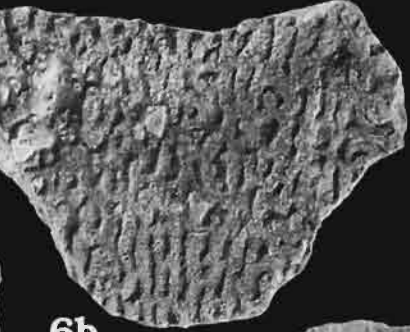

2


3


4


5

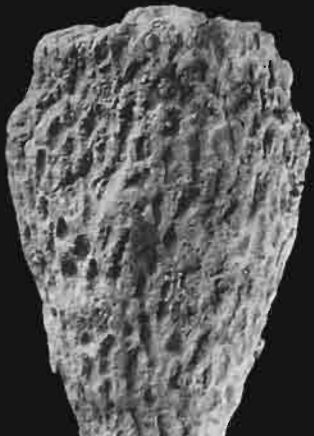

6a


6b


7


11


8


10


9

PLATE 9

Laocoetis sp. n. 41

1. Specimen ZPAL Pf.VIII/65, Bärenthal, Oxfordian limestones (Beta); *a* and *b* opposite side views; × 1.

8. Specimen ZPAL Pf.VIII/64, Bärenthal, Kimmeridgian marls (Gamma); × 1.5.

Centrosia jurassica MÜLLER, 1994 75

2. Specimen ZPAL Pf.VIII/402, Hermaringen, Kimmeridgian limestones (Epsilon); *a* upper side view, *b* lower side view; × 1.2.

Laocoetis lineata (SCHRAMMEN, 1937) 43

3. Specimen ZPAL Pf.VIII/409, Genkingen, Kimmeridgian marls (Delta); × 1.

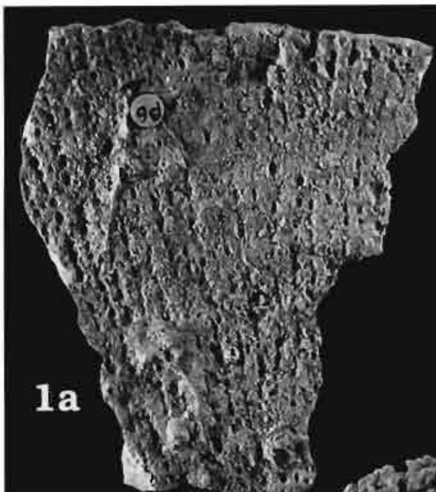
5. Specimen ZPAL Pf.VIII/291, Bärenthal, Kimmeridgian marls (Gamma); × 1.5.

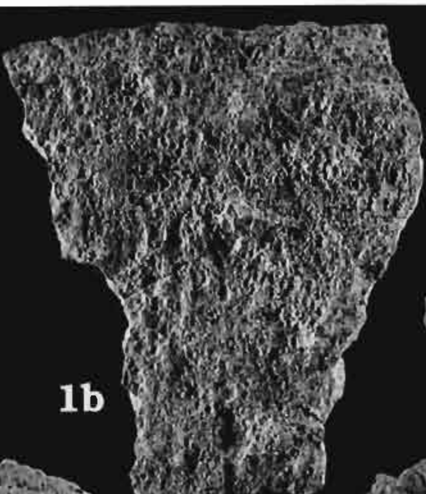
6. Specimen ZPAL Pf.VIII/73, Plettenberg, Oxfordian limestones (Beta); × 1.5.

Laocoetis schweiggeri (GOLDFUSS, 1833) 43

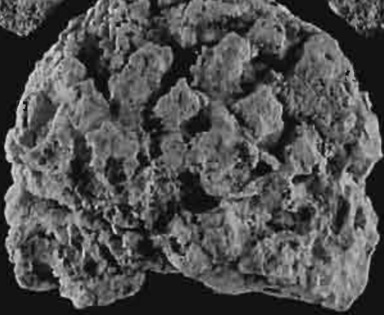
4. Specimen ZPAL Pf.VIII/401, Asselfingen, Kimmeridgian limestones (Zeta); × 1.

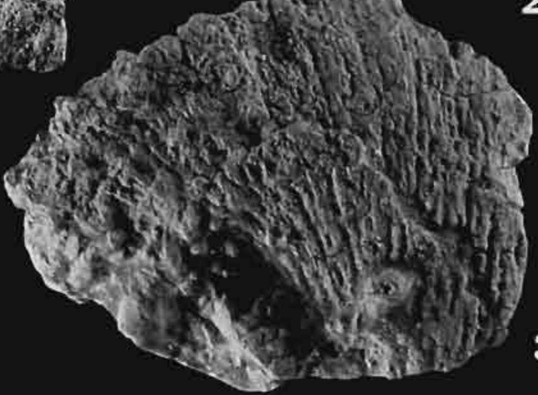
7. Specimen ZPAL Pf.VIII/277, Bärenthal, Kimmeridgian marls (Gamma); × 1.


1a


1b


2a

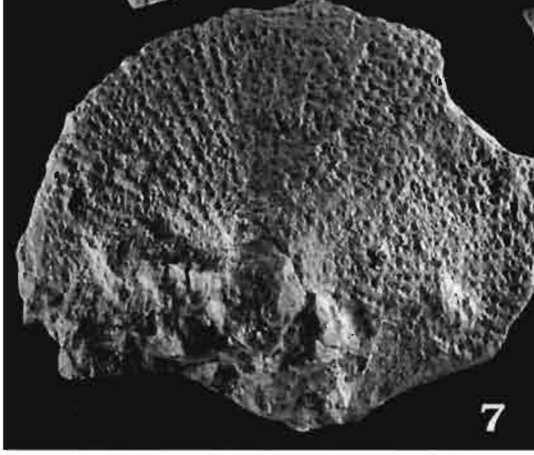

2b


3


4


5


6


7


8

PLATE 10

Sphenaulax costata (GOLDFUSS, 1826) 44

1. Specimen ZPAL Pf.VIII/256, Genkingen, Kimmeridgian limestones (Delta); × 1.
2. Holotype (GOLDFUSS 1826: pl. 2: 10a), Eifel, IPUB; × 1.
7. Specimen ZPAL Pf.VIII/204, Hochwang, Kimmeridgian marls (Delta); × 1.
8. GOLDFUSS' specimen (1826: pl. 3: 7), Switzerland, IPUB; × 1.5.
9. Specimen ZPAL Pf.VIII/255, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); × 1.

Polypyge pusilla SCHRAMMEN, 1937 57

3. Specimen ZPAL Pf.VIII/94, Bärenthal, crumpled marly limestones of the Oxfordian (Alfa); × 2.6.

Sphenaulax progenis SCHRAMMEN, 1937 45

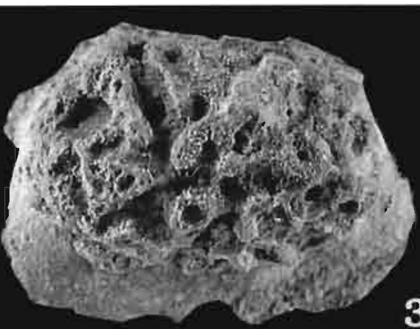
4. SMNS collection, Upper Jurassic (exact locality and age unknown); × 1.

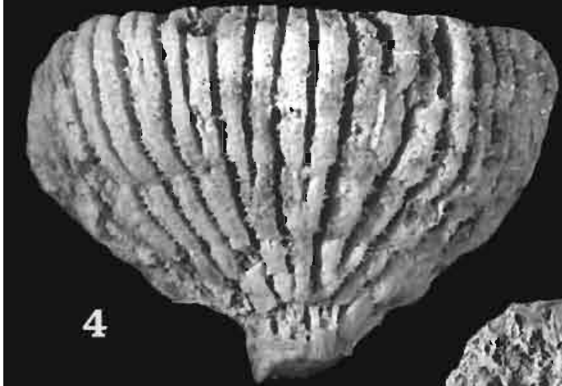
Sphenaulax irregularis sp. n. 45

5. Specimen ZPAL Pf.VIII/205, holotype, Erkenbrechtsweiler, Kimmeridgian limestones (Delta); × 1.
6. Specimen ZPAL Pf.VIII/292, Hochwang, Kimmeridgian marls (Delta); × 1.

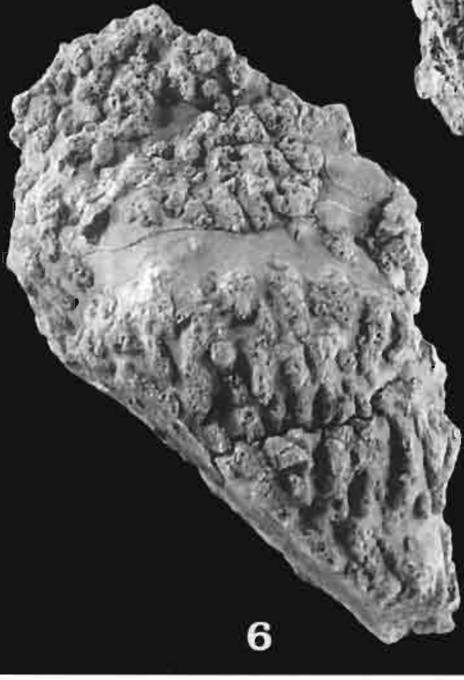

1


2

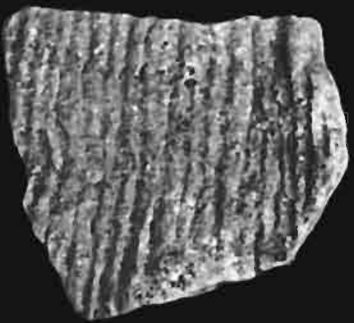

3

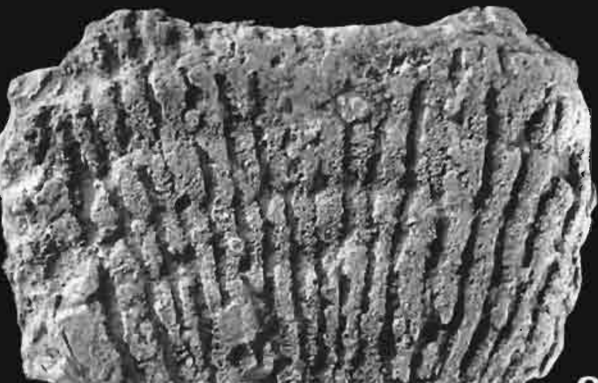

4


5


6


7


8


9

Pl. 11

Xenoschrammenum venosum (SCHRAMMEN, 1937) 76

1. SMNS collection, Heuchstetten, Kimmeridgian; *a* lower (outer) side view, *b* upper (inner) side view; × 2.
8. SMNS collection, upper (inner) side view, Heidenheimer Alb (exact locality and age unknown); × 1.

Hexactinosa indeterminata 66

2. Specimen morphologically resembling *Sporadopyle obliqua* (GOLDFUSS, 1833) but having clearly hexactinosan skeleton, ZPAL Pf.VIII/40, × 2.

Caesaria articulata (SCHMIDEL, 1780) 55

3. Specimen ZPAL Pf.VIII/201, Erkenbrechtsweiler, Kimmeridgian limestones (Delta); × 1.

Ramispongia ramosa QUENSTEDT, 1878 53

4. Specimen ZPAL Pf.VIII/207, Bärenthal, Kimmeridgian marls (Gamma); × 0.61.
5. Specimen ZPAL Pf.VIII/406, Bärenthal, crumpled marly limestones of the Oxfordian (Alfa); × 1.

Cypellia inberbis (QUENSTEDT, 1878) 61

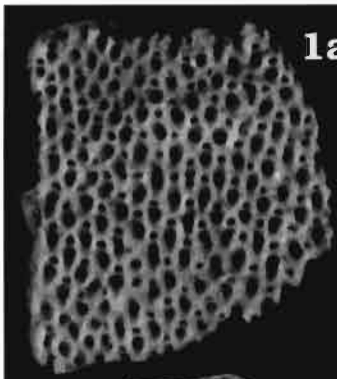
6. Specimen ZPAL Pf.VIII/72, Bärenthal, Kimmeridgian marls (Gamma); × 1.2.

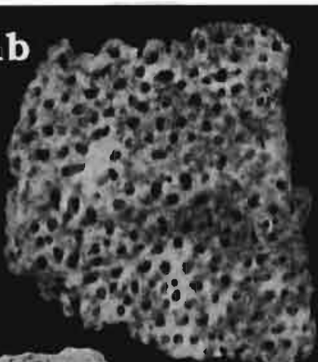
Lecanella sp. B 94

7. Specimen ZPAL Pf.VIII/307, Bärenthal, Kimmeridgian marls (Gamma); × 2.

Cribrospongia? *tesselata* (QUENSTEDT, 1878) 48

9. Specimen ZPAL Pf.VIII/12, Bärenthal, Oxfordian limestones (Beta); *a* lower (outer) side view, *b* upper (inner) side view; × 1.


1a

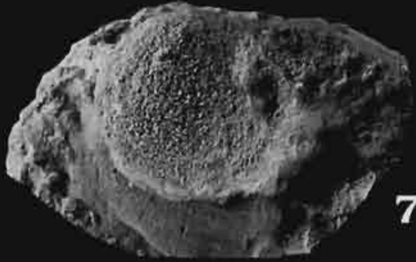

1b


2


3

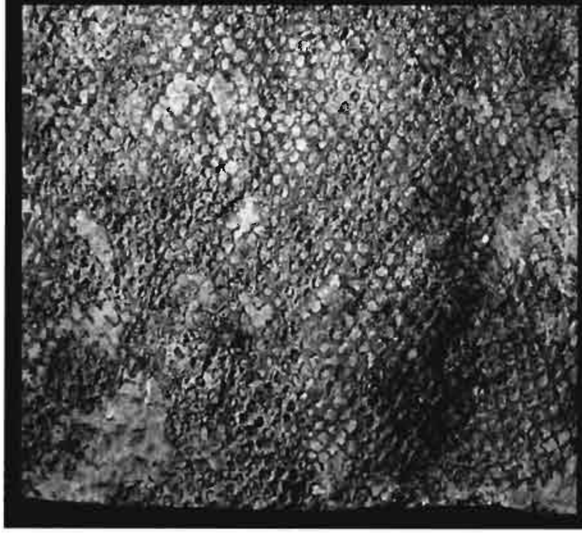

4


6


7


5

9a


8


9b

PLATE 12

Cavispongia cylindrata Quenstedt, 1878 75

1. Specimen ZPAL Pf.VIII/73, Hettingen, crumpled marly Kimmeridgian limestones (Delta); *a* upper surface view, *b* lateral view; × 1.5.
2. Specimen ZPAL Pf.VIII/262, Wilmandingen, Kimmeridgian marls (Gamma); lateral view; × 1.8.

Porospongia marginata (Münster *in* Goldfuss, 1829) 56

3. Goldfuss' specimen (1833: pl. 34: 9), Streitberg, Oxfordian, IPUB; × 1.
4. Specimen ZPAL Pf.VIII/33, Plettenberg, Oxfordian marls (Alfa); × 1.2.
5. Specimen ZPAL Pf.VIII/32, Bärenthal, Kimmeridgian marls (Gamma); × 1.

Tremaphorus apertus (Oppliger, 1915) 50

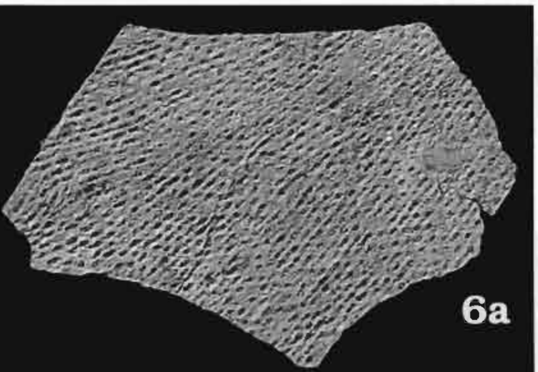
6. Specimen ZPAL Pf.VIII/79, Bärenthal, Oxfordian limestones (Beta); *a* and *b* view of opposite sides; × 1.5.
7. Specimen ZPAL Pf.VIII/43, Hochwang, Kimmeridgian marls (Delta); lower side view; × 1.

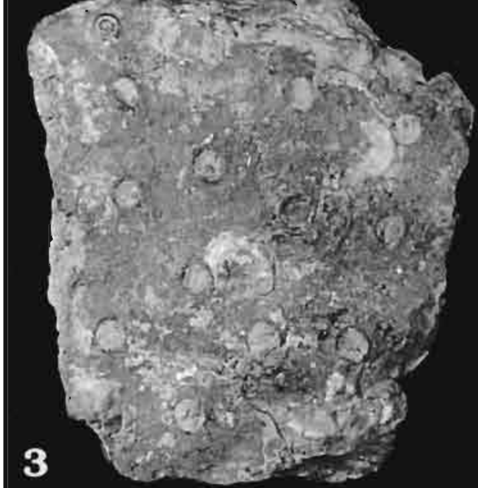
Xenoschrammenum venosum (Schrammen, 1937) 76

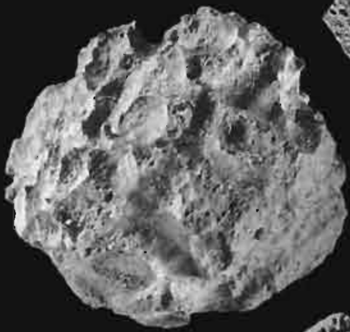
8. Specimen ZPAL Pf.VIII/98, Plettenberg, Oxfordian limestones (Beta); upper (inner) side view; × 1.

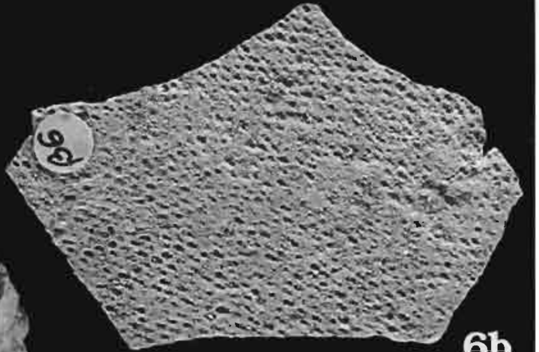

1a


2

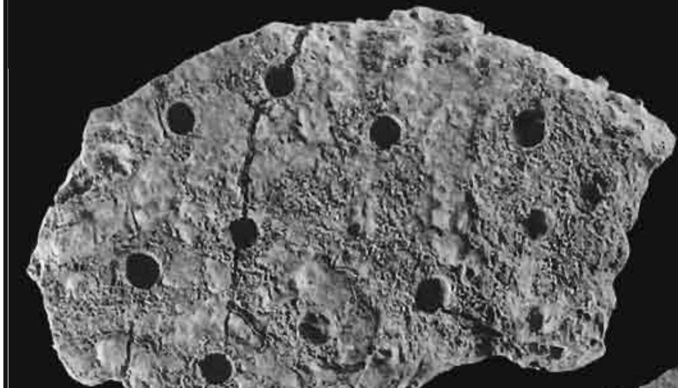

6a


3

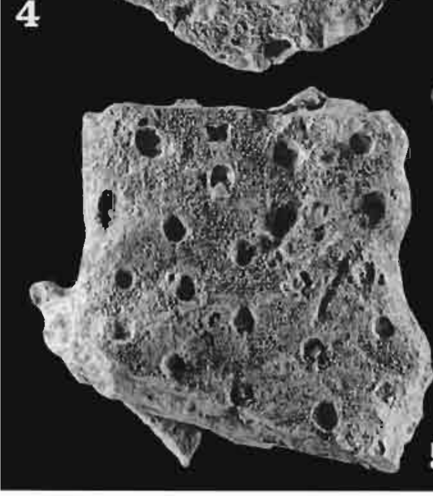

1b



6b


4


7


5

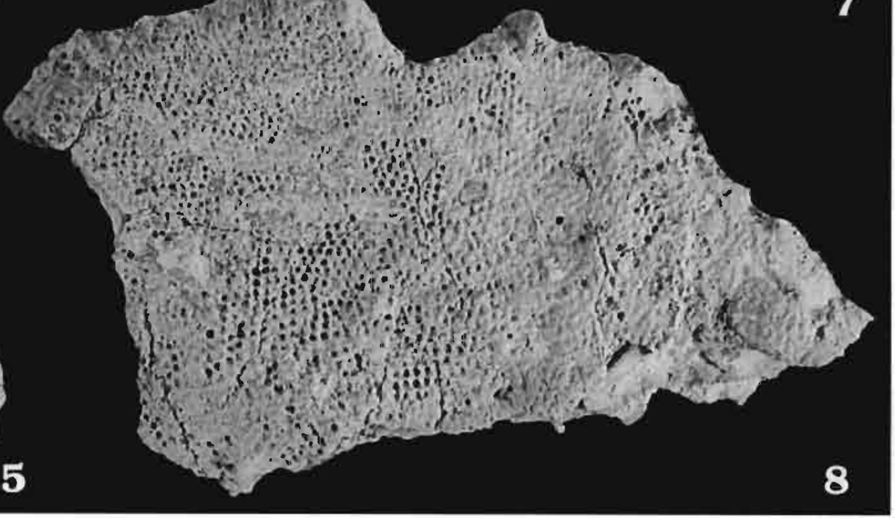

8

PLATE 13

Platychonia schlotheimi (Münster *in* Goldfuss, 1833) 84

1. Specimen ZPAL Pf.VIII/305, Bärenthal, Kimmeridgian marls (Gamma); upper surface view; × 1.
2. Specimen ZPAL Pf.VIII/507, Bärenthal, Kimmeridgian marls (Gamma); cross section; × 1.

Trochobolus labyrinthicus (Schrammen, 1937) 73

3. Specimen ZPAL Pf.VIII/45, Hochwang, Kimmeridgian marls (Delta); *a* and *b* lateral views of the opposite sides; × 1.
7. Schrammen's collection, IGPTU, Heuchstetten, Kimmeridgian; × 1.

Cypellia inberbis (Quenstedt, 1878) 61

4. Specimen ZPAL Pf.VIII/106, Plettenberg, Oxfordian limestones (Beta); *a* oscular view, *b* lateral view; × 1.6.

Cribrospongia reticulata (Goldfuss, 1826) 47

5. Specimen ZPAL Pf.VIII/67, Plettenberg, Oxfordian limestones (Beta); × 1.
6. Goldfuss' specimen (1833: pl. 34: 2), Streitberg, BSPHGM; × 1.

Laocoetis schweiggeri (Goldfuss, 1833) 43

8. Specimen ZPAL Pf.VIII/21, Bärenthal, Oxfordian limestones (Beta); lower (outer) surface view; × 1.

1

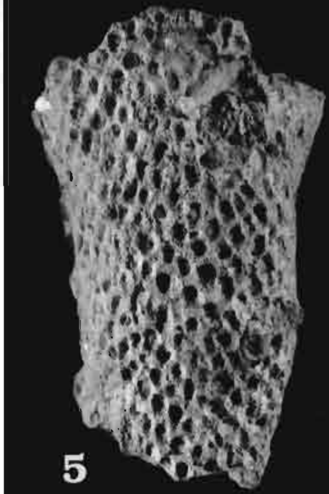
3a

3b

2

4a

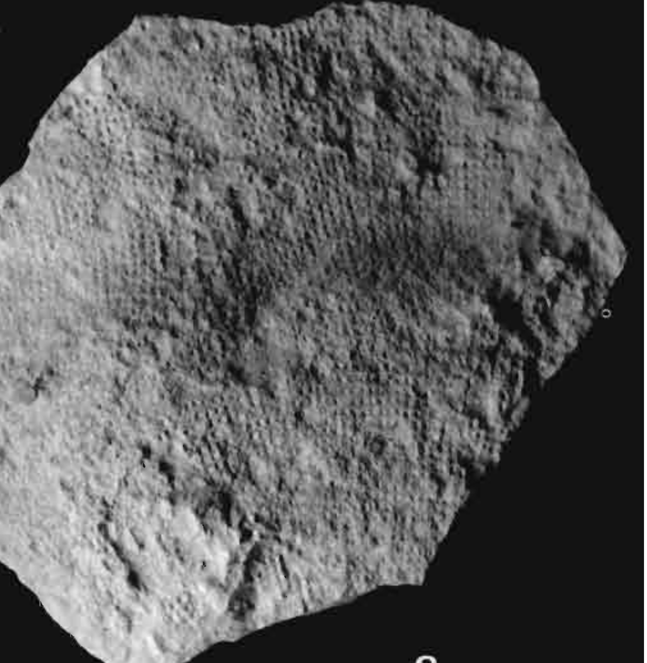
4b



5

6

7



8

PLATE 14

Cavispongia cylindrata QUENSTEDT, 1878 75

1. SMNS collection, Upper Jurassic, exact locality and age unknown; *a* upper surface view, *b* lower surface view, *c* lateral view; × 0.75.

Linonema calyx (SCHRAMMEN, 1937) 58

2. Specimen ZPAL Pf.VIII/51, Hochwang, Kimmeridgian marls (Gamma); × 2.
5. Specimen ZPAL Pf.VIII/216, Hochwang, Kimmeridgian marls (Delta); × 0.75.
6. Specimen ZPAL Pf.VIII/23, Bärenthal, crumpled marly limestones of the Oxfordian (Alfa); *a* lateral view, *b* cross section; × 0.7.

Pachyteichisma lamellosa (QUENSTEDT, 1878) 67

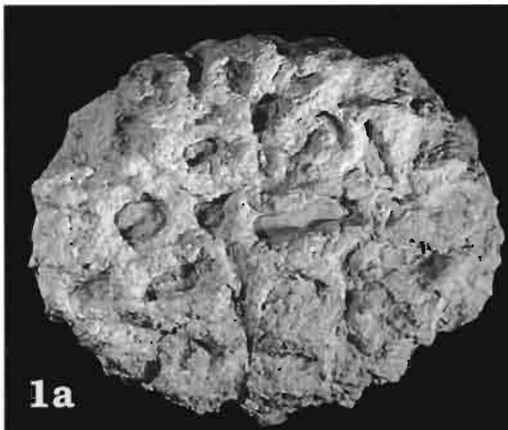
3. Specimen ZPAL Pf.VIII/235, Bärenthal, Kimmeridgian marls (Gamma); × 0.75.

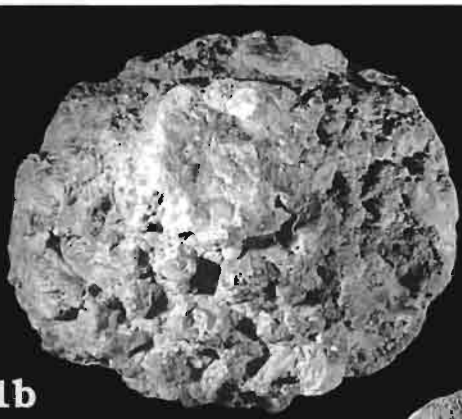
Platychonia striata (SCHRAMMEN, 1937) 85

4. Specimen ZPAL Pf.VIII/131, Hochwang, Kimmeridgian limestones (Delta); × 1.3.

Stauractinella jurassica ZITTEL, 1878 36

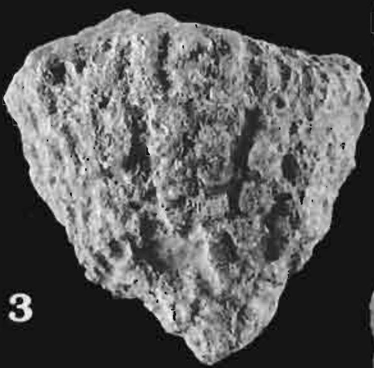
7. Specimen ZPAL Pf.VIII/64, Plettenberg, Oxfordian marls (Alfa); *a* lateral view, *b* oscular view; × 0.75.


1a


1b


2


1c

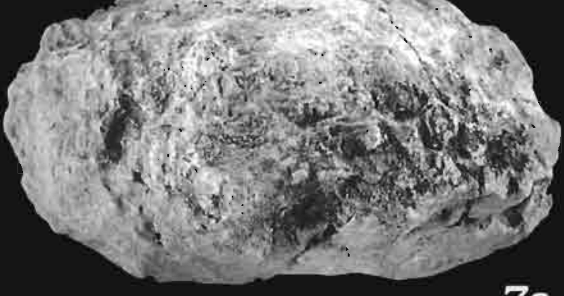

3


4


6b


5


6a


7a


7b

PLATE 15

Pachyteichisma gresslyi (ETALLON, 1860) 70

1. SMNS collection, Tieringen, Kimmeridgian (Gamma), *a* lateral view, *b* oscular view; × 1.

Pachyteichisma microstoma (QUENSTEDT, 1878) 69

2. Specimen ZPAL Pf.VIII/226, Bärenthal, Kimmeridgian marls (Gamma), *a* lateral view, *b* oscular view; × 1.
3. SMNS collection, Bärenthal, Kimmeridgian (Gamma/Delta boundary), *a* lateral view, *b* oscular view, *c* lower side view; × 1.
4. Specimen ZPAL Pf.VIII/227, Bärenthal, Kimmeridgian marls (Gamma), *a* oscular view, *b* lateral view; × 1.

Pachyteichisma lopas (QUENSTEDT, 1878) 68

5. Holotype (QUENSTEDT 1878: pl. 119: 5), Hossingen, Kimmeridgian (Delta), IGPTU, upper (inner) side view; × 0.5.

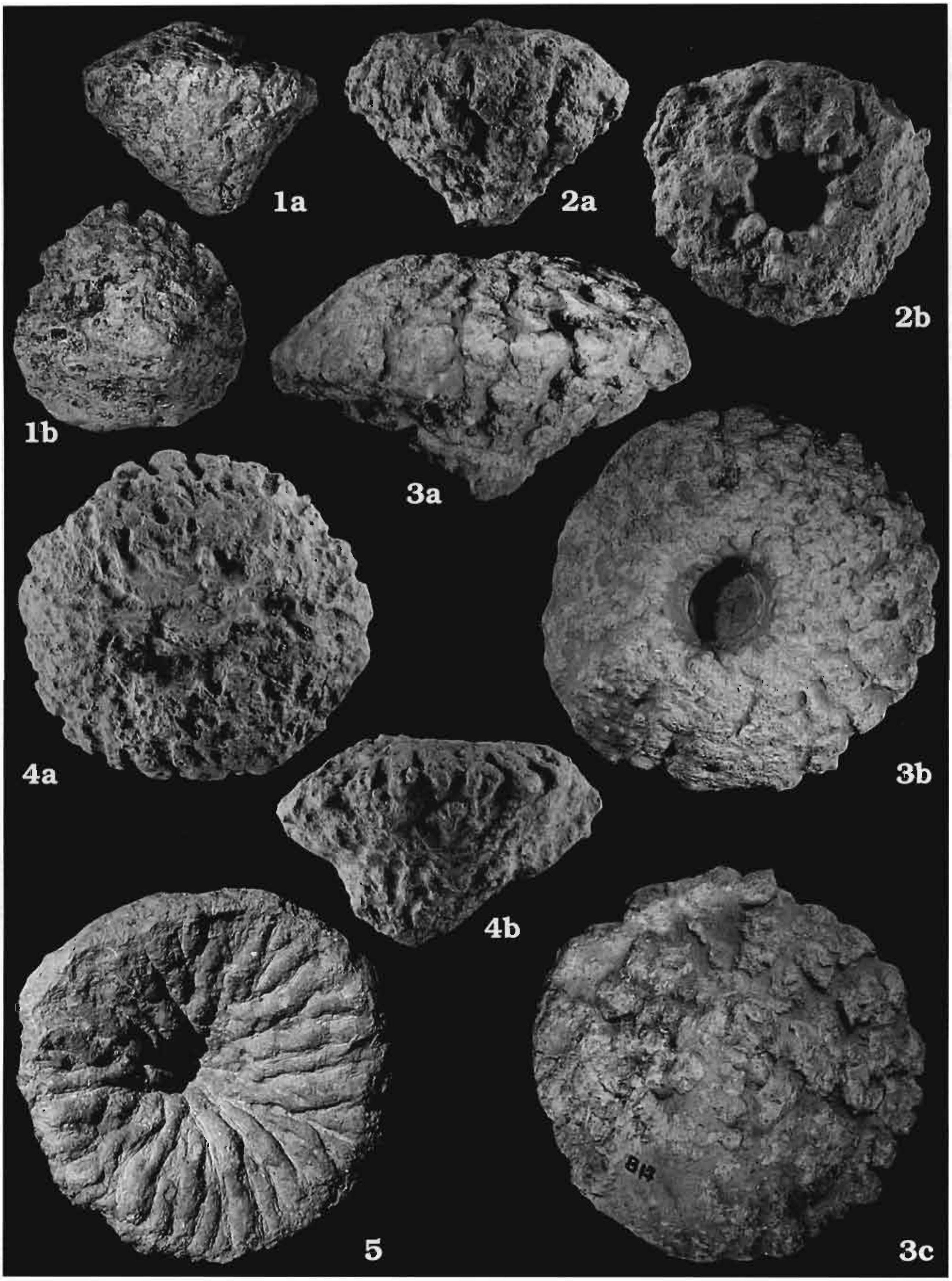

1a
2a
2b
1b
3a
4a
3b
4b
5
B13
3c

PLATE 16

Cypellia rugosa (GOLDFUSS, 1833) 60

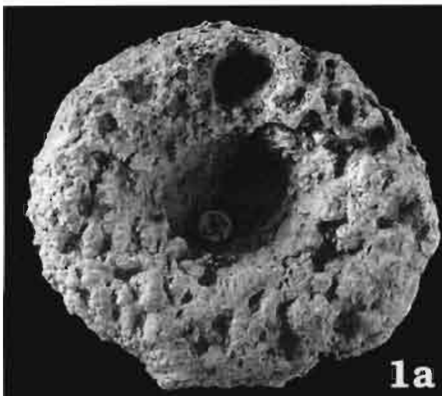
1. Specimen ZPAL Pf.VIII/59, Bärenthal, Oxfordian limestones (Beta), *a* oscular view, *b* lateral view; × 0.77.

Pachyteichisma microstoma (QUENSTEDT, 1878) 69

2. Specimen illustrated in GOLDFUSS (1833: pl. 6: 1a–b) under the name *Cnemidium lamellosum*, Randen, Switzerland, IPUB; *a* oscular view, *b* lateral view, *c* lower side view, × 0.45.

Pachyteichisma lamellosa (QUENSTEDT, 1878) 67

3. Specimen ZPAL Pf.VIII/1, Hochwang, Kimmeridgian marls (Delta); × 0.85.
4. Specimen ZPAL Pf.VIII/37, Hettingen, crumpled marly Kimmeridgian limestones (Delta); × 0.75.
5. Holotype, (QUENSTEDT 1878: pl. 119: 1), Hossingen, Kimmeridgian (Delta), IGPTU; *a* oscular view, *b* lateral view, *c* lower side view; × 0.46.

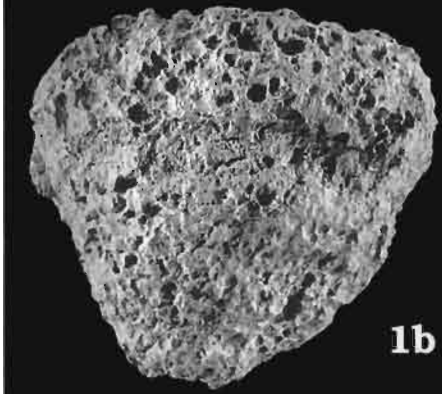


1a

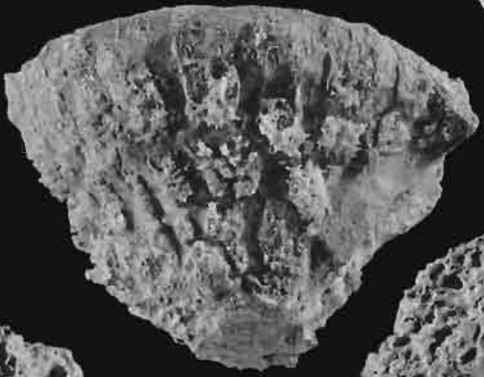
2a

2b

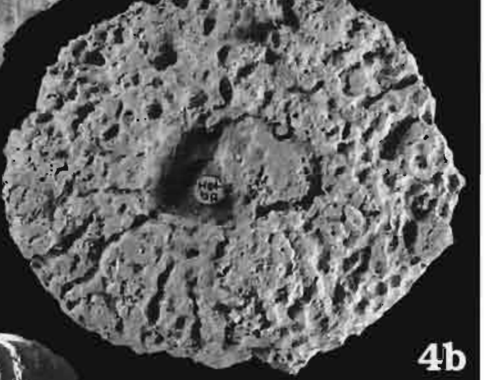
2c



1b

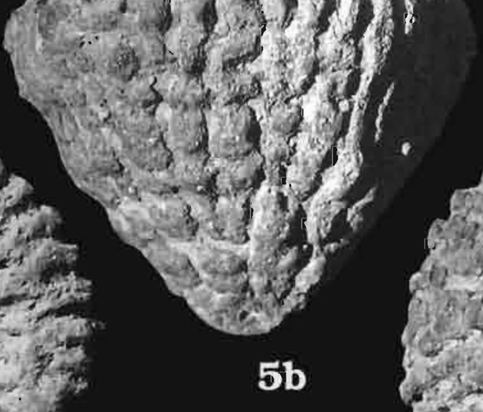


3



4b

4a



5b

5a

5c

PLATE 17

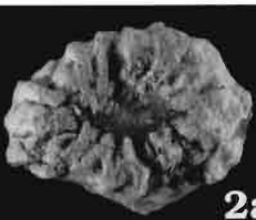
Trochobolus texatus (GOLDFUSS, 1833) 71

1. Specimen ZPAL Pf.VIII/281, Bärenthal, Kimmeridgian marls (Gamma); × 1.5.
2. Specimen ZPAL Pf.VIII/298, Genkingen, Kimmeridgian marls (Delta), *a* oscular view; *b* lateral view; × 1.5.
4. Specimen ZPAL Pf.VIII/202, Erkenbrechtsweiler, Kimmeridgian limestones (Delta); × 1.
5. Specimen ZPAL Pf.VIII/300, Bärenthal, Kimmeridgian marls (Gamma); × 1.
6. Specimen ZPAL Pf.VIII/301, Bärenthal, Kimmeridgian marls (Gamma); × 1.

Trochobolus suevicus SCHRAMMEN, 1937 72

3. Specimen ZPAL Pf.VIII/279, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); × 1.
7. Specimen ZPAL Pf.VIII/265, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); × 1.
8. Specimen ZPAL Pf.VIII/203, Hochwang, Kimmeridgian marls (Delta); × 1.
9. Specimen ZPAL Pf.VIII/3, Hochwang, Kimmeridgian marls (Delta); × 1.

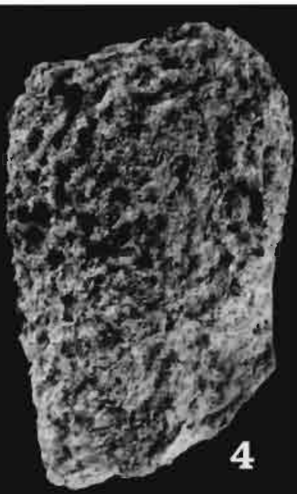
1



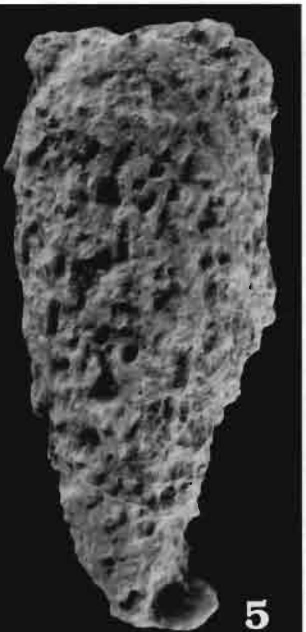
2a

2b

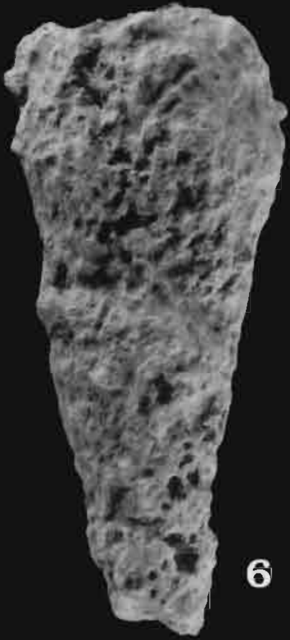
3



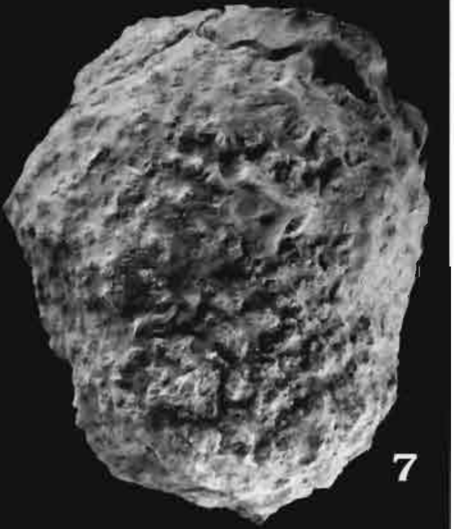
4



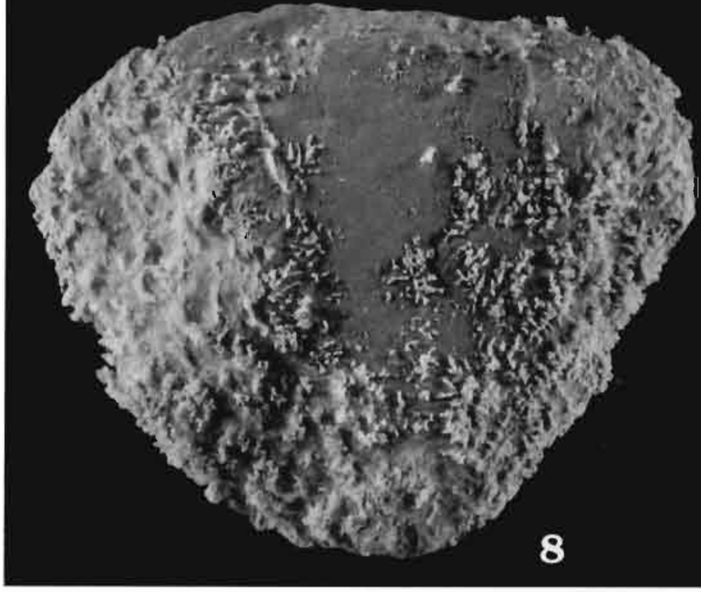
5



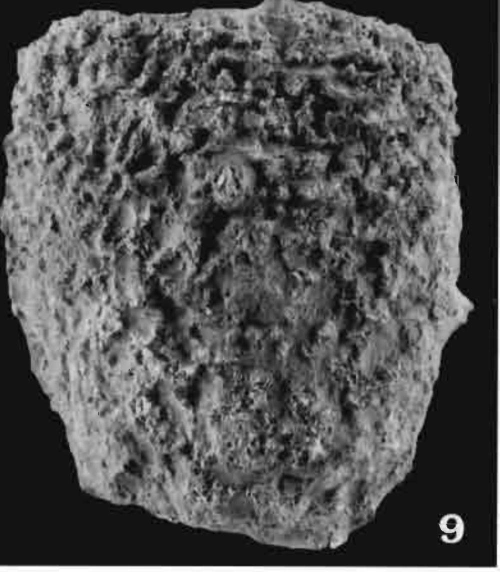
6



7



8



9

PLATE 18

Trochobolus cylindratus OPPLIGER, 1915 72

1. SCHRAMMEN's collection, Kimmeridgian (Gamma), IGPTU; × 1.
4. Specimen ZPAL Pf.VIII/218, Bärenthal, Kimmeridgian marls (Gamma); × 1.
6. Specimen ZPAL Pf.VIII/217, Genkingen, Kimmeridgian marls (Delta); × 1.

Phlyctaenium coniforme (QUENSTEDT, 1878) 74

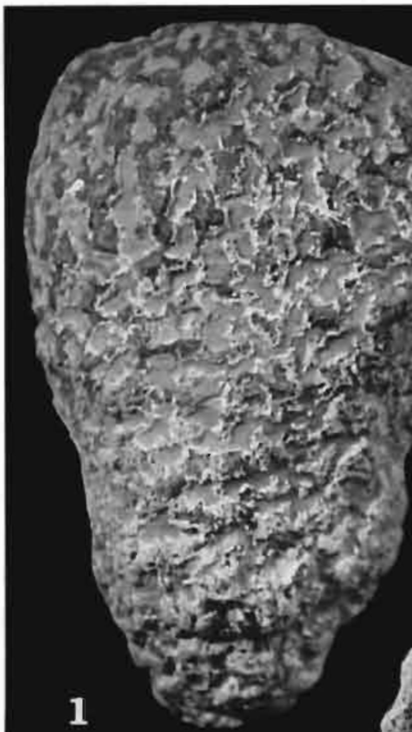
2. GOLDFUSS' specimen (1833: pl. 2: 11) described as *Scyphia verrucosa* nobis, Chaumont, IPBU; × 1.
7. Specimen ZPAL Pf.VIII/261, Bärenthal, Kimmeridgian marls (Gamma); × 1.

Rhombedonium cypelliaeforme SCHRAMMEN, 1937 60

3. SCHRAMMEN's specimen (1937: pl. 4: 5: pl. 10: 1); Streitberg, IGPTU; × 1.5.

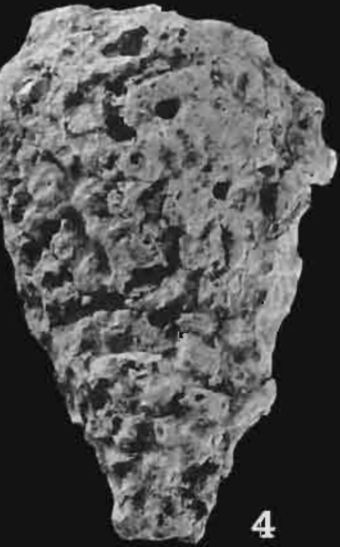
Trochobolus cupulus (SCHRAMMEN, 1937) 74

5. SCHRAMMEN's collection, Erkenbrechtsweiler (Gamma/Delta), IGPTU; × 1.
8. Specimen ZPAL Pf.VIII/257, Bärenthal, Kimmeridgian marls (Gamma); × 1.

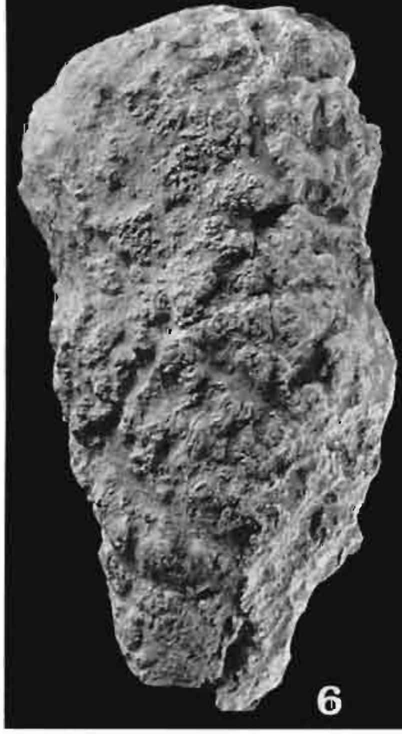

1


2


3


4


5


6


7


8

PLATE 19

Sporadopyle obliqua (GOLDFUSS, 1833) 66

1. QUENSTEDT's specimen (1878: pl. 120: 30), Lochen, Oxfordian (Alfa), IGPTU; × 2.
2. GOLDFUSS' specimen (1833: pl. 3: 5a–b), Thurnau, IPUB; × 1.5.
3. GOLDFUSS' specimen (1833: pl. 3: 5c); Streitberg, IPUB; × 1.5.

4–5. QUENSTEDT's specimens (1878: pl. 120: 31, 35), Lochen, Oxfordian (Alfa), IGPTU; × 2.

6. SCHRAMMEN's collection (as *S. consorbina*), Kimmeridgian (Gamma), Oberdigisheim, IGPTU; × 2.
8. Specimen ZPAL Pf.VIII/92, Bärenthal, Kimmeridgian marls (Gamma), *a* oscular view, *b* lateral view; × 1.8.
9. Specimen ZPAL Pf.VIII/91, Kimmeridgian marls (Gamma), Bärenthal, *a* oscular view, *b* lateral view; × 1.8.
10. Specimen ZPAL Pf.VIII/93, Bärenthal, Kimmeridgian marls (Gamma); × 1.8.

Sporadopyle pusilla SCHRAMMEN, 1937 66

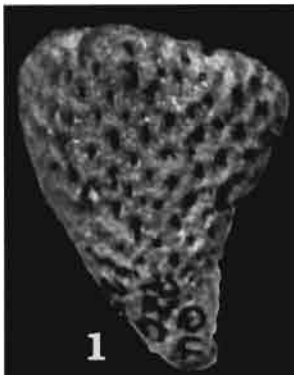
7. Specimen ZPAL Pf.VIII/287, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); × 1.1.

Sporadopyle sp. n. 67

11. Specimen ZPAL Pf.VIII/39, Hochwang, Kimmeridgian marls (Delta); × 1.

Lychniscosa sp. n. 66

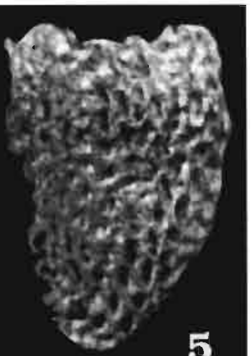
12. Specimen ZPAL Pf.VIII/54, Bärenthal, Kimmeridgian marls (Gamma); × 1.2.
13. Specimen ZPAL Pf.VIII/55, Bärenthal, Kimmeridgian marls (Gamma); × 1.5.
14. Specimen ZPAL Pf.VIII/142, Bärenthal, Kimmeridgian marls (Gamma); × 2.

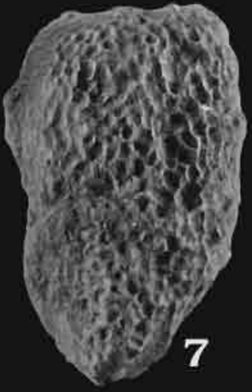

1


2


3


4


5


7

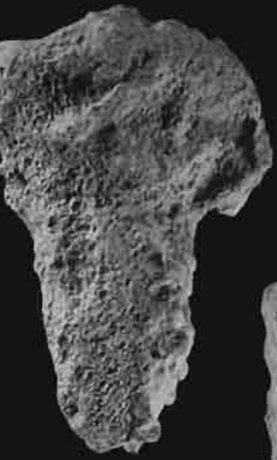

8a


9a

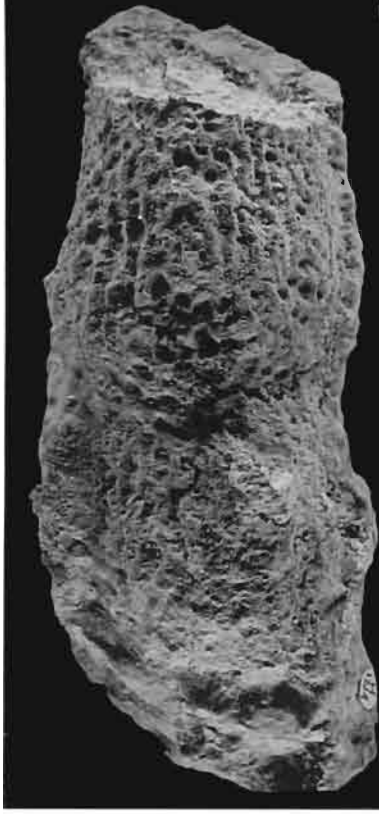

6


8b


9b


12


10


11


13


14

PLATE 20

Porocypellia piriformis (GOLDFUSS, 1833) 76

1. Specimen ZPAL Pf.VIII/260, Genkingen, Kimmeridgian limestones (Delta); oscular view; × 2.

2–3. GOLDFUSS' collection (1833: pl. 3: 9), Giengen, IPUB; × 2.

Cypellia prolifera (ZITTEL, 1878) 62

4. Specimen ZPAL Pf.VIII/209, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); × 1.

5. Specimen ZPAL Pf.VIII/210, Hochwang, Kimmeridgian marls (Gamma); × 1.

6. Specimen ZPAL Pf.VIII/208, Bärenthal, Kimmeridgian marls (Gamma); × 1.

10. Colonial specimen, Hochwang, Kimmeridgian (Delta), SMNS collection; *a* oscular view, *b* lateral view; × 0.5.

Cypellia rugosa (GOLDFUSS, 1826) 60

7. Specimen ZPAL Pf.VIII/302, Bärenthal, Kimmeridgian marls (Gamma); *a* oscular view, *b* lateral view; × 1.

8. Specimen ZPAL Pf.VIII/95, Plettenberg, Oxfordian marls (Alfa); *a* lateral view, *b* oscular view; × 1.

Cypellia trabeculata (QUENSTEDT, 1878) 63

9. Specimen ZPAL Pf.VIII/276, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); × 1.


1


2

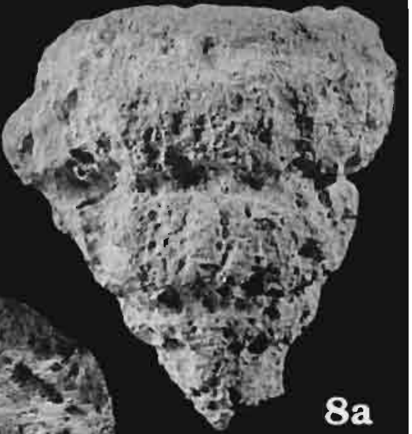

3

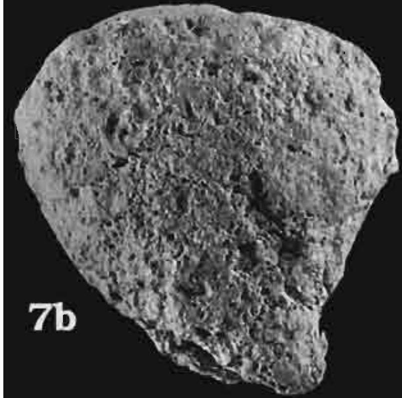

4


5

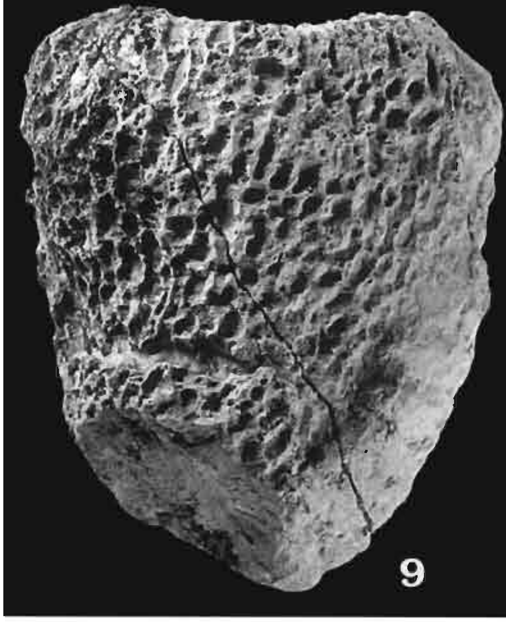

7a


6


8a


7b


8b


9


10a


10b

PLATE 21

Verrucocoelia verrucosa (GOLDFUSS, 1829) 37

1. Specimen ZPAL Pf.VIII/282, Kimmeridgian marls (Gamma), Bärenthal; × 1.
2. GOLDFUSS' original (1829: pl. 33: 8), Streitberg, BSPHGM; × 1.5.
5. Specimen from SMNS, Wilmandingen, Kimmeridgian (Delta); × 2.

Walcotella sp. n. 52

3. Specimen ZPAL Pf.VIII/97, Plettenberg, Oxfordian marls (Alfa); *a* oscular view, *b* lateral view; × 1.

Porocypellia piriformis (GOLDFUSS, 1833) 76

4. Specimen ZPAL Pf.VIII/99, Plettenberg, Oxfordian marls (Alfa); *a* oscular view, *b* side view; × 4.

Tremaphorus? *tenuis* (OPPLIGER, 1915) 52

6. Specimen ZPAL Pf.VIII/80, Bärenthal, Oxfordian limestones (Beta); × 1.5.

Polygonatiumn sphaeroides SCHRAMMEN, 1937 36

7. Specimen ZPAL Pf.VIII/71, Hochwang, Kimmeridgian marls (Delta); × 1.

Placotelia marcoui (FROMENTAL, 1859) 64

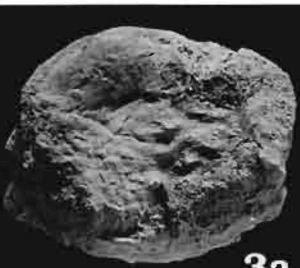
8. Specimen ZPAL Pf.VIII/74, Bärenthal, Oxfordian limestones (Beta); × 0.5.

Placotelia dolata OPPLIGER, 1907 65

9. Specimen ZPAL Pf.VIII/303, Lochen Nordwand, Oxfordian limestones (Beta); × 0.8.

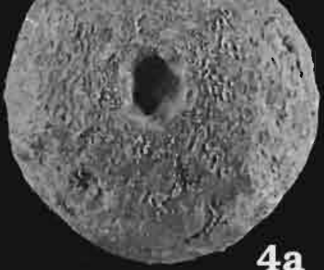
1

2

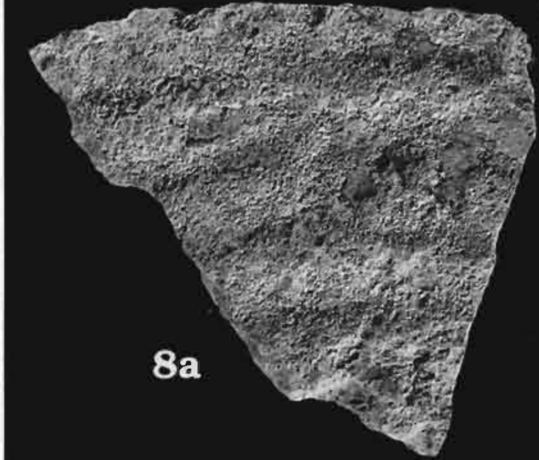


3a

3b



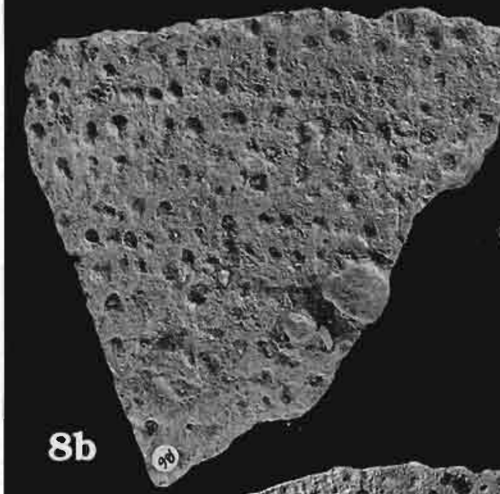
4a



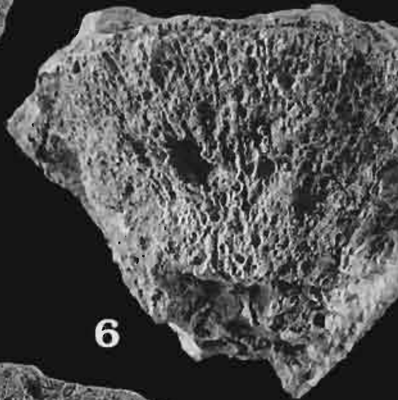
8a

4b

5

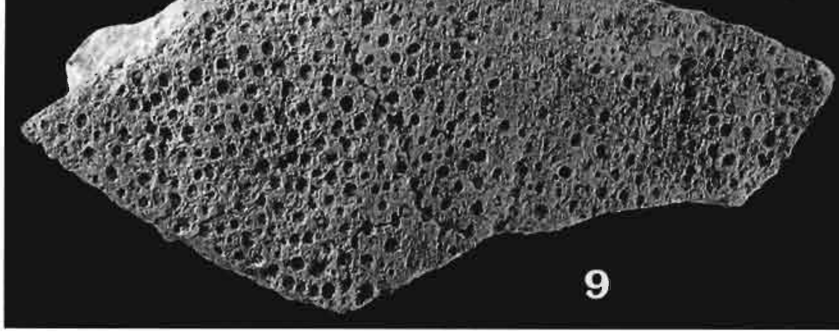


8b



6

7



9

PLATE 22

Multiloqua fungulus (QUENSTEDT, 1878) 56

1. Specimen from SMNS, Wilmandingen, Kimmeridgian (Delta); oscular view; × 0.75.
2. Specimen from SMNS, Obernheim, Kimmeridgian (Gamma); oscular view; × 0.75.

Pyrgochonia radiata (MÜNSTER *in* GOLDFUSS, 1833) 88

3. Specimen ZPAL Pf.VIII/212, Bärenthal, Kimmeridgian marls (Gamma); *a* lower surface view, *b* upper surface view; × 0.75
4. Specimen ZPAL Pf.VIII/121, Bärenthal, Kimmeridgian marls (Gamma); *a* lateral view, *b* lower surface view, *c* upper surface view; × 0.75.

Platychonia striata (SCHRAMMEN, 1937) 85

5. Specimen ZPAL Pf.VIII/254, Bärenthal, crumpled marly limestones of the Oxfordian (Alfa); upper surface view; × 0.55.

Amphibleptula jurassica sp. n. 89

6. Specimen ZPAL Pf.VIII/133, Hochwang, Kimmeridgian limestones (Delta); *a* lower (outer) side view, *b* upper (inner) side view; × 0.75.

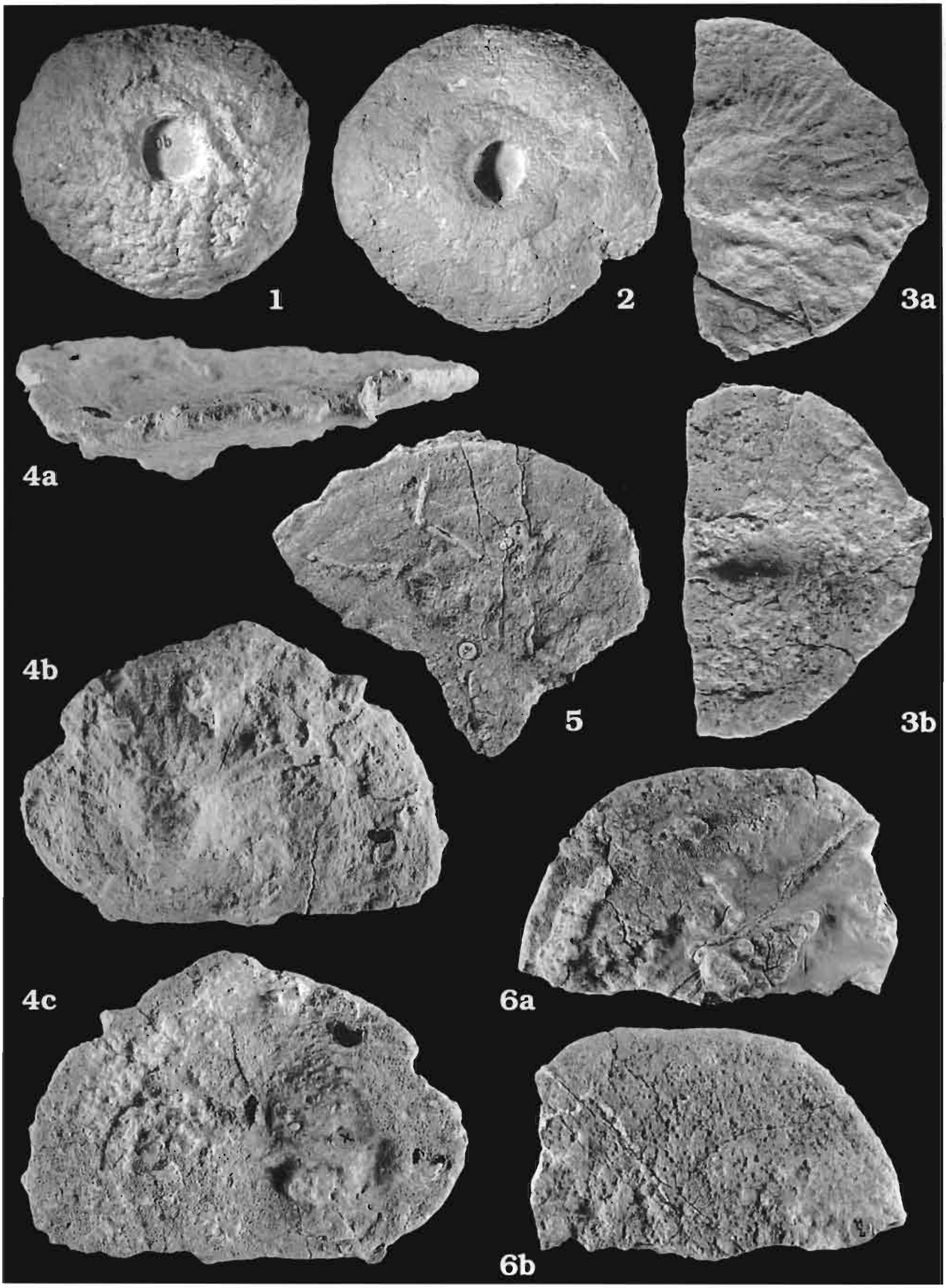

1
2
3a
4a
3b
5
4b
6a
4c
6b

PLATE 23

Cnemidiastrum pluristellatum ZITTEL, 1878 87

1. Specimen ZPAL Pf.VIII/259, Bärenthal, Kimmeridgian marls (Gamma); *a* upper surface view, *b* lateral view; × 1.5.

Cnemidiastrum rimulosum (GOLDFUSS, 1826) 86

2. Specimen ZPAL Pf.VIII/241, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); *a* upper surface view, *b* lower surface view; × 1.5.
3. Fan-like specimen with meandring canals on the surface, ZPAL Pf.VIII/270, Bärenthal, Kimmeridgian marls (Gamma); *a* upper surface view, *b* lower surface view; × 1.
4. Vase-shaped specimen with thick walls, ZPAL Pf.VIII/243, Bärenthal, Kimmeridgian marls (Gamma), *a* upper surface view, *b* lateral view; × 1.
5. Fragment of vase-shaped specimen with nearly straight (weathered) canals on the surface, ZPAL Pf.VIII/240, Hochwang, Kimmeridgian marls (Delta); top view; × 1.
6. Fan-shaped specimen with weathered surface, ZPAL Pf.VIII/272, Bärenthal, Kimmeridgian marls (Gamma); *a* upper surface view, *b* lower surface view; × 1.

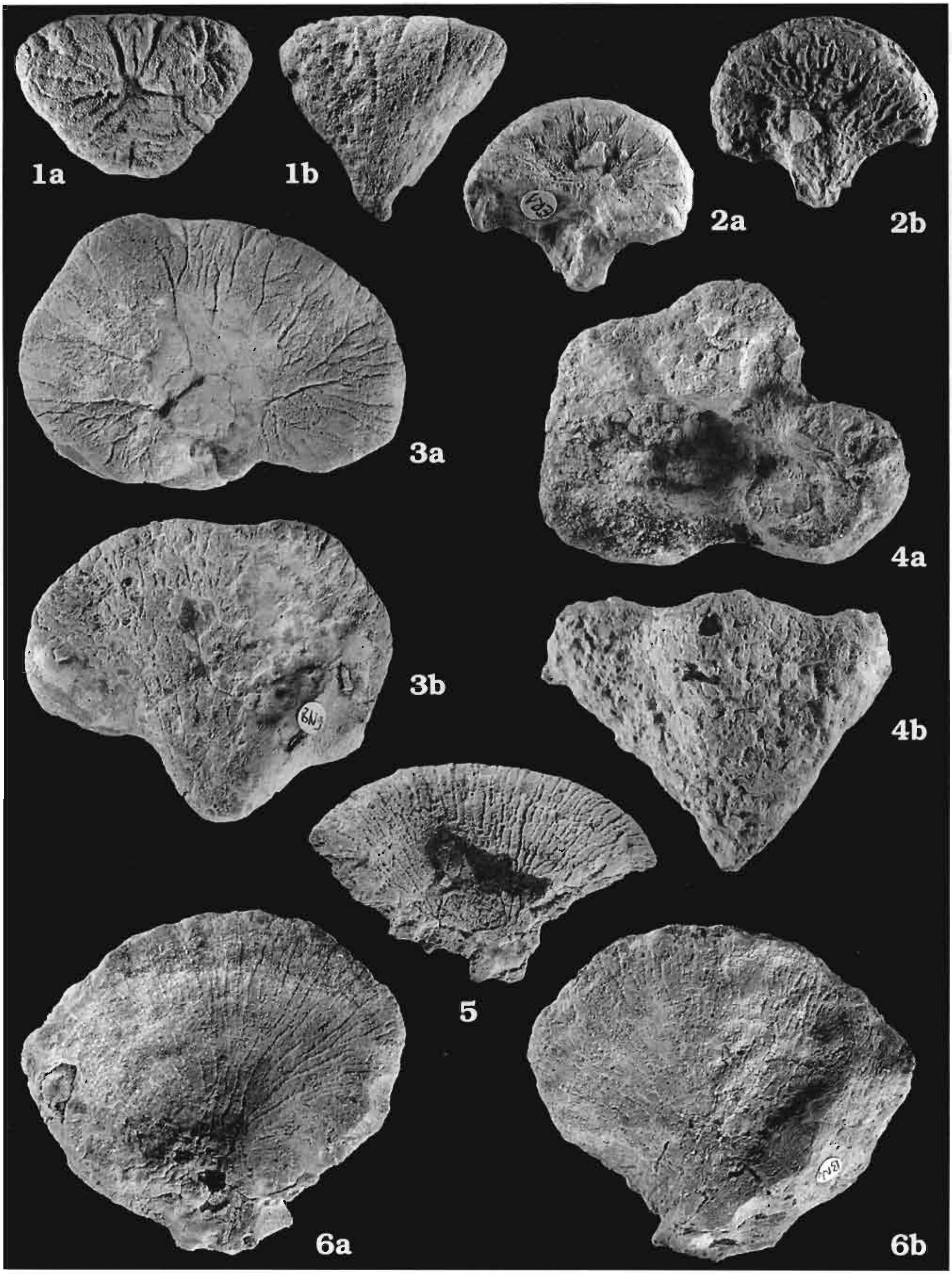

1a
1b
2a
2b
3a
4a
3b
4b
5
6a
6b

PLATE 24

Cytoracea variabilis (KOLB, 1910) 87

1. Specimen ZPAL Pf.VIII/252, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); *a* oscular view, *b* lateral view; × 1.5.

Pyrgochonia radiata (MÜNSTER *in* GOLDFUSS, 1826) 88

2. Specimen ZPAL Pf.VIII/268, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); *a* upper surface view, *b* lateral view; × 1.

Platychonia folium (SCHRAMMEN, 1937) 85

3. Specimen ZPAL Pf.VIII/268, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); upper surface view; × 1.
4. Specimen ZPAL Pf.VIII/267, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); upper surface view; × 1.

Leiocarenus planus SCHRAMMEN, 1937 83

5. Specimen ZPAL Pf.VIII/236, Hochwang, Kimmeridgian marls (?Delta); upper surface view; × 1.5.

Cnemidiastrum stellatum (GOLDFUSS, 1826) 86

6. Morphological form intermediate between typical *C. stellatum* and "*C. goldfussi*", ZPAL Pf.VIII/221, Bärenthal, Kimmeridgian marls (Gamma) (note that a new small individual grew from the oscular surface); lateral view; × 1.
7. Typical morphological form (specimen strongly weathered), ZPAL Pf.VIII/222, Bärenthal, Kimmeridgian marls (Gamma), *a* oscular top, *b* lateral view; × 1.
8. Morphological form close to "*C. goldfussi*", ZPAL Pf.VIII/253, Bärenthal, Kimmeridgian marls (Gamma), *a* oscular view, *b* lateral view; × 1.

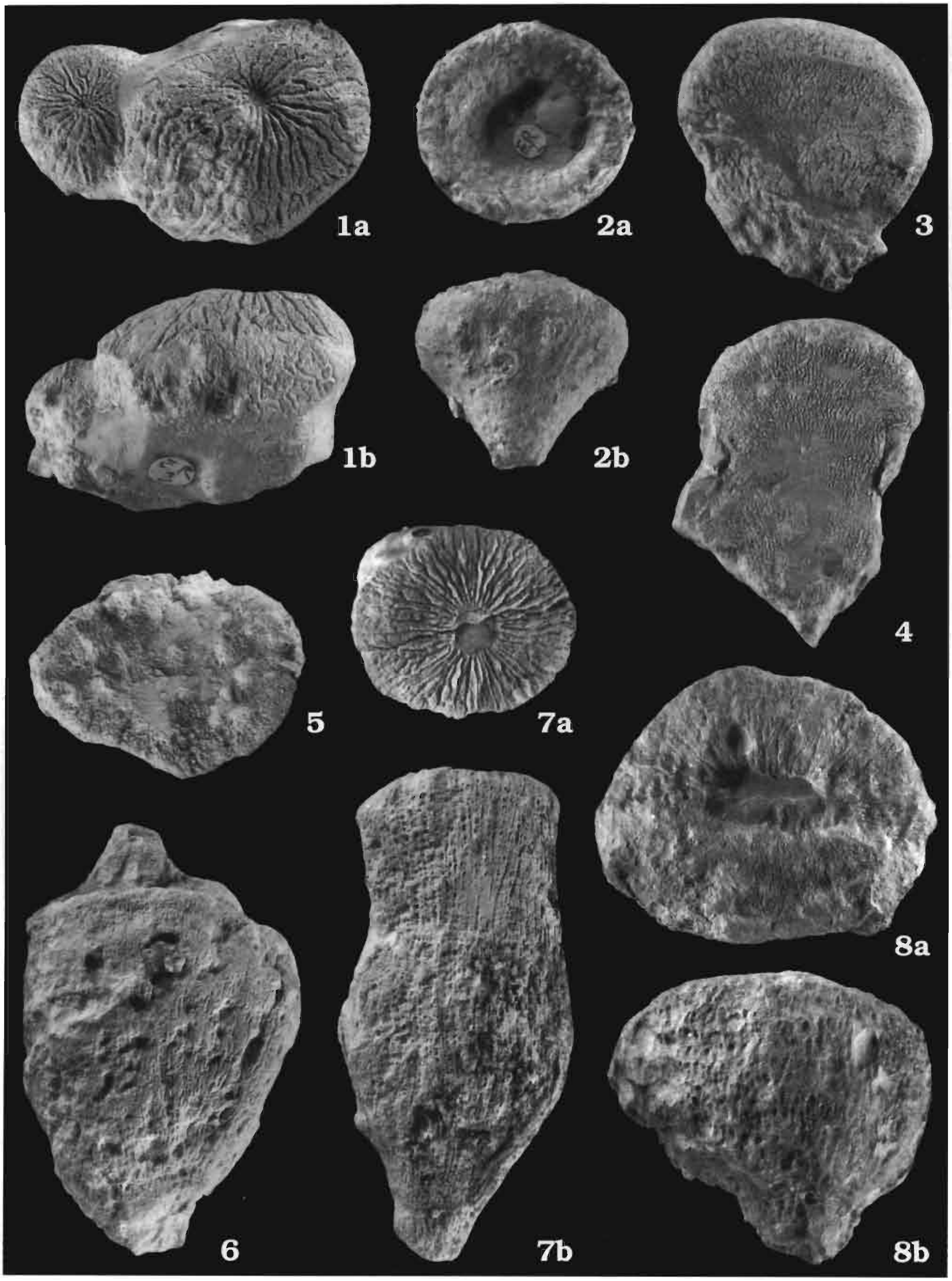

1a
2a
3
1b
2b
4
5
7a
8a
6
7b
8b

PLATE 25

Hyalotragos patella (GOLDFUSS, 1826) 87

1. Specimen ZPAL Pf.VIII/128, Hochwang, Kimmeridgian marls (Delta); *a* lateral view, *b* upper surface view, *c* lower surface view; × 1.4.
2. Specimen ZPAL Pf.VIII/124, Hochwang, Kimmeridgian marls (Gamma); *a* lateral view, *b* upper surface view, *c* lower surface view; × 1.

Reiswigia sp. 90

3. Specimen ZPAL Pf.VIII/264, Bärenthal, Kimmeridgian marls (Gamma); × 1.5.

Callopegma cf. *plana* LAGNEAU-HÉRENGER, 1962 82

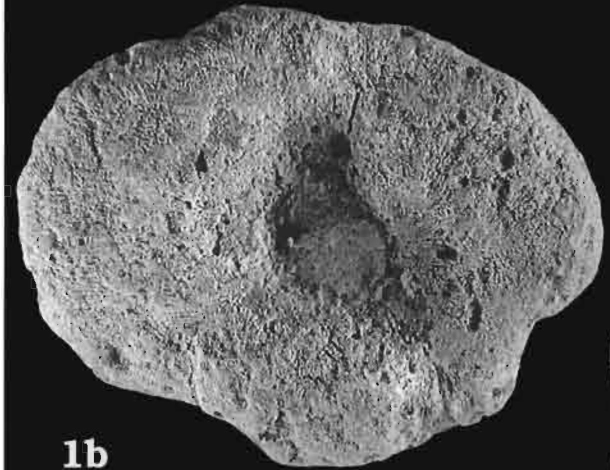
4. Specimen ZPAL Pf.VIII/211, Plettenberg, Oxfordian limestones (Beta); top view; × 1.5.

Trachydictya sp. 85

5. Specimen ZPAL Pf.VIII/130, Hettingen, crumpled marly limestones Kimmeridgian (Delta); *a* lower surface, *b* upper surface; × 1.5.

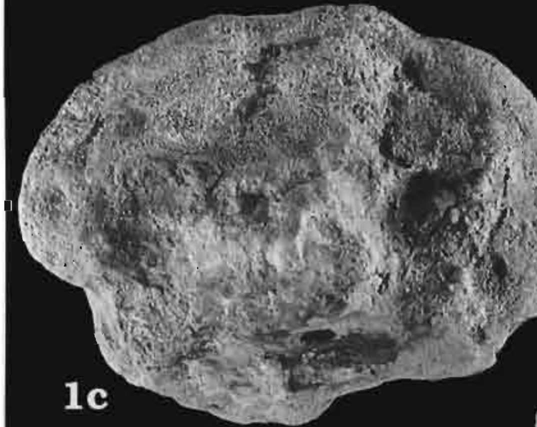

1a

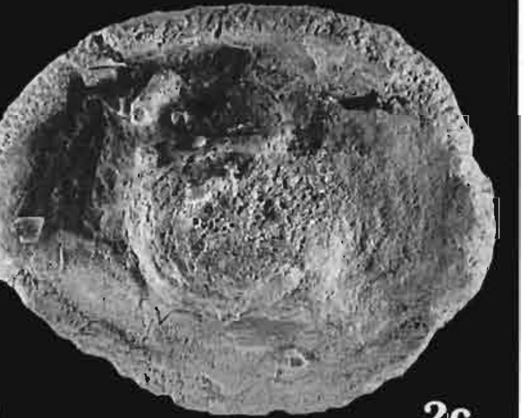

2a


1b

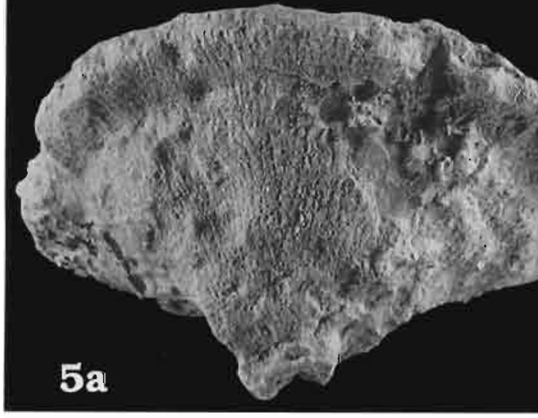

3


2b


1c


2c


4


5a


5b

PLATE 26

Hyalotragos pezizoides (GOLDFUSS, 1826) 87

1–7. Variously shaped specimens; *1* Specimen ZPAL Pf.VIII/249, Erkenbrechtsweiler, Kimmeridgian marls (Gamma), *a* lateral view, *b* oscular view; × 1. *2* Specimen ZPAL Pf.VIII/251, Bärenthal, Kimmeridgian marls (Gamma), *a* oscular view; *b* lateral view; × 1. *3* Specimen ZPAL Pf.VIII/125, Hochwang, Kimmeridgian marls (Delta), *a* lateral view, *b* upper surface view: note the bundle of canal openings in the centre; × 1.5. *4* Specimen ZPAL Pf.VIII/248, Bärenthal, Kimmeridgian marls (Gamma), *a* lateral view, *b* oscular view; × 1. *5* Specimen ZPAL Pf.VIII/126, Hochwang, Kimmeridgian marls (Delta), *a* upper surface view; *b* lateral view; × 1.5. *6* Specimen ZPAL Pf.VIII/110, Hettingen, crumpled marly Kimmeridgian limestones (Delta), *a* upper surface view; *b* lateral view; × 1. *7* Specimen ZPAL Pf.VIII/250, Genkingen, Kimmeridgian marls (Delta); *a* upper surface view, *b* lateral view; × 1.

Kalpinella cf. *pateraeformis* HINDE, 1883 81

8. Specimen ZPAL Pf.VIII/225, Heuchstetten, Kimmeridgian limestones (Epsilon); outer view; × 1.5.

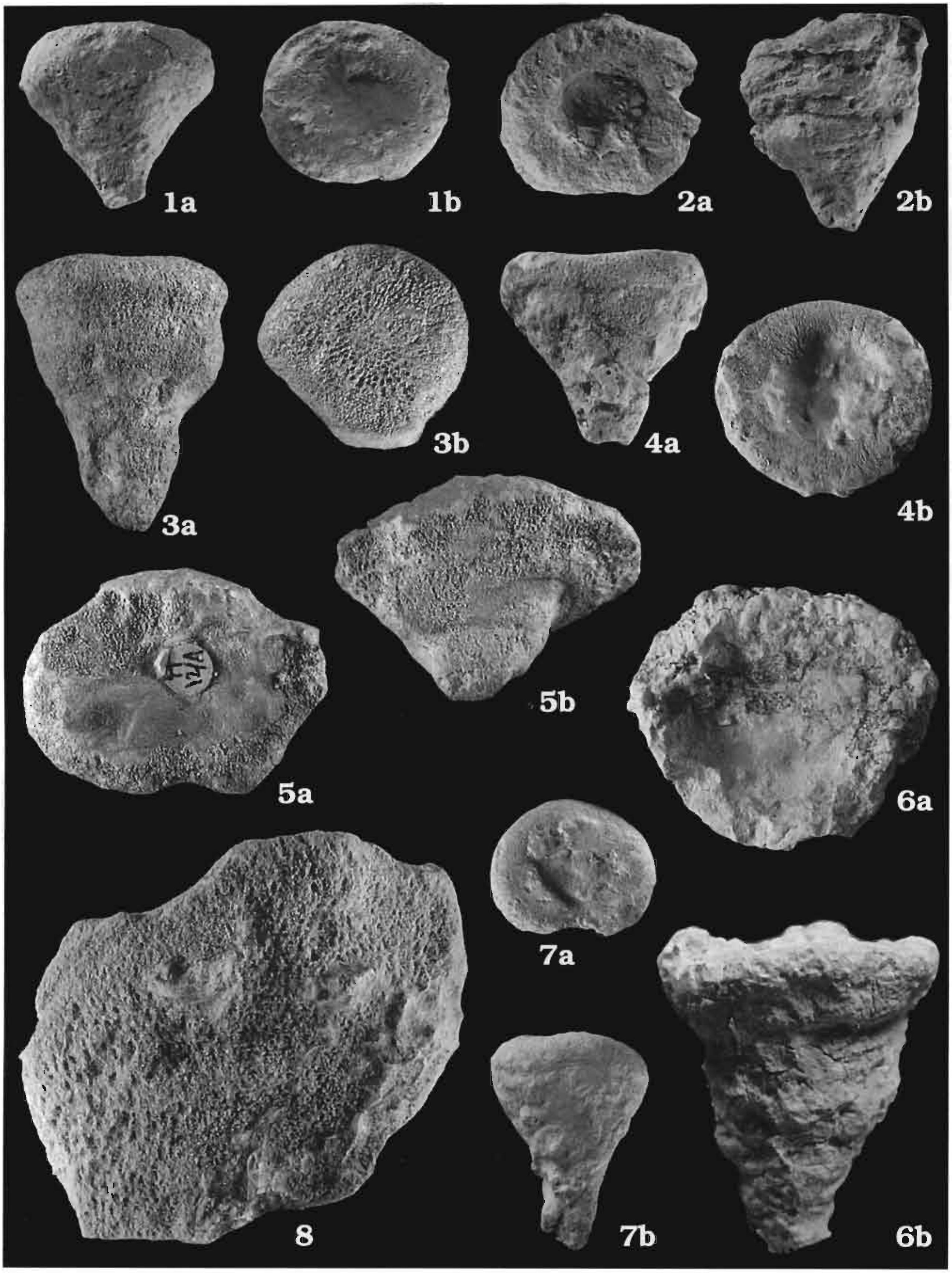

1a
1b
2a
2b
3b
4a
3a
4b
5b
5a
6a
7a
8
7b
6b

PLATE 27

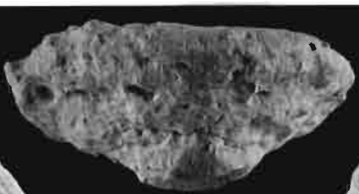
Discostroma intricatum (QUENSTEDT, 1878) 89

1. Specimen ZPAL Pf.VIII/263, Genkingen, Kimmeridgian marls (Delta), *a* upper surface view, *b* lateral view, *c* lower surface view; × 1.

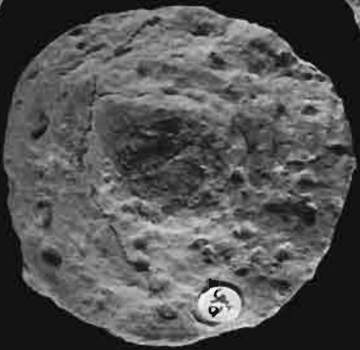
Hyalotragos rugosum (MÜNSTER *in* GOLDFUSS, 1833) 88

2. Specimen with outer layer preserved, and showing rounded holes formed above oscular openings, ZPAL Pf.VIII/232, Bärenthal, Kimmeridgian marls (Gamma); × 1.
3. Fragmentary preserved specimen devoid of outer calcareous layer, ZPAL Pf. VIII/109, Hochwang, Kimmeridgian limestones (Delta), *a* upper surface view; *b* lower surface view; × 1.
4. Holotype, (GOLDFUSS 1833: pl. 35: 4), Streitberg, IPUB, *a* upper surface view (outer calcium carbonate layer has been removed by etching), *b* lower surface view; × 1.

1a



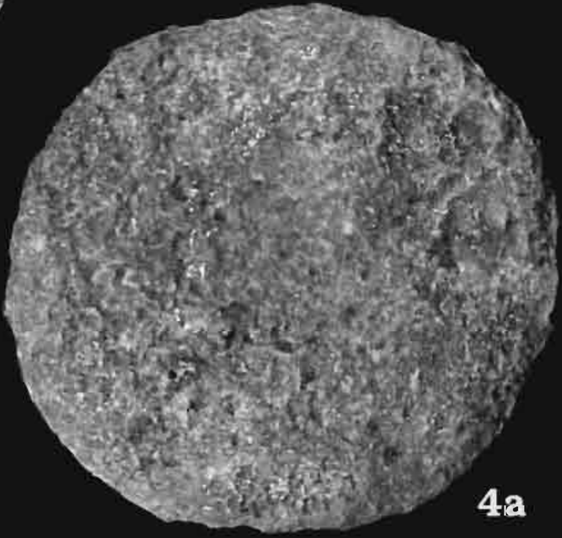
1b



1c

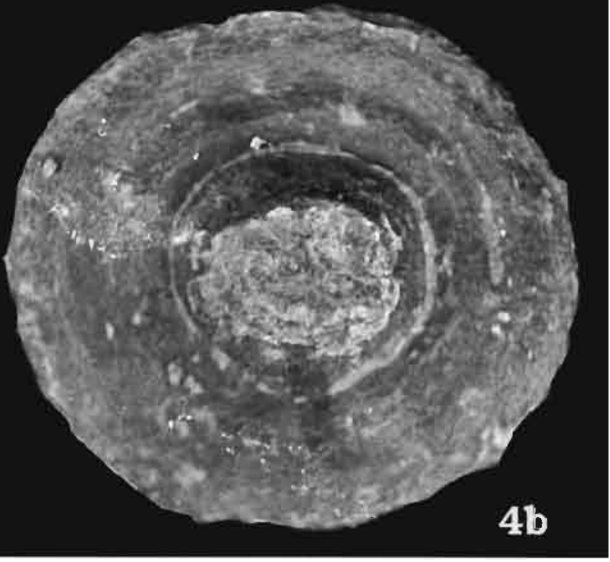
2

3a



4a

3b



4b

PLATE 28

Pyrgochonia acetabulum (GOLDFUSS, 1829) 88

1. Holotype (GOLDFUSS 1833: pl. 5: 8a), Muggendorf, IPUB; *a* lower surface view, *b* lateral view, *c* upper surface view; × 1.
2. Specimen ZPAL Pf.VIII/110, Hettingen, crumpled marly Kimmeridgian limestones (Delta); *a* lateral view, *b* upper surface view; × 1.

Hyalotragos rugosum (MÜNSTER *in* GOLDFUSS, 1833) 88

3. Specimen described as *Agaricia rotata* GOLDFUSS (1833: pl. 12: 10a, b), Randen, IPUB; × 1.
4. Specimen ZPAL Pf.VIII/233, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); *a* upper surface view (calcium carbonate layer removed), *b* lower surface view; × 1.


1a

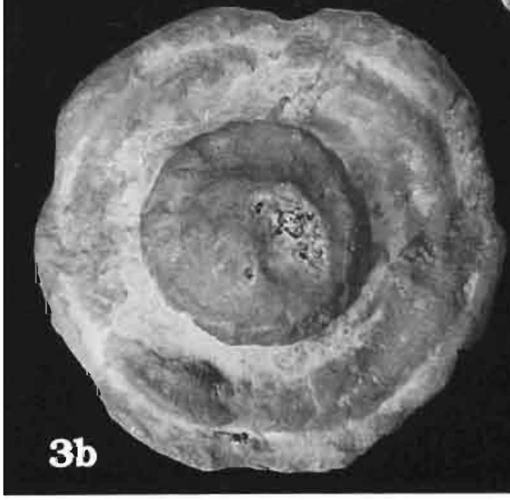

1b

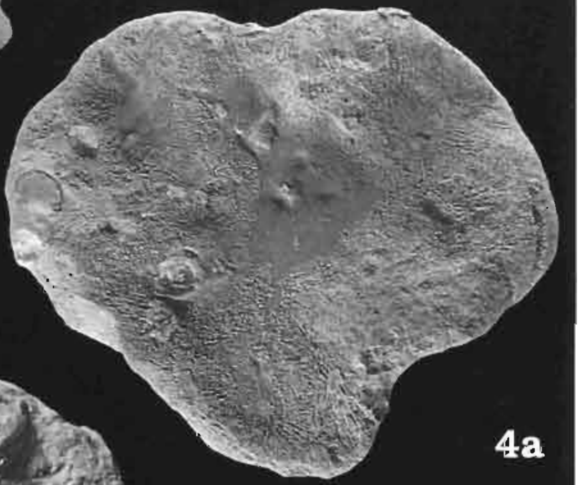

1c


2a


2b


3a


3b


4a

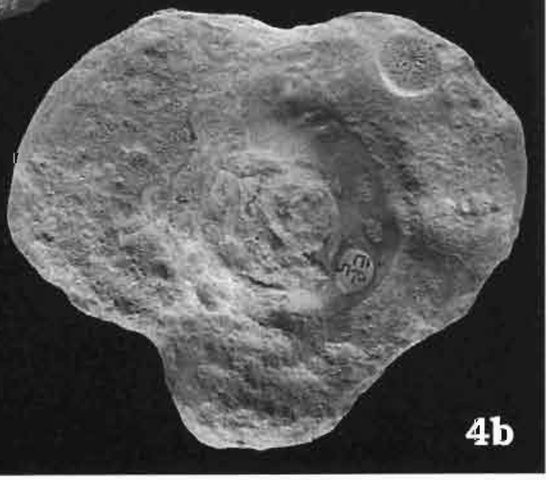

4b

PLATE 29

Platychonia schlotheimi (Münster *in* Goldfuss, 1833) 84

1. SMNS specimen, Sozenhausen, Kimmeridgian (Zeta); lateral view; × 0.6.
5. SMNS specimen, Sozenhausen, Kimmeridgian (Zeta); lateral view; × 0.66.

Megalithistia cf. *foraminosa* Zittel, 1878 80

2. SMNS specimen, Sozenhausen, Kimmeridgian (Zeta); upper surface view; × 0.66.
3. SMNS specimen, locality and horizon unknown; upper surface view; × 0.33.

Platychonia striata (Schrammen, 1937) 85

4. Specimen ZPAL Pf.VIII/237, Bärenthal, Kimmeridgian marls (Gamma); lower surface view; × 0.66.

Pyrgochonia radiata (Münster *in* Goldfuss, 1826) 88

6. Specimen ZPAL Pf.VIII/120, Hettingen, crumpled marly Kimmeridgian limestones (Delta); lower surface view; × 0.66.

Trachydictya sp. 85

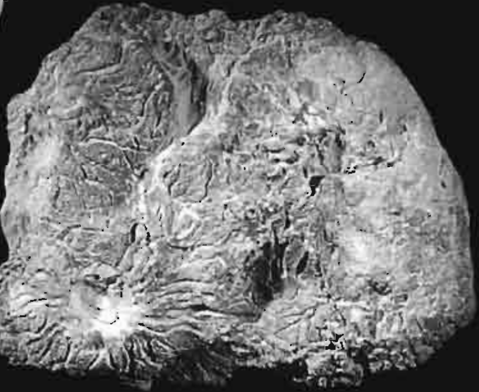
7. Specimen ZPAL Pf.VIII/115, Hettingen, crumpled marly Kimmeridgian limestones (Delta); lower surface view; × 0.66.

1a

1b

2

4



3

5

6

7

PLATE 30

Lecanella cf. *nuda* (SCHRAMMEN, 1937) 93

1. Specimen ZPAL Pf.VIII/224, Bärenthal, Kimmeridgian marls (Gamma); × 1.
9. Specimen ZPAL Pf. VIII/140, Plettenberg, Oxfordian limestones (Beta); × 0.9.

Sontheimia perforata KOLB, 1910 81

2. Specimen ZPAL Pf.VIII/244, longitudinal cross-section, Plettenberg, Oxfordian limestones (Beta); × 1.
3. Specimen ZPAL Pf.VIII/247, Bärenthal, Kimmeridgian marls (Gamma); × 1.
4. Specimen ZPAL Pf.VIII/246, Bärenthal, Kimmeridgian marls (Gamma); × 1.
5. Specimen ZPAL Pf.VIII/245, Plettenberg, Oxfordian limestones (Beta); longitudinal cross-section; × 1.

Kyphoclonella? sp. 82

6. Specimen ZPAL Pf.VIII/309, Bärenthal, Kimmeridgian marls (Gamma), *a* top view, *b* side view; × 1.

Trachydictya sp. 85

7. Specimen ZPAL Pf.VIII/284, Hettingen, crumpled marly Kimmeridgian limestones (Delta); lower surface view; × 1.
10. Specimen ZPAL Pf.VIII/137, Hochwang, Kimmeridgian limestones (Delta); lower surface view; × 1.

Sontheimia cf. *parasitica* KOLB, 1910 81

8. Specimen ZPAL Pf.VIII/136, Plettenberg, Oxfordian marls (Alfa); × 1.


1

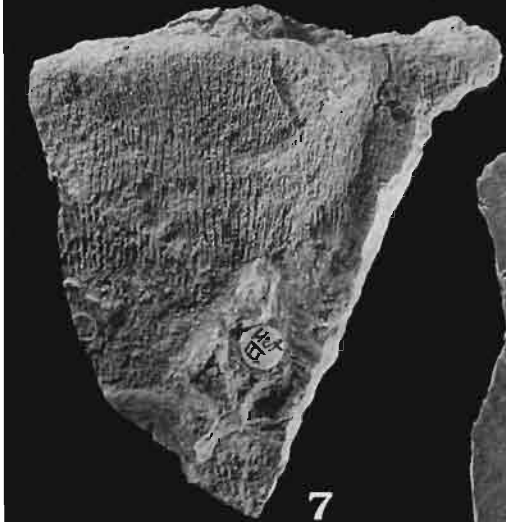

2


3


6a


4


6b


7


5


8


9

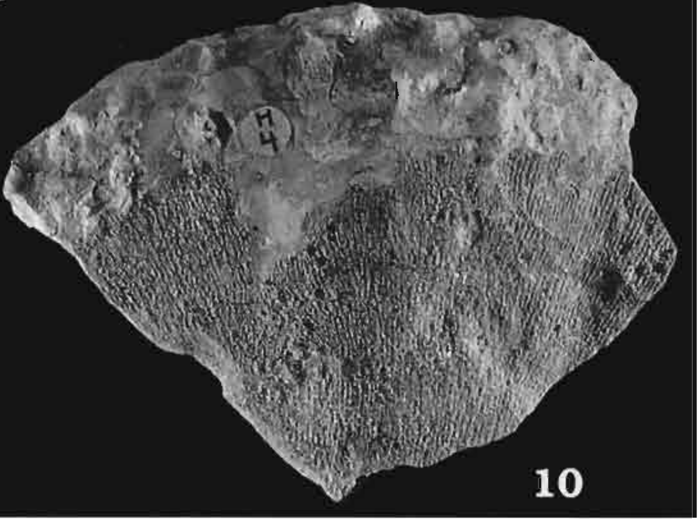

10

PLATE 31

Epistomella sp. 90

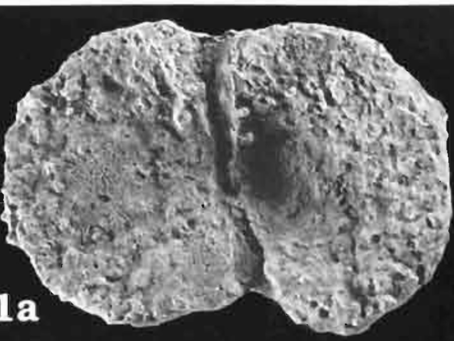
1. Specimen ZPAL Pf.VIII/230, Genkingen, Kimmeridgian limestones (Delta); *a* upper surface view; *b* lower surface view; × 1.
2. Specimen ZPAL Pf.VIII/231, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); upper surface view; × 1.5.

Linochone rimosa SCHRAMMEN, 1937 91

3. Specimen ZPAL Pf.VIII/219, Wilmandingen, Kimmeridgian marls (Gamma); × 1.
4. Holotype (never previously illustrated original of SCHRAMMEN, IGPTU), Gerstetten, Kimmeridgian (Zeta); × 1.

Cylindrophyma milleporata (GOLDFUSS, 1833) 90

5. Specimen ZPAL Pf.VIII/214, Wilmandingen, Kimmeridgian marls (Gamma); × 1.
6. Specimen ZPAL Pf.VIII/215, Bärenthal, Kimmeridgian marls (Gamma); × 1.
7. Specimen ZPAL Pf.VIII/117, Pletteneberg, Oxfordian marls (Alfa); × 0.75.
8. Specimen ZPAL Pf.VIII/118, Plettenberg, Oxfordian marls (Alfa); *a* oscular view, *b* lateral view; × 1.5.

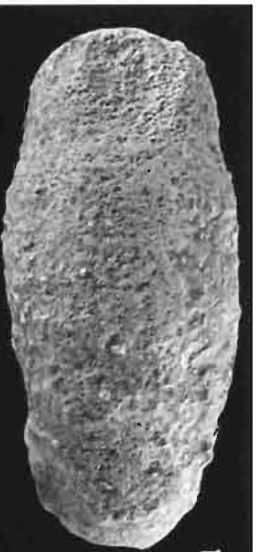

1a


1b

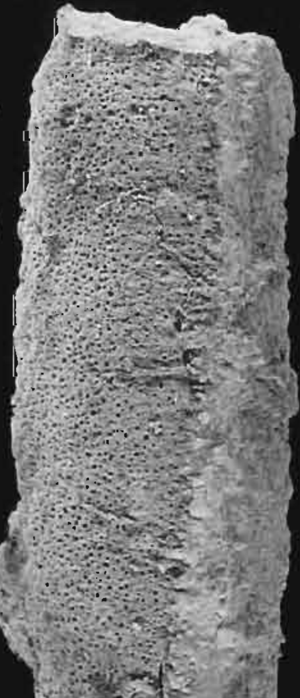

2


3


4


5


6


7


8a

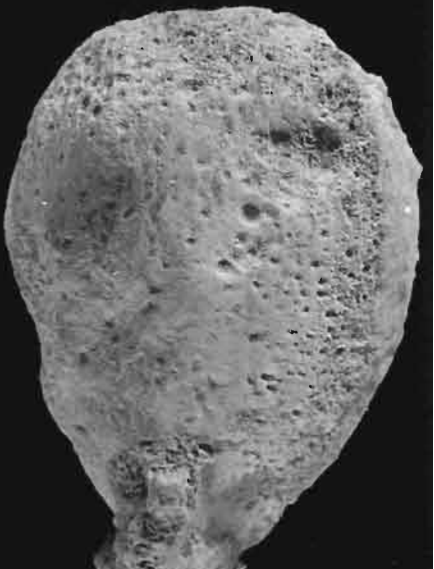

8b

PLATE 32

Anomorphites trigonus KOLB, 1910 80

1. Specimen ZPAL Pf.VIII/220, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); × 1.5.

Lecanella pateraeformis ZITTEL, 1878 93

2. Specimen ZPAL Pf.VIII/228, Hettingen, crumpled marly Kimmeridgian limestones (Delta); × 1.
7. Specimen ZPAL Pf.VIII/229, Bärenthal, Kimmeridgian marls (Gamma); × 0.9.

Camerospongia? sp. n. 74

3. Specimen ZPAL Pf.VIII/408, Bärenthal, Kimmeridgian marls (Gamma); *a* top view; *b* lateral view; × 1.

Multiloqua fungulus (QUENSTEDT, 1878) 56

4. Specimen ZPAL Pf.VIII/304, Bärenthal, Kimmeridgian marls (Gamma); lateral view; × 1.

Coscinodiscus suevicus SCHRAMMEN, 1937 92

5. Holotype (previously unillustrated specimen), SCHRAMMEN's collection, IGPTU, Schwabtal (exact locality and age unknown); *a* upper surface view, *b* lateral view; × 1.

Melonella radiata (QUENSTEDT, 1878) 91

6. Specimen ZPAL Pf.VIII/119, Hettingen, crumpled marly Kimmeridgian limestones (Delta); *a* oscular view; *b* lateral view; × 1.

1

3a

3b

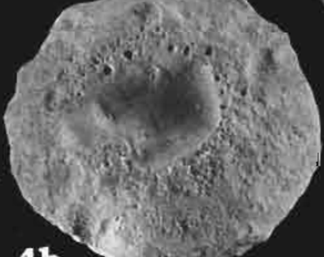
5a

2

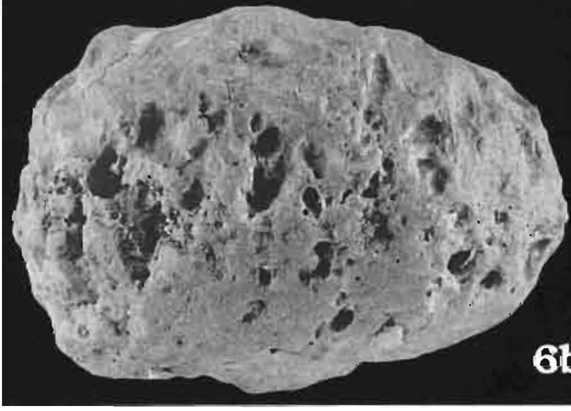
4a

5b

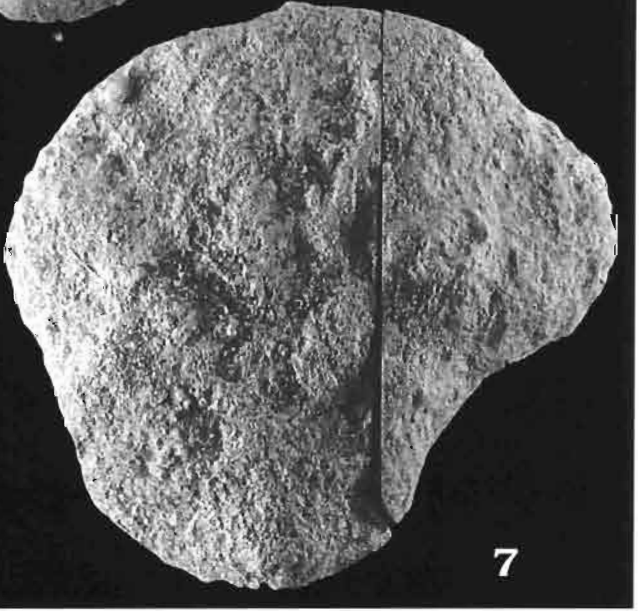
6a



4b



6b



7

PLATE 33

Cribrospongia cucullata (QUENSTEDT, 1878) 49

1–4. Specimen ZPAL Pf.VIII/327, Erkenbrechtsweiler, Kimmeridgian marls (Gamma), SEM; *1* isolated dermal pentactine, × 100; *2* veil of gastral stauractines, × 50; *3* veil of dermal pentactines, × 60; *4* dermal surface of the choanosomal skeleton, note thick cortex, × 50.

5. Choanosomal skeleton in the oblique view, Streitberg, Oxfordian (Alfa), SCHRAMMEN's collection, IGPTU; × 34.

Cribrospongia reticulata (GOLDFUSS, 1826) 47

6. Choanosomal skeleton in tangentianl section, two canals visible, Ettenscheiss-Bucaker, Kimmeridgian (Zeta), SMNS collection; × 12.

7. Choanosomal skeleton in oblique section, SCHRAMMEN's collection, (SCHRAMMEN 1937: pl. 3: 2), Sontheim, Kimmeridgian (Epsilon), IGPTU; × 34.

Aulodomus farreides SCHRAMMEN,1937 38

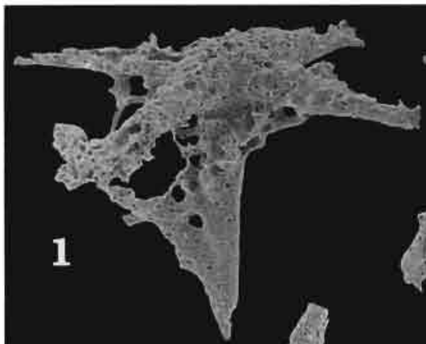
8. Choanosomal skeleton, SCHRAMMEN's collection (from the specimen illustrated in SCHRAMMEN 1937: pl. 1: 7, pl. 2: 15), Streitberg, Oxfordian (Alfa), IGPTU; × 30.

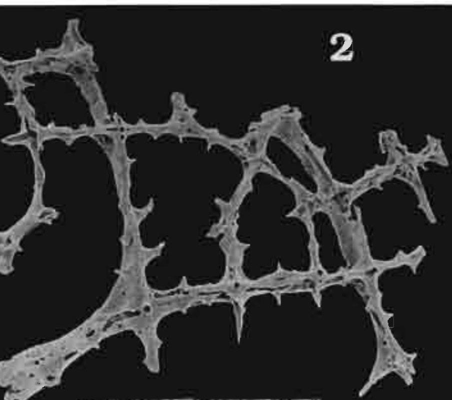
"*Linonema*" *infundibuliformis* (SCHRAMMEN, 1937) 58

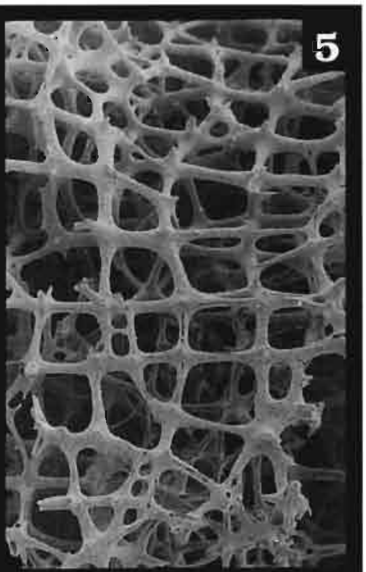
9–10. Holotype, SCHRAMMEN's collection (1937: pl. 12: 5), Erkenbrechtsweiler, Kimmeridgian (Gamma/Delta), IGPTU; × 40; *9* outermost part of the choanosomal skeleton with the dermal pentactine attached; *10* interior of the choanosomal skeleton with lychniscosan nature clearly visible (compare with Pl. 33: 11).

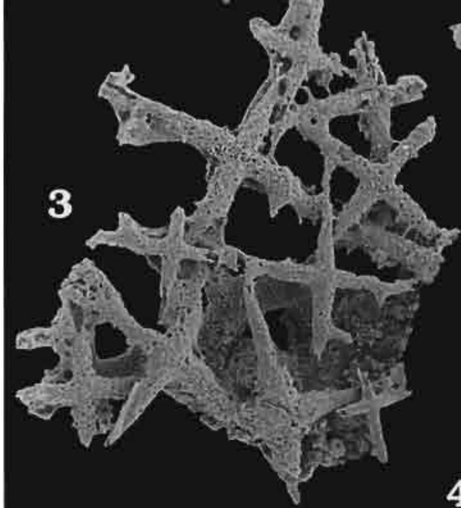
Linonema calyx (SCHRAMMEN, 1937) 58

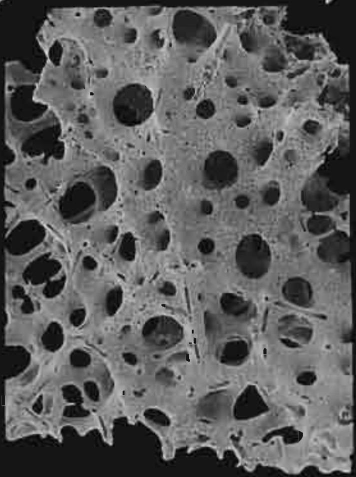
11. Regular choanosomal skeleton specimen 1937, pl. 15: 2), Streitberg, Oxfordian (Alfa), IGPTU; × 20.

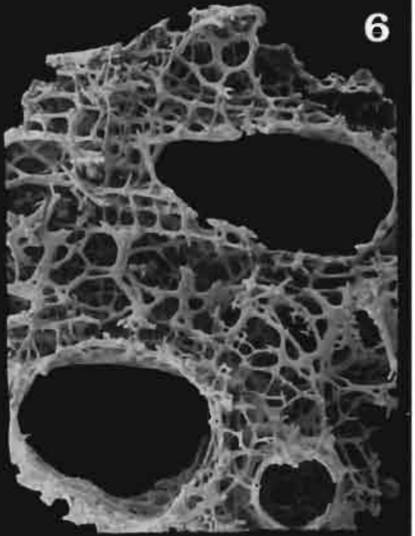

1

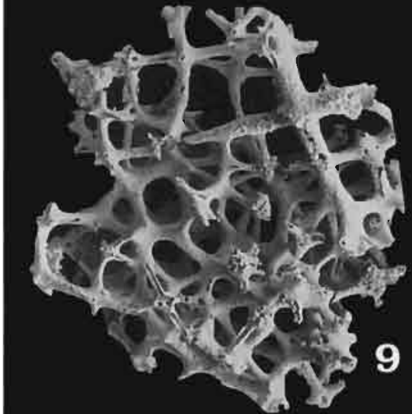

2

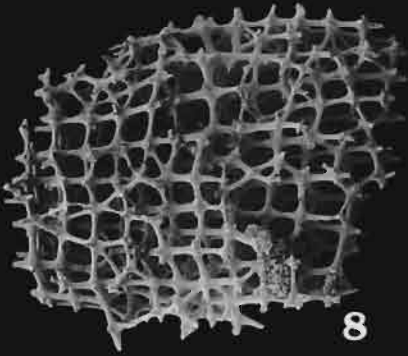

5

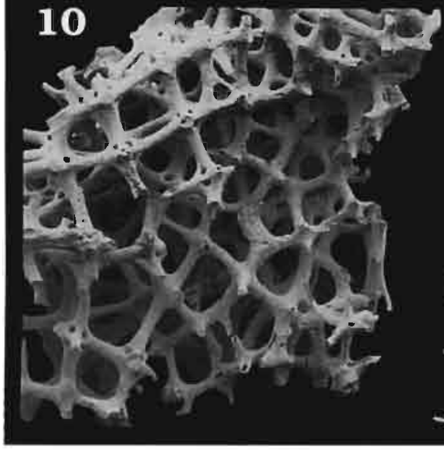

3

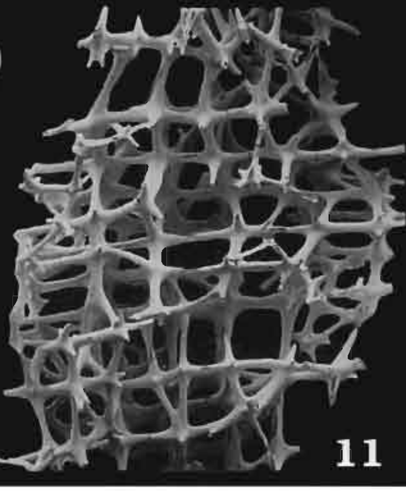

4


6


9


8


10


11


7

PLATE 34

Walcotella pertusa (GOLDFUSS, 1833) 52

1. Secondary skeleton ("Deckgespinst" of SCHRAMMEN) over canal openings (upper part) and dermal surface of choanosomal skeleton (lower part) (from the specimen illustrated in SCHRAMMEN 1937: pl. 7: 7, pl. 26: 4), Schwabtal, Kimmeridgian (Gamma/Delta), IGPTU; × 20.
2. Regular choanosomal skeleton (from the specimen illustrated in SCHRAMMEN 1937: pl. 3: 13 and pl. 14: 6, 7), IGPTU; × 30.
3. Subdermal skeleton in a tangential view, canal opening in the middle (from the specimen illustrated in SCHRAMMEN 1937: pl. 7: 7, pl. 26: 4), Schwabtal, Kimmeridgian (Gamma/Delta), IGPTU; × 20.

Pachyascus formosus SCHRAMMEN, 1937 44

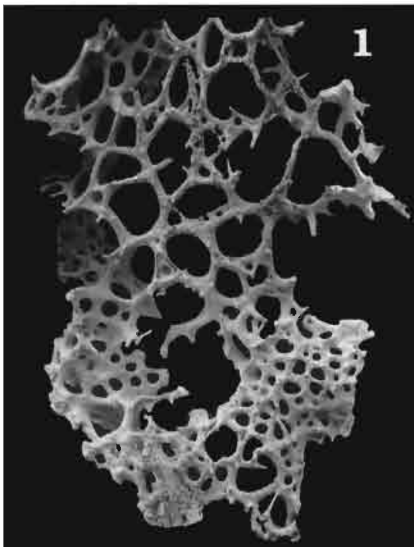
4. Fragment of the choanosomal skeleton of the holotype (from the specimen illustrated in SCHRAMMEN 1937: pl. 11: 2), IGPTU; × 20.

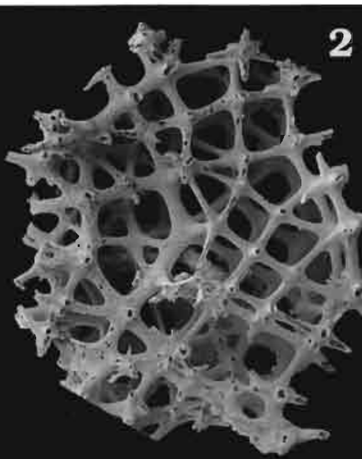
Laocoetis parallela (GOLDFUSS, 1826) 38

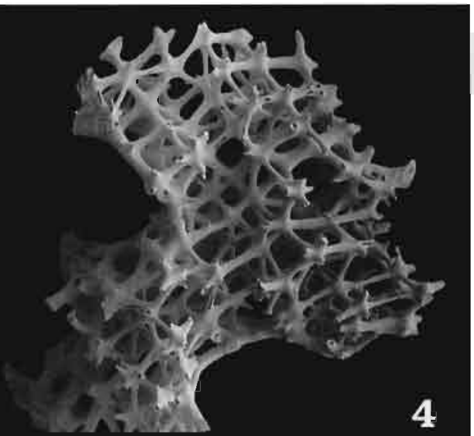
5. Choanosomal skeleton (SCHRAMMEN 1937: pl. 13: 1), Heuchstetten, Kimmeridgian (Epsilon), IGPTU; × 27.
6. Fragment of the choanosomal skeleton pierced by canals in surface view (SCHRAMMEN 1937: pl. 13: 1), Heuchstetten, Kimmeridgian (Epsilon), IGPTU; × 20.

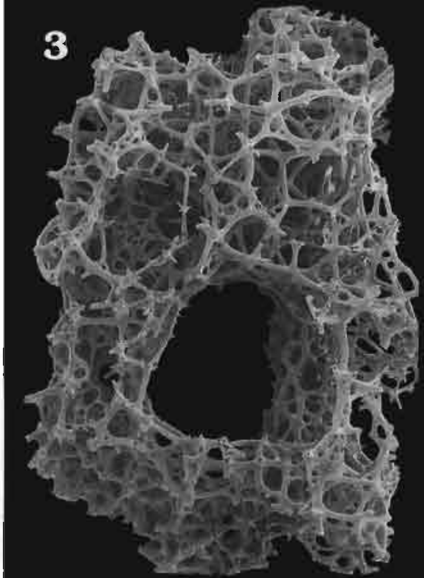
Laocoetis paradoxa (MÜNSTER *in* GOLDFUSS, 1833) 41

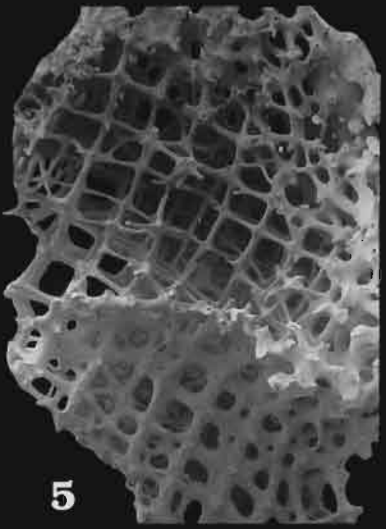
7–9. Specimen from SMNS, Sirchingen; *7* gastral side of the choanosomal skeleton showing two canals and secondary skeleton within in one of the canals, × 12; *8* surface of the basal skeleton, × 30; *9* dictyonal strands in the choanosomal skeleton, × 30.

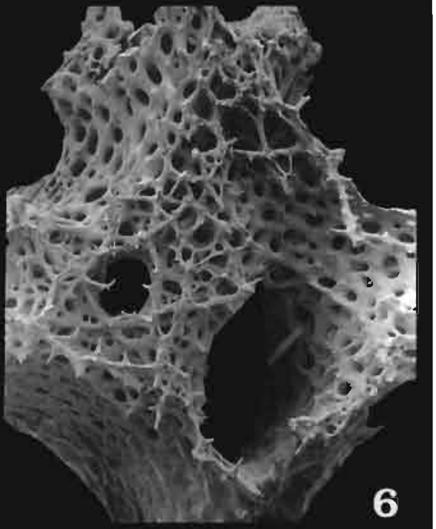

1

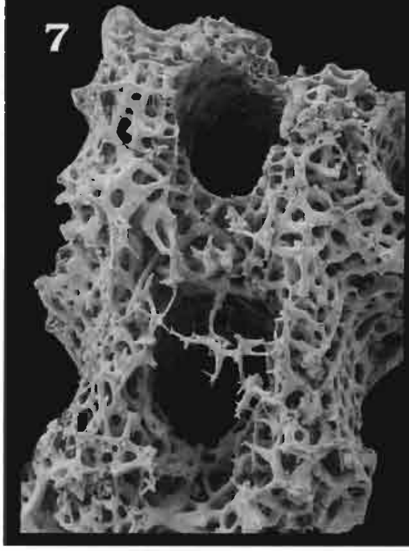

2

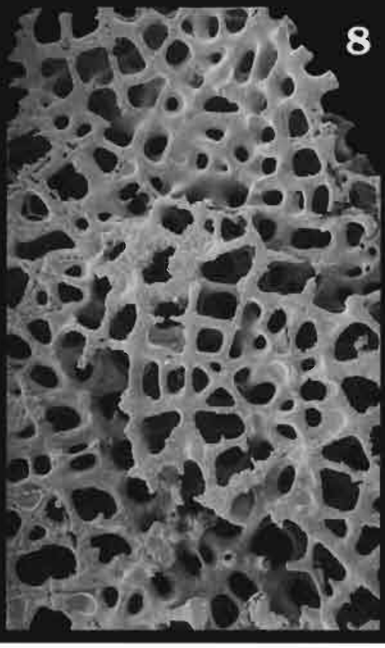

4


3


5


6


7


8


9

PLATE 35

Sphenaulax progenis SCHRAMMEN, 1937 45

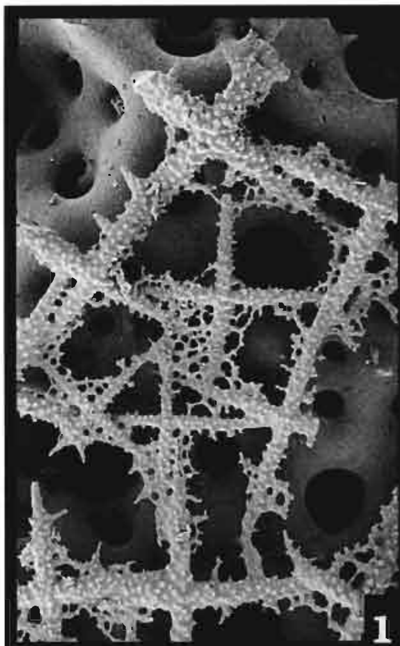
1–2. Specimen from SMNS, locality and exact age unknown; *1* dermal skeleton of ornamented pentactines (below cortex of the choanosomal skeleton visible), × 30; *2* interior of the very regular choanosomal skeleton with dictyonal strands inclining toward the dermal surface, × 30.

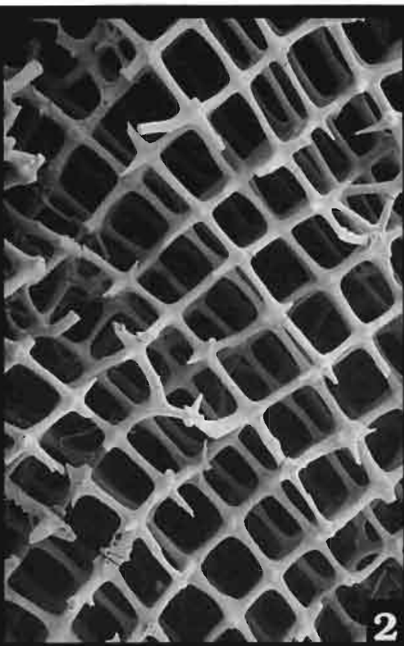
Sphenaulax costata (GOLDFUSS, 1829) 44

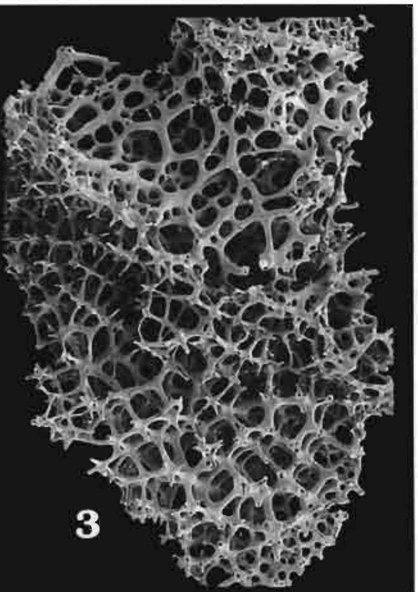
3–5. Specimen ZPAL Pf.VIII/204, Hochwang, Kimmeridgian marls (Delta); *3* interior of the choanosomal skeleton (a wall of a canal is visible in the upper part), × 18; *4* dermal surface of the choanosomal skeleton with numerous pores and only slightly thickened spicules; side view of the surface ridge with numerous outgrowths to which dermal pentactines are attached, × 16; *5* dermal pentactine (at the left, side view) attached to the main choanosomal skeleton with proximal ray and numerous synapticulae, × 100.

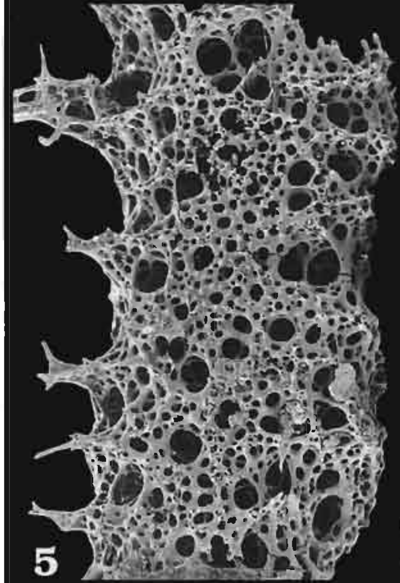
Casearia articulata (SCHMIDEL, 1780) 55

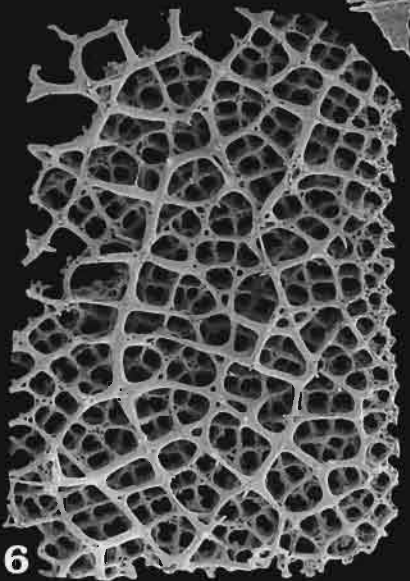
6–9. Specimen ZPAL Pf.VIII/201, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); *6* subdermal part of the choanosomal skeleton, section tangential to the surface, × 12; *7* dermal part of the choanosomal skeleton, × 40; *8* details of the choanosomal skeleton with pseudolychniscs, × 100; *9* pseudolychnisc in close view (note the presence of only 3 perforations), × 200.


1


2

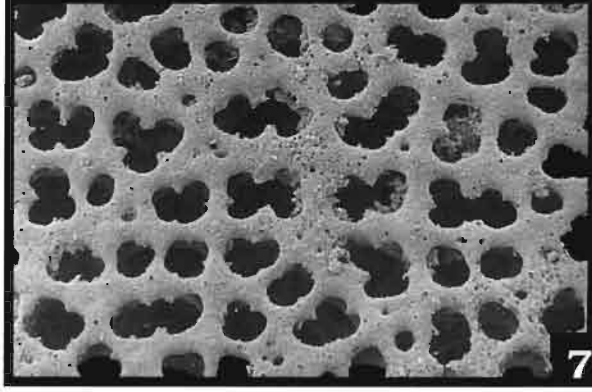

3


5


6


4


9


7

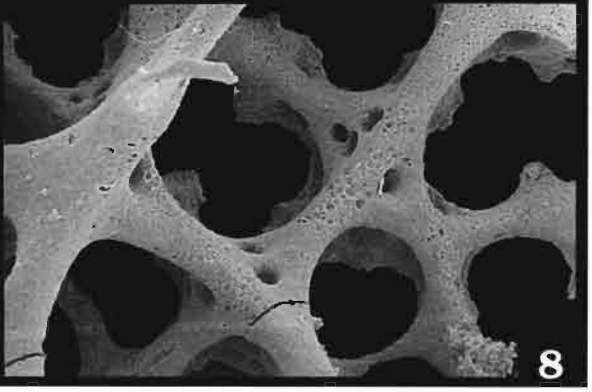

8

PLATE 36

Porospongia marginata (Münster *in* Goldfuss, 1833) 56

1–3. Specimen ZPAL Pf.VIII/299, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); *1* ?dermal surface of the choanosomal skeleton, × 20; *2* dictyonal strands of the choanosomal skeleton and ?gastral surface (bottom), × 17; *3* ?gastral surface showing siliceous membrane with embedded pentactines; note that pentactines have a small knob in place of outer reduced ray; × 38.

Verrucocoelia verrucosa (Goldfuss, 1829) 37

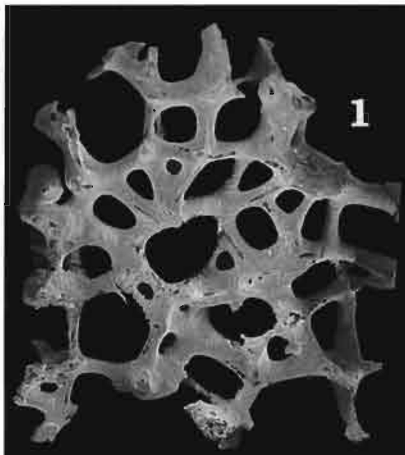
4–5. Holotype (Goldfuss 1829: pl. 33: 8), Streitberg, IPUB; *4* choanosomal skeleton, × 22; *5* dermal surface of the choanosomal skeleton, *a* × 17; *b*. details of 5a, × 66.

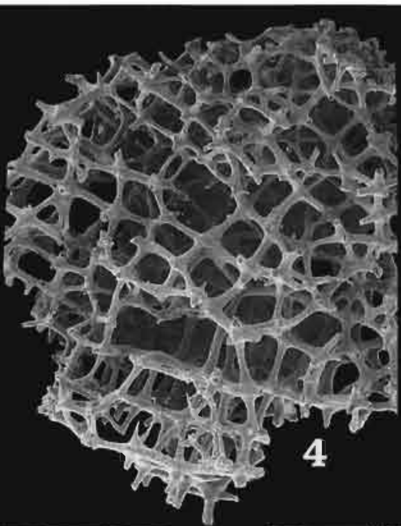
Tremaphorus apertus (Oppliger, 1915) 50

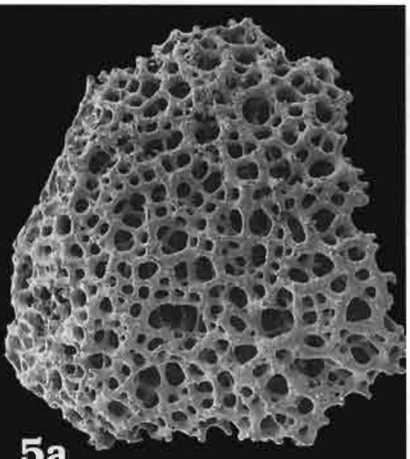
6. Very regular choanosomal skeleton, with dictyonal strands diverging toward both surfaces, Schrammen's original (1937: pl. 15: 8), Streitberg, Oxfordian (Alfa), IGPTU; × 20.

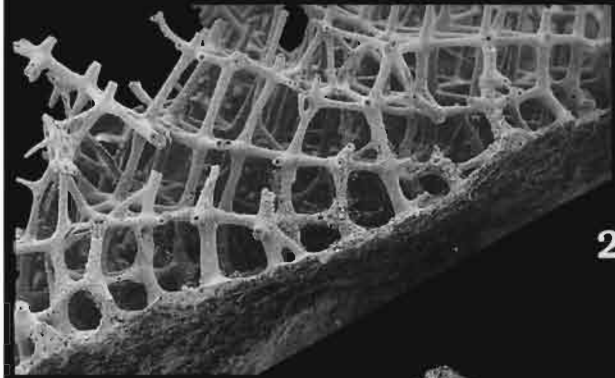
Laocoetis lineata (Schrammen, 1937) 43

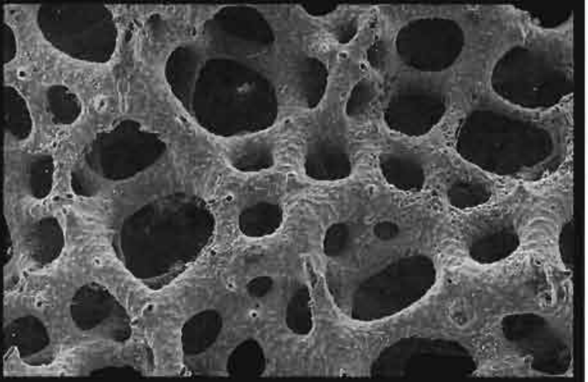
7–8. Specimen ZPAL Pf.VIII/291, Bärenthal, Kimmeridgian marls (Gamma); *7* surface of the choanosomal skeleton showing very regular distribution of canal openings and thickened spicules, × 15; *8* interior of the choanosomal skeleton showing very regular disposition of dictyonal strands in a view tangential to the surface, × 30.

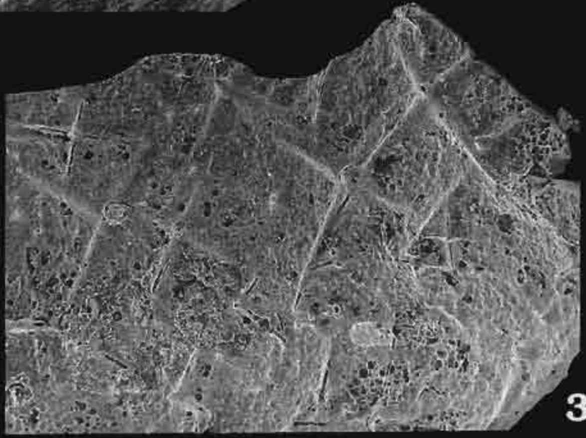

1

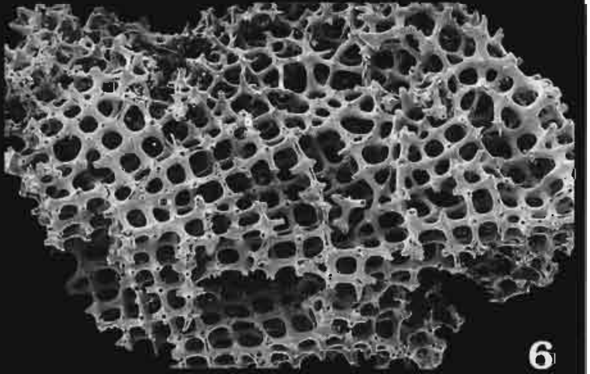

4

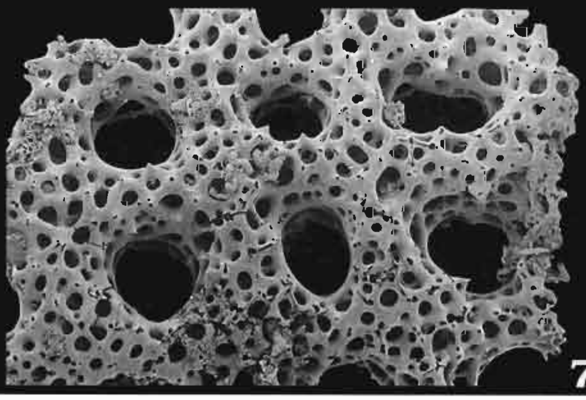

5a


2


5b


3


6


7


8

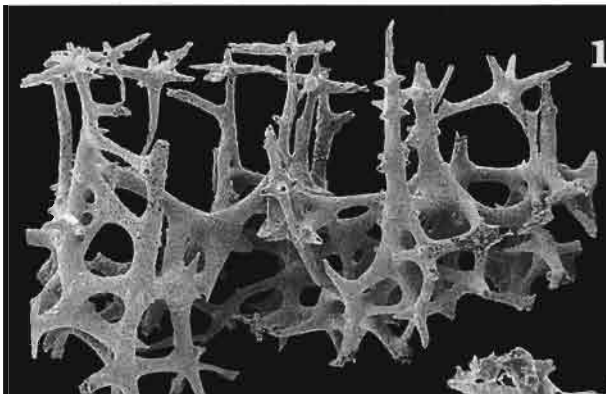
PLATE 37

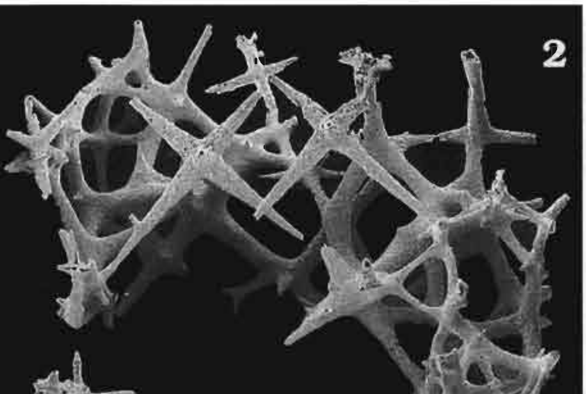
Hexactinosa gen. et sp. n. 59

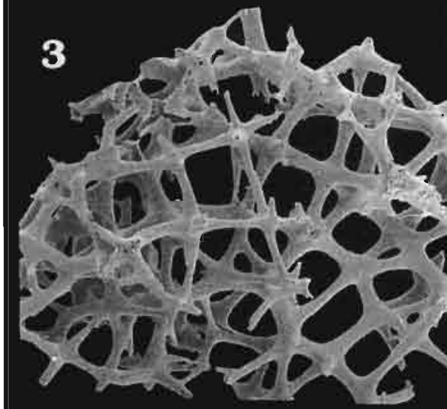
1–5. Specimen ZPAL Pf.VIII/329, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); *1* dermal hexactines fused with subdermal dictyonal skeleton in transverse view, × 40; *2* dermal skeleton consisting of hexactines in oblique view, × 50; *3* choanosomal dictyonal skeleton in surface view, × 40; *4* isolated dermal hexactine, × 60; *5* surface of the dictyonal skeleton with few dermal hexactines attached to it, oblique view, × 30.

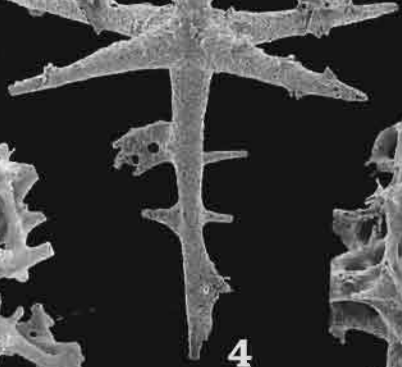
Xenoschrammenum venosum (SCHRAMMEN, 1937) 76

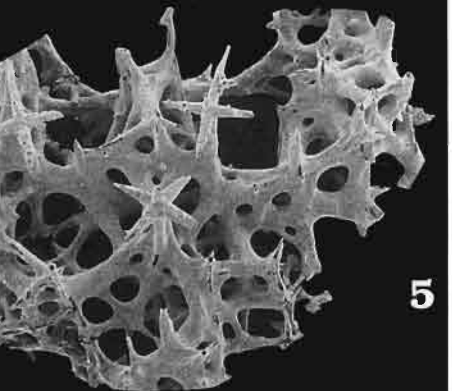
6–8. Hedeinheimer Alb, SMNS collection; *6a* choanosomal skeleton pierced by two canals, × 27; *6b* details of *6a* showing the lychniscosan nature of choanosomal skeleton in section tangential to the surface (note that some nodes are occluded), × 60; *7* surface showing the alternating nature of canal openings and thickened spicules, × 13; *8a* choanosomal skeleton with canals, section perpendicular to the surface, × 13; *8b* details of *8a* showing lychniscosan nature of the spiculation (some nodes are, however, occluded and may be mistaken for hexactinosan structure), × 30.

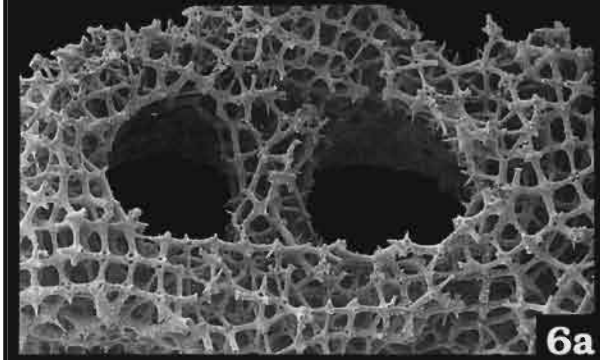

1

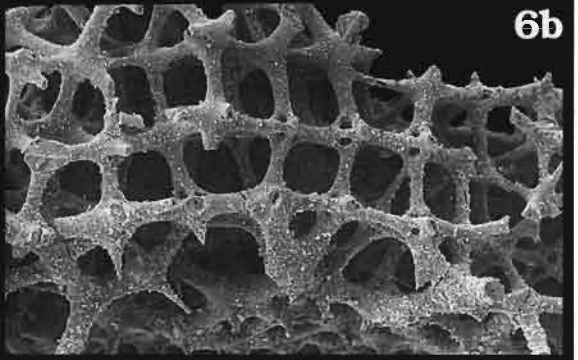

2

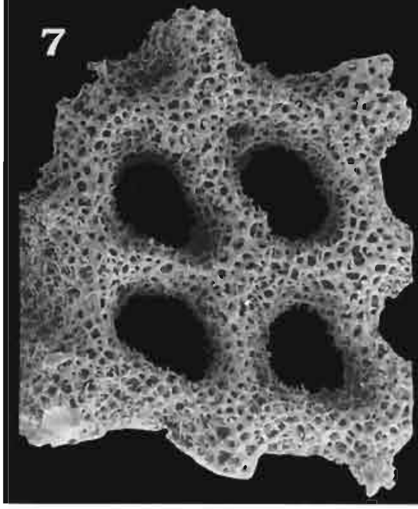

3

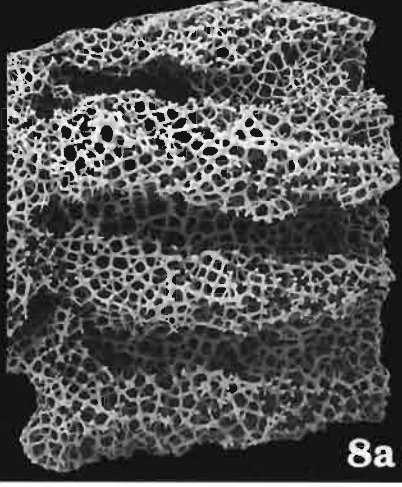

4


5


6a


6b


7


8a

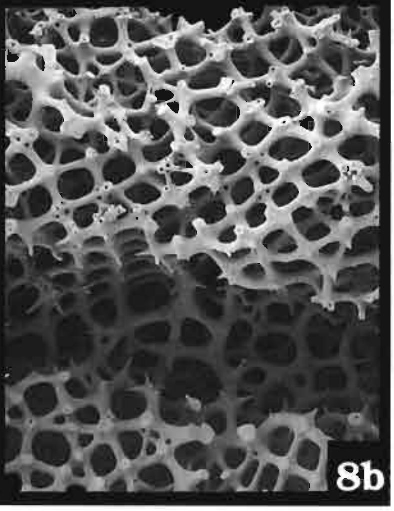

8b

PLATE 38

Leptolacis striata SCHRAMMEN, 1937 46

1–3. Holotype (SCHRAMMEN 1937: pl. 5: 11, pl. 10: 3), Gerstetten, Kimmeridgian (Zeta), IGPTU; *1* inner (upper) surface view, *2* outer (lower) surface view, *3* interior view of dictyonal skeleton and canals; × 30.

Sphenaulax irregularis sp. n. 45

4–5. Specimen ZPAL Pf.VIII/318, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); *4* dermal side of choanosomal skeleton showing cortex and a small canal opening, × 20; *5* choanosomal skeleton; dictyonal strands are at the dermal (right) surface, × 34.

Trochobolus suevicus SCHRAMMEN, 1937 72

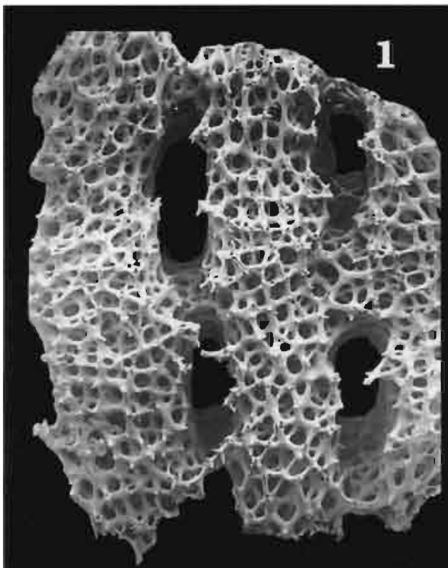
6–7. Specimen ZPAL Pf.VIII/203, Hochwang, Kimmeridgian marls (Delta); *6* dermal surface of the choanosomal skeleton, × 24; *7* choanosomal skeleton, × 37.

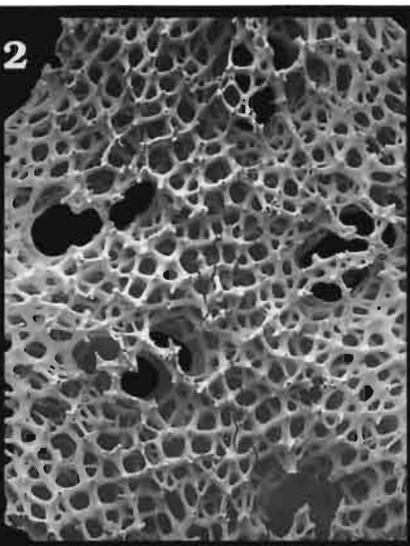
Nitidus nitidus SCHRAMMEN, 1937 59

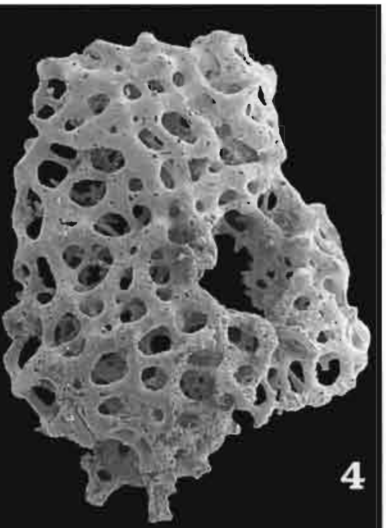
8. Choanosomal skeleton of the holotype (SCHRAMMEN 1937: pl. 10: 1), Streitberg, Oxfordian (Alfa), IGPTU; × 66.

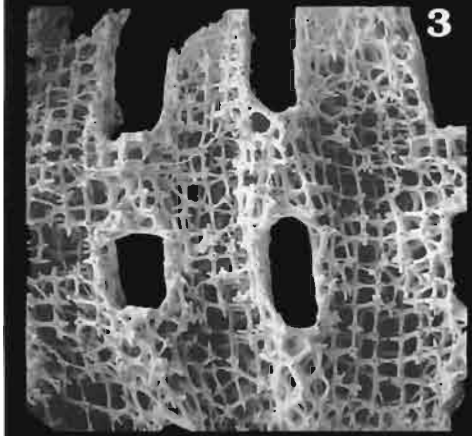
Desmoderma evestigata SCHRAMMEN, 1937 70

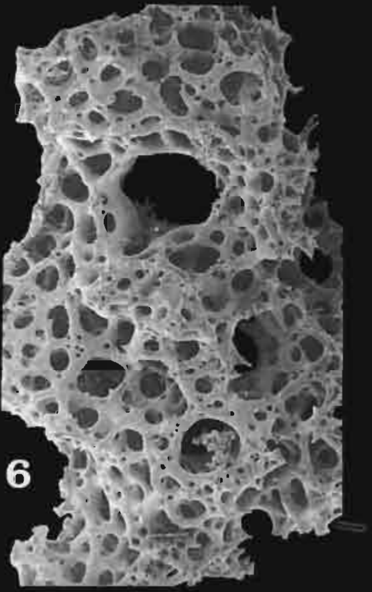
9. Choanosomal skeleton of the holotype (SCHRAMMEN 1937: pl. 16: 3, 4), Schwabtal, Kimmeridgian (Gamma/Delta), IGPTU; × 100.

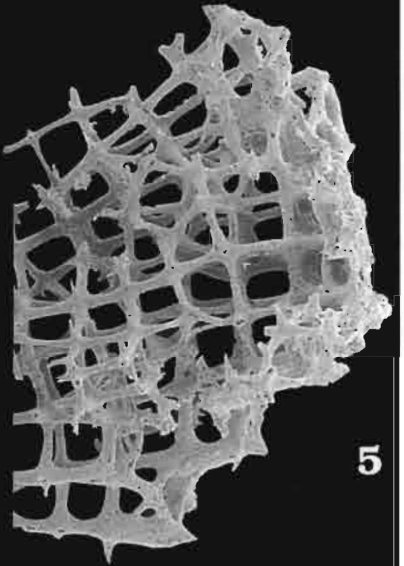

1

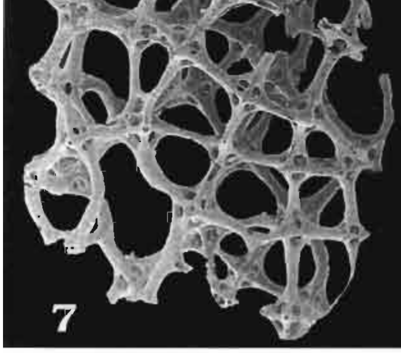

2

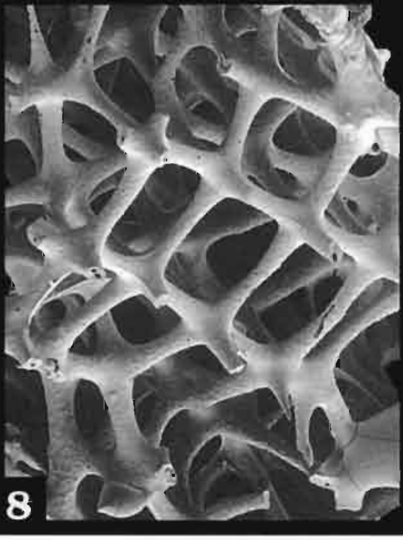

4


3


6


5


7


8

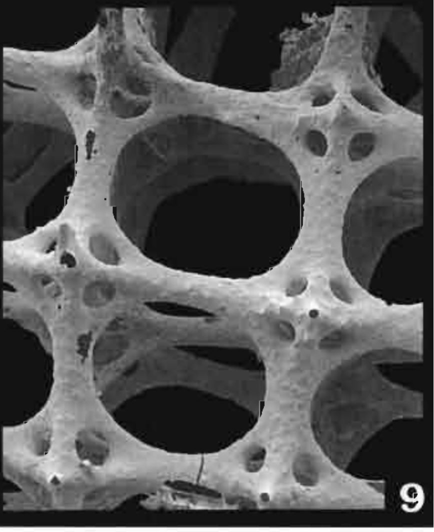

9

PLATE 39

Cypellia rugosa (GOLDFUSS, 1833) 60

1. Two dermal pentactines joined at the points of contact, specimen ZPAL Pf.VIII/401, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); × 34.
2. Dermal pentactines joined at the multiple points by synapticular bridges, specimen ZPAL Pf.VIII/325, Bärenthal, Kimmeridgian marls (Gamma); × 40.
3. Isolated dermal pentactine, specimen ZPAL Pf.VIII/325, Bärenthal, Kimmeridgian marls (Gamma); × 50.
4. Dermal pentactines embedded in a siliceous membrane, specimen ZPAL Pf.VIII/325, Bärenthal, Kimmeridgian marls; × 24.
5. Dermal pentactines fused to the subdermal complicated skeleton (transverse view), specimen ZPAL Pf.VIII/401, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); × 27.
6. Subdermal complicated (top) and inner regular (lower part) of the choanosomal skeleton, SCHRAMMEN's collection Tübingen (1937: pl. 11: 7), IGPTU; × 27.

Cypellia inberbis (QUENSTEDT, 1878) 61

7–8. SCHRAMMEN's collection (1937: pl. 4: 8), Streitberg, Oxfordian (Alfa), IGPTU; *7* dermal layer of slender pentactines with partly visible complicated subdermal skeleton, × 20; *8* subdermal complicated skeleton, × 66.

Trochobolus dentatus KOLB, 1910 73

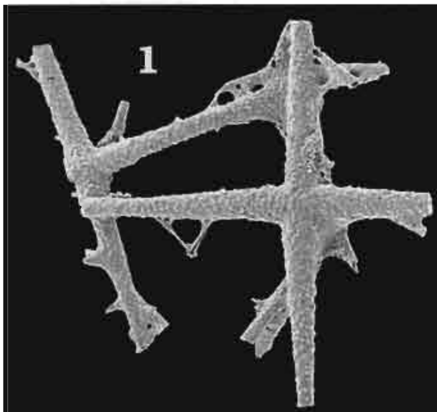
9. Choanosomal skeleton, SCHRAMMEN's collection (1937: pl. 12: 2), Erkenbrechtsweiler, Kimmeridgian (Gamma/Delta), IGPTU; × 27.

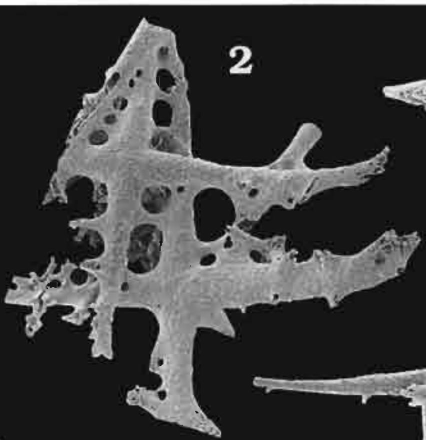
Rhogostomium corrugatum SCHRAMMEN, 1937 77

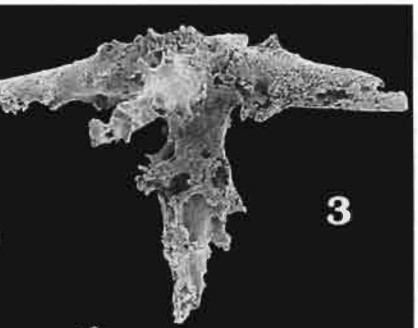
10. Choanosomal skeleton showing its lychniscosan nature; SCHRAMMEN's collection (1937: pl. 27: 3), Heuchstetten, Kimmeridgian (Epsilon), IGPTU; × 52.

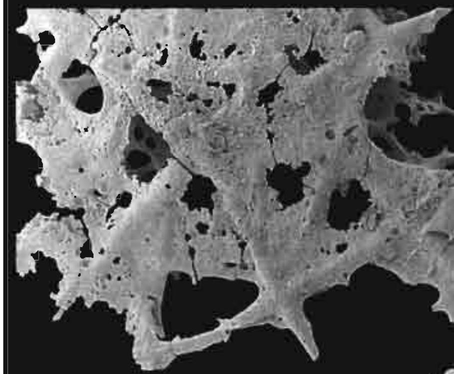
"*Rhogostomium corrugatum*" SCHRAMMEN, 1937 77

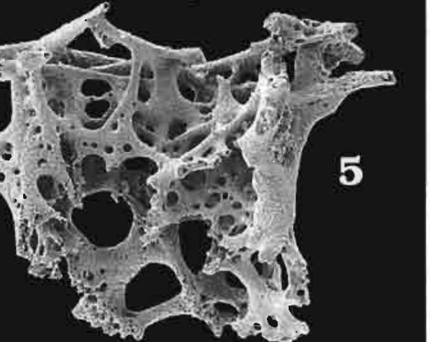
11. Another of SCHRAMMEN's specimens (1937: pl. 5: 6) described under the same name, but which is clearly a hexactinosan sponge, Heuchstetten, Kimmeridgian (Epsilon), IGPTU; × 60.


1

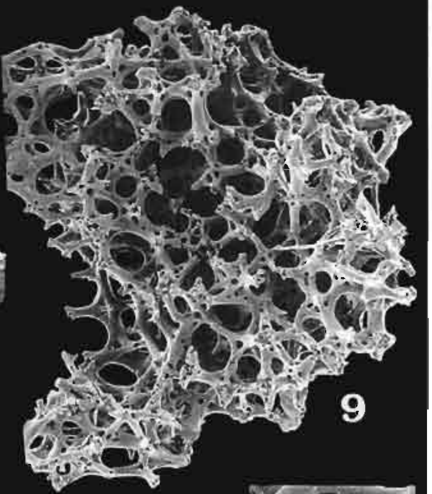

2

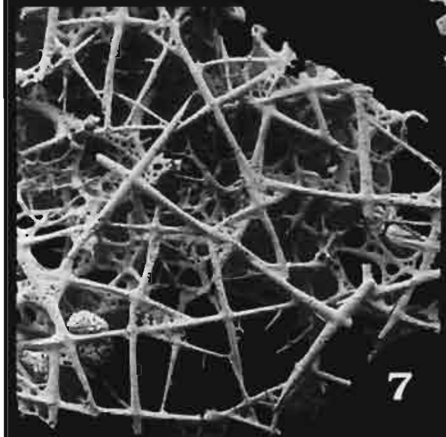

3

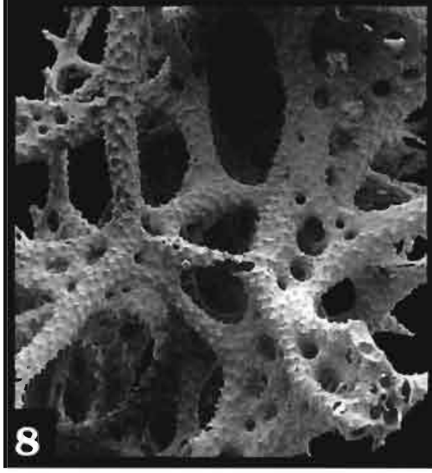

4

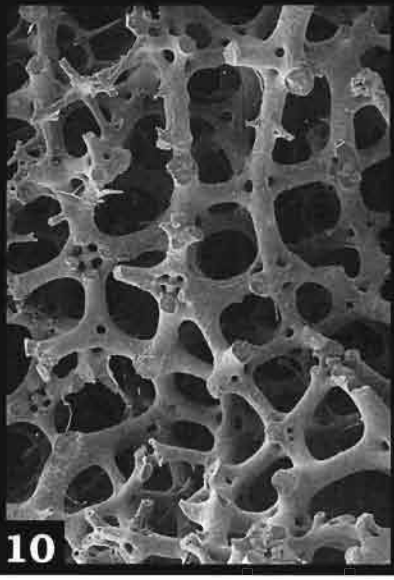

5


6


9


7


8


10

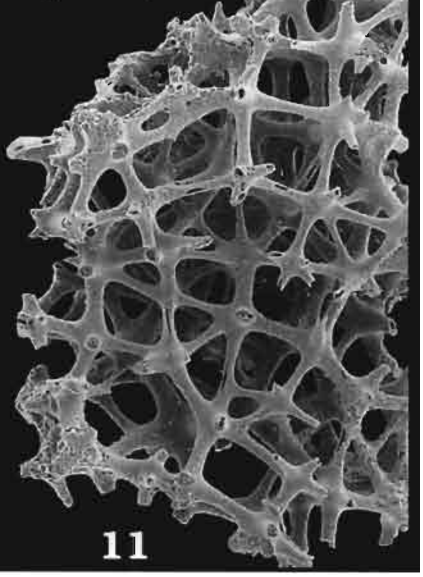

11

PLATE 40

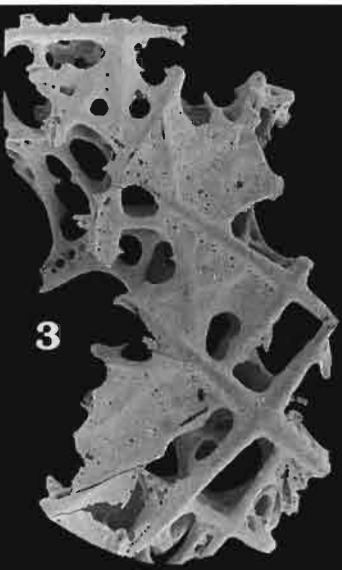
Cypellia prolifera (Quenstedt, 1878) 62

1–6. Specimen ZPAL Pf. VIII/324, Erkenbrechtsweiler, Kimmeridgian marls (Gamma); *1* dermal pentactines (seen from below) fused at the points of contact, × 20; *2* central part of the choanosomal skeleton, × 20; *3* dermal layer of pentactines with well developed siliceous membrane, × 27; *4* subdermal irregularly developed choanosomal skeleton, × 20; *5–6* siliceous structures surrounding gastral canal openings, × 23.

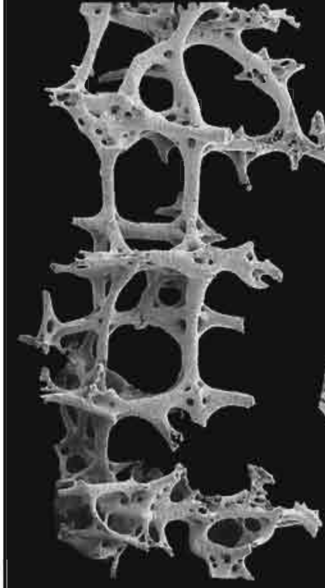
Cypellia? sp. n. 63

7–10. Specimen ZPAL Pf.VIII/326, Genkingen, Kimmeridgian marls (Delta); *7* smooth dermal pentactines fused at the points of contact, × 24; *8* smooth dermal pentactines fused with siliceous membrane, × 24; *9* subdermal irregular choanosomal skeleton with openings of two canals (tangential section), × 17; *10* dermal layer composed of pentactines (top) fused with subdermal choanosomal skeleton, transverse section, × 24.


1

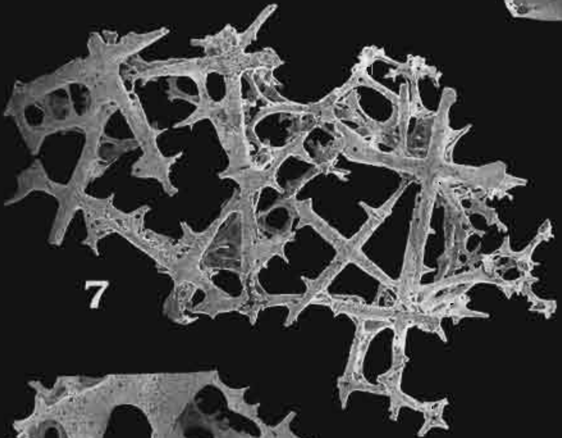

3

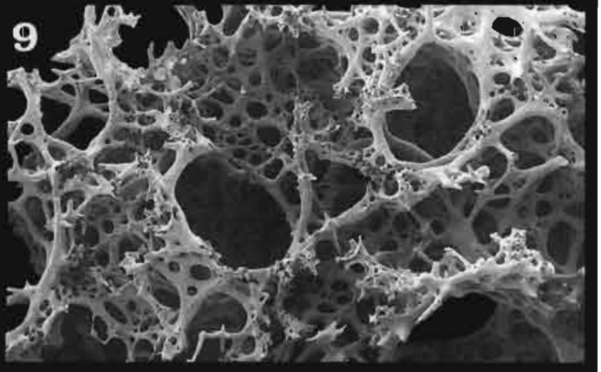

5

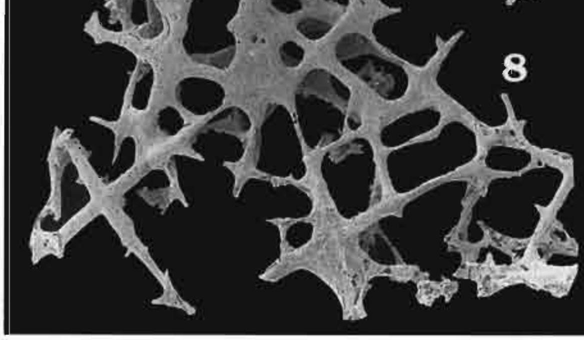

2


4


6


7


9


8


10

PLATE 41

Trochobolus labyrinthicus (SCHRAMMEN, 1937) 73

1–2. Specimen ZPAL Pf.VIII/5, Hochwang, Kimmeridgian marls (Delta); *1* regular choanosomal skeleton; *2* more irregular choanosomal skeleton pierced by two canals; × 34.
3. SCHRAMMEN's specimen (1937: pl. 25: 3), Gerstetten, Kimmeridgian (Zeta), IGPTU; × 66.

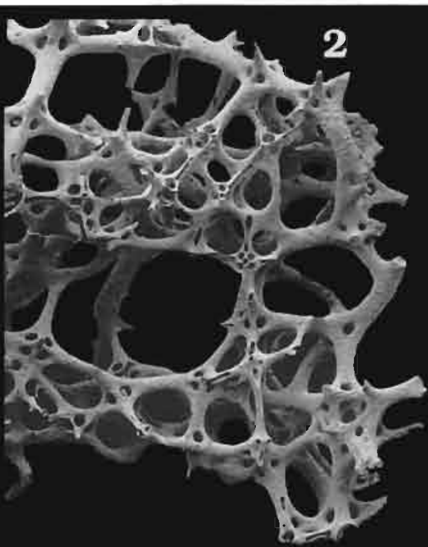
Trochobolus texatus (GOLDFUSS, 1833) 71

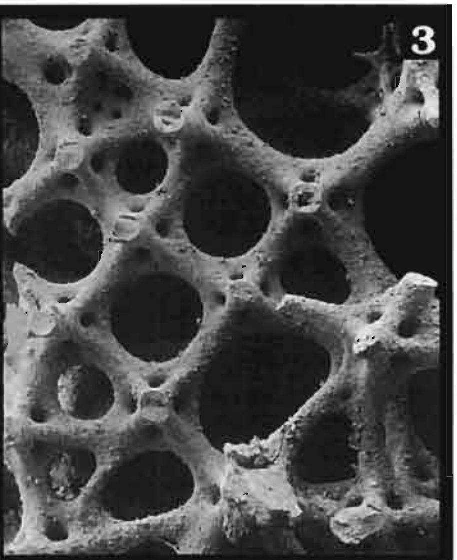
4–6. Specimen ZPAL Pf.VIII/315, Erkenbrechtsweiler, Kimmeridgian limestones (Delta); *1* very regular choanosomal skeleton, × 23; *5* round skeletal bodies (larval skeleton?) dispersed among regular choanosomal skeleton of the same specimen, × 23; *6* transverse section of such a body, to show that its irregular skeleton is interspersed between normal very regular choanosomal skeleton, × 40.

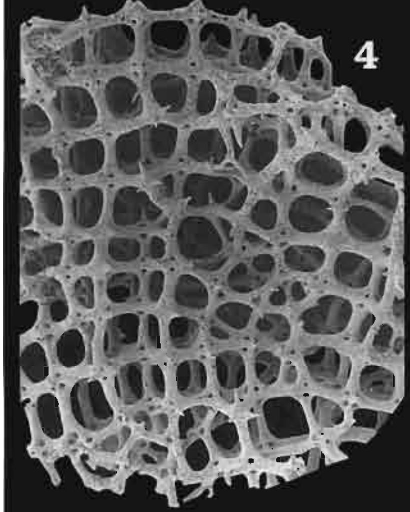
Stauroderma lochense (QUENSTEDT, 1858) 54

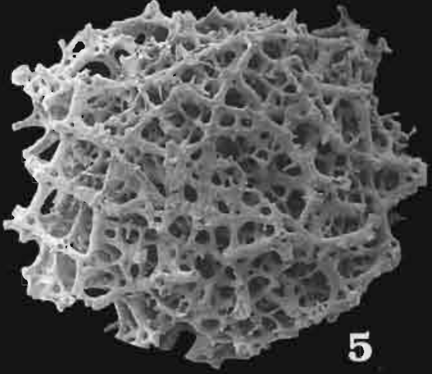
7. Subdermal choanosomal skeleton, SCHRAMMEN's collection (1937, pl. 3: 1, pl. 5: 3), Streitberg (Alfa), IGPTU; × 2.
8. Subdermal skeleton in transverse section (two canals visible), Streitberg, Oxfordian, SCHRAMMEN's collection, IGPTU; × 37.
9. Choanosomal skeleton of the specimen ZPAL Pf.VIII/2, Hochwang, Kimmeridgian marls (Delta); × 34.
10. Thickened skeleton of the canal walls, ZPAL Pf.VIII/2, Hochwang, Kimmeridgian marls (Delta); × 20.

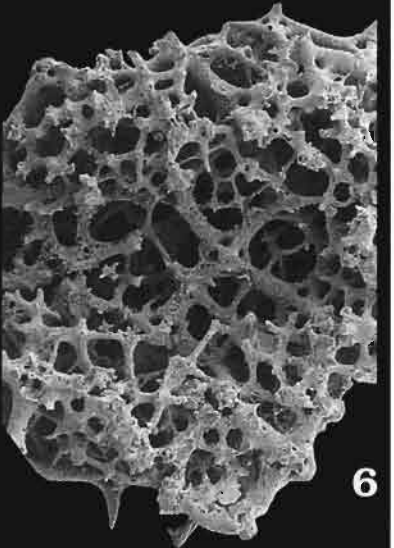

1


2


3

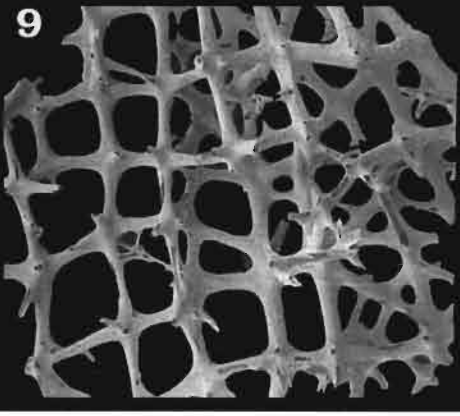

4


5


6


7


8


9


10

PLATE 42

Sporadopyle obliqua (GOLDFUSS, 1833) 66

1–3. Streitberg, SCHRAMMEN's collection, BSPHGM; *1* subdermal skeleton in tangential section, × 34; *2* slightly thickened surface of choanosomal skeleton with openings of two canals visible, × 27; *3a* regular choanosomal skeleton, × 27; *3b* details of the choanosomal skeleton showing secondary regularly fused hexactines attached to the primary choanosomal skeleton composed of lychniscs, × 100.

Sporadopyle pusilla SCHRAMMEN, 1937 66

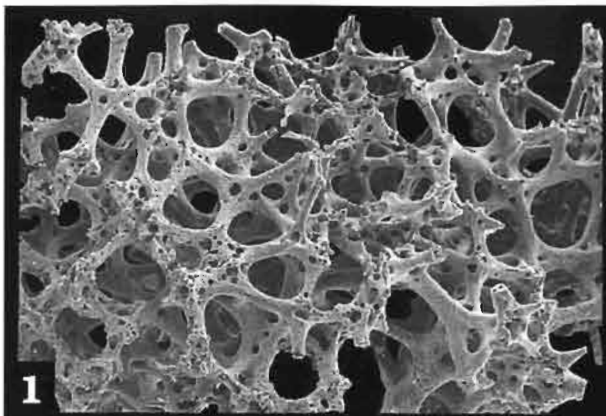
4. Dermal surface of dictyonal skeleton with round canal opening, ZPAL Pf.VIII/320, Erkenbrechtsweiler, Kimmeridgian limestones (Delta); × 30.
5. Details of dictyonal skeleton from the wall interior, ZPAL Pf.VIII/328, Erkenbrechtsweiler, Kimmeridgian limestones (Delta); × 76.

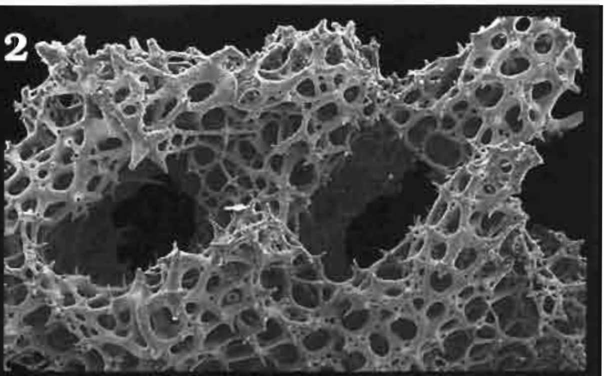
Trochobolus texatus (GOLDFUSS, 1826) 71

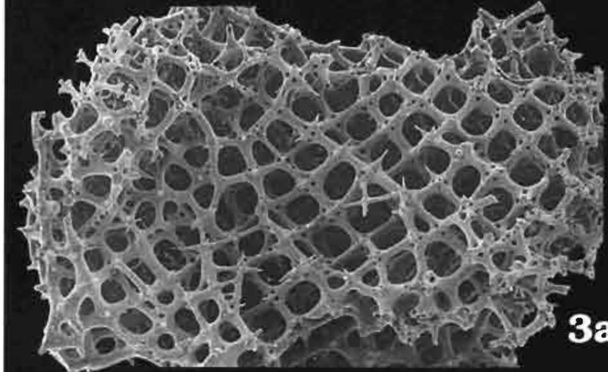
6. Choanosomal skeleton of SCHRAMMEN's specimen (1937: pl. 10: 8, 9), Streitberg, Oxfordian (Alfa), IGPTU; × 66.

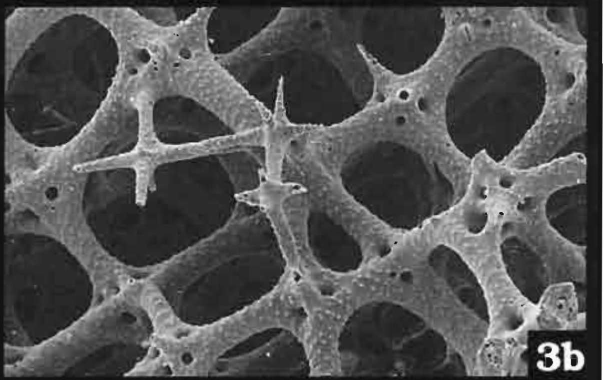
Trochobolus suevicus SCHRAMMEN, 1937 72

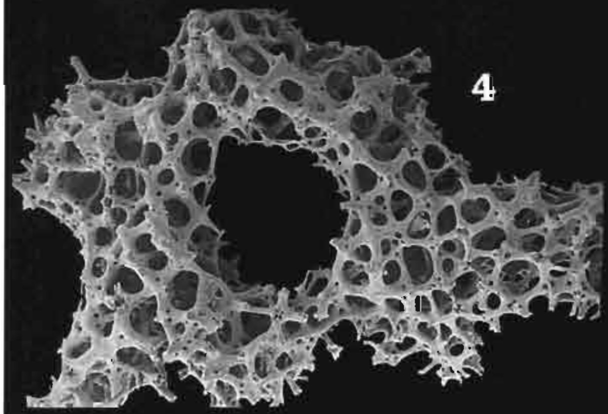
7. Choanosomal skeleton of the holotype (SCHRAMMEN 1937: pl. 24: 3), Gerstetten, Kimmeridgian (Zeta), IGPTU; × 27.
8. Specimen ZPAL Pf.VIII/3, Hochwang, Kimmeridgian marls (Delta); × 66.

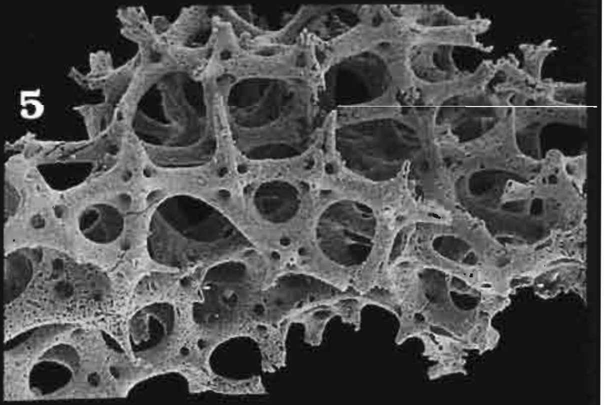

1

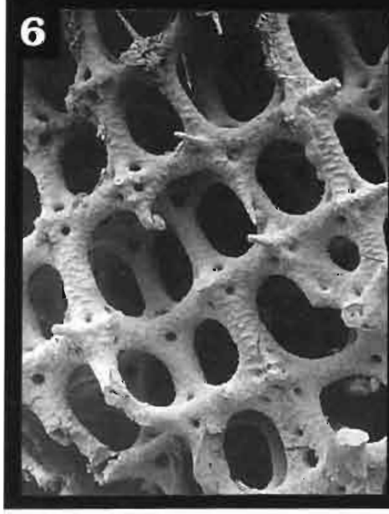

2

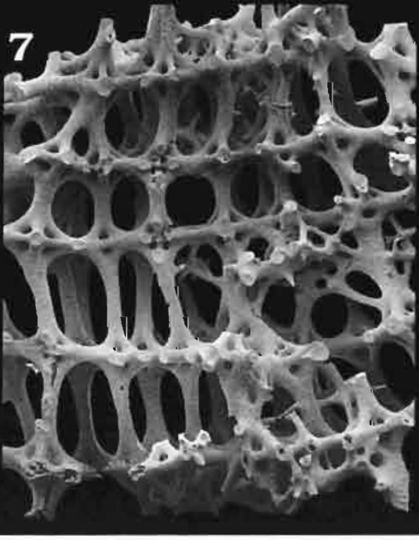

3a


3b


4


5


6


7

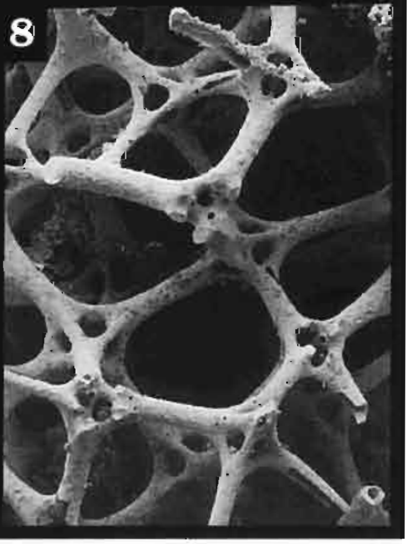

8

PLATE 43

Tetracladine sponge sp. 82

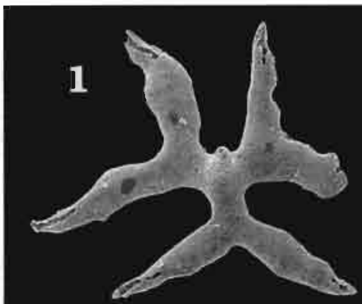
1–9. Specimen ZPAL Pf.VIII/320, Heuchstetten, Kimmeridgian limestones (Epsilon); *1* dermal dichotriaene, × 86; *2* choanosomal tetraclone, × 10; *3* near-dermal tetraclone, × 20; *4* choanosomal tetraclone, × 86; *5* modified near-dermal tetraclone, × 165; *6* choanosomal tetraclone, × 86; *7* near-dermal tetraclone, × 134; *8* articulated tuberculated choanosomal tetraclones, × 110. *9* fragment of choanosomal skeleton composed of tuberculated tetraclones, × 110.

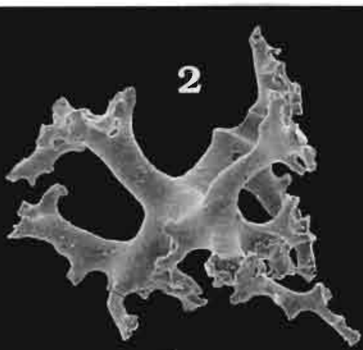
Pachyteichisma lamellosa (QUENSTEDT, 1878) 67

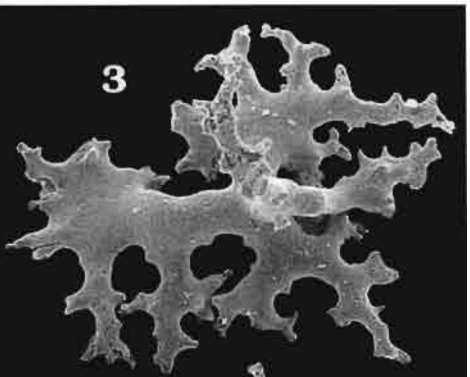
10–11. Specimen ZPAL Pf.VIII/1, Hochwang, Kimmeridgian marls (Delta)); *10* regular choanosomal skeleton, × 25; *11* irregular surface of dictyonal skeleton, × 20.

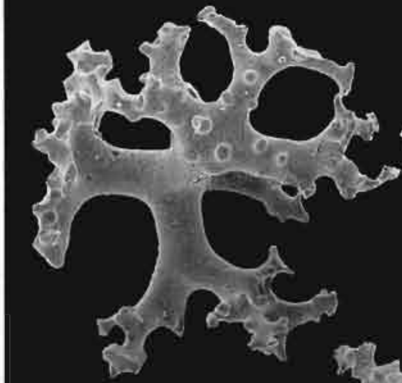
"Rhombedonium" cypelliaeforme SCHRAMMEN, 1937 60

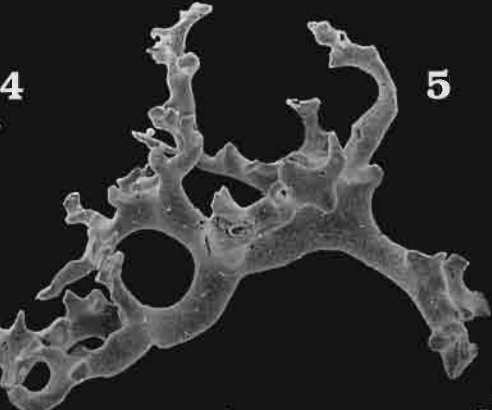
12. Holotype, SCHRAMMEN's collection (1937: pl. 4: 5, pl. 10: 11), Streitberg, Oxfordian (Alfa), IGPTU; × 45.

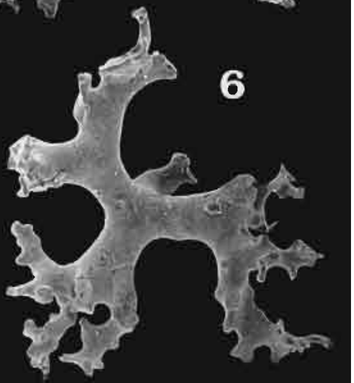

1

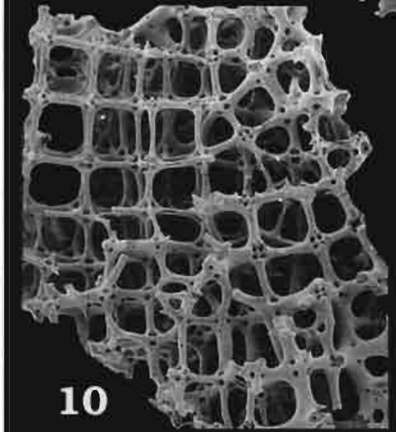

2

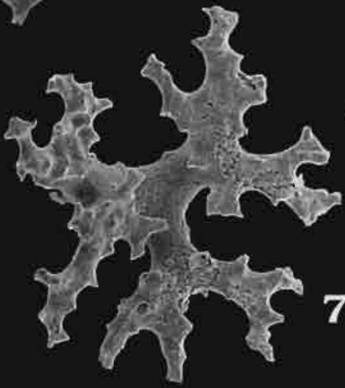

3

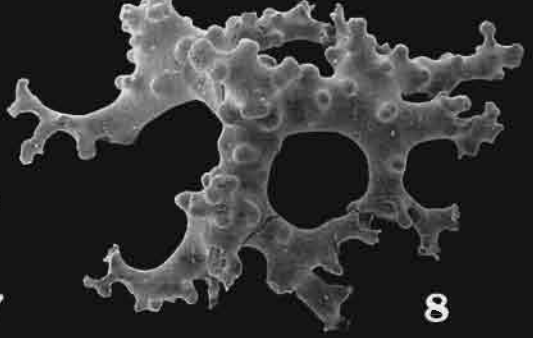

4

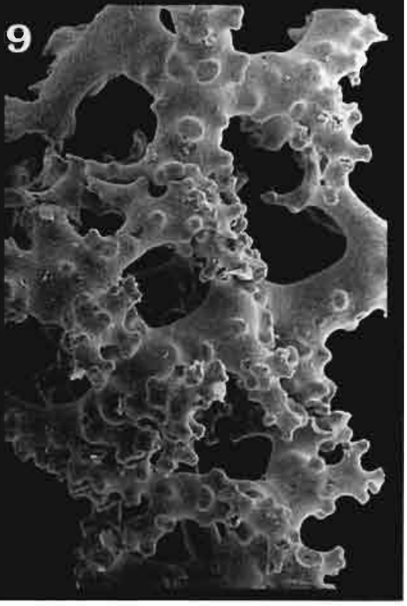

5

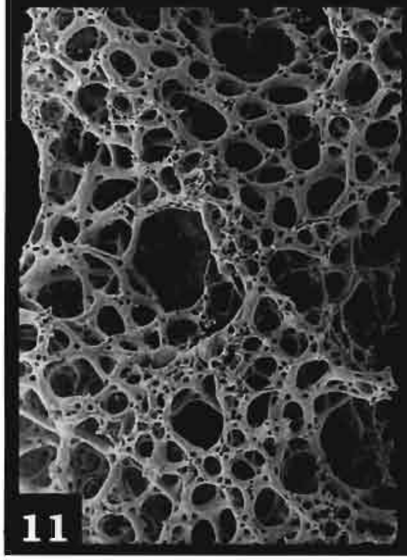

6


10


7


8


9


11

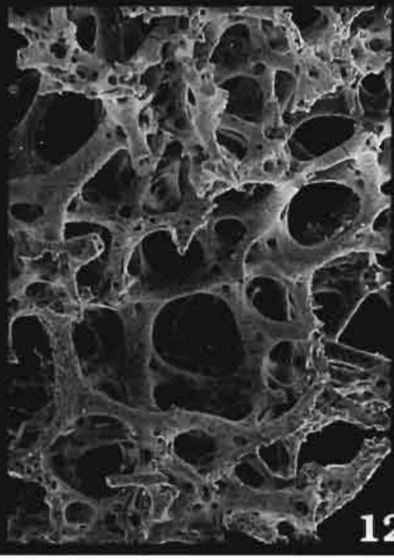

12

PLATE 44

Hyalotragos pezizoides (GOLDFUSS 1826) 87

1–9. Variously shaped rhizoclones, ZPAL Pf.VIII/316, Hochwang, Kimmeridgian marls (Delta); × 115.

Desmas 96

10–13. Strongly branched and ornamented ?rhizoloclones, Arnegg, Kimmeridgian limestones (Zeta); *10* × 120; *11–13* × 135.

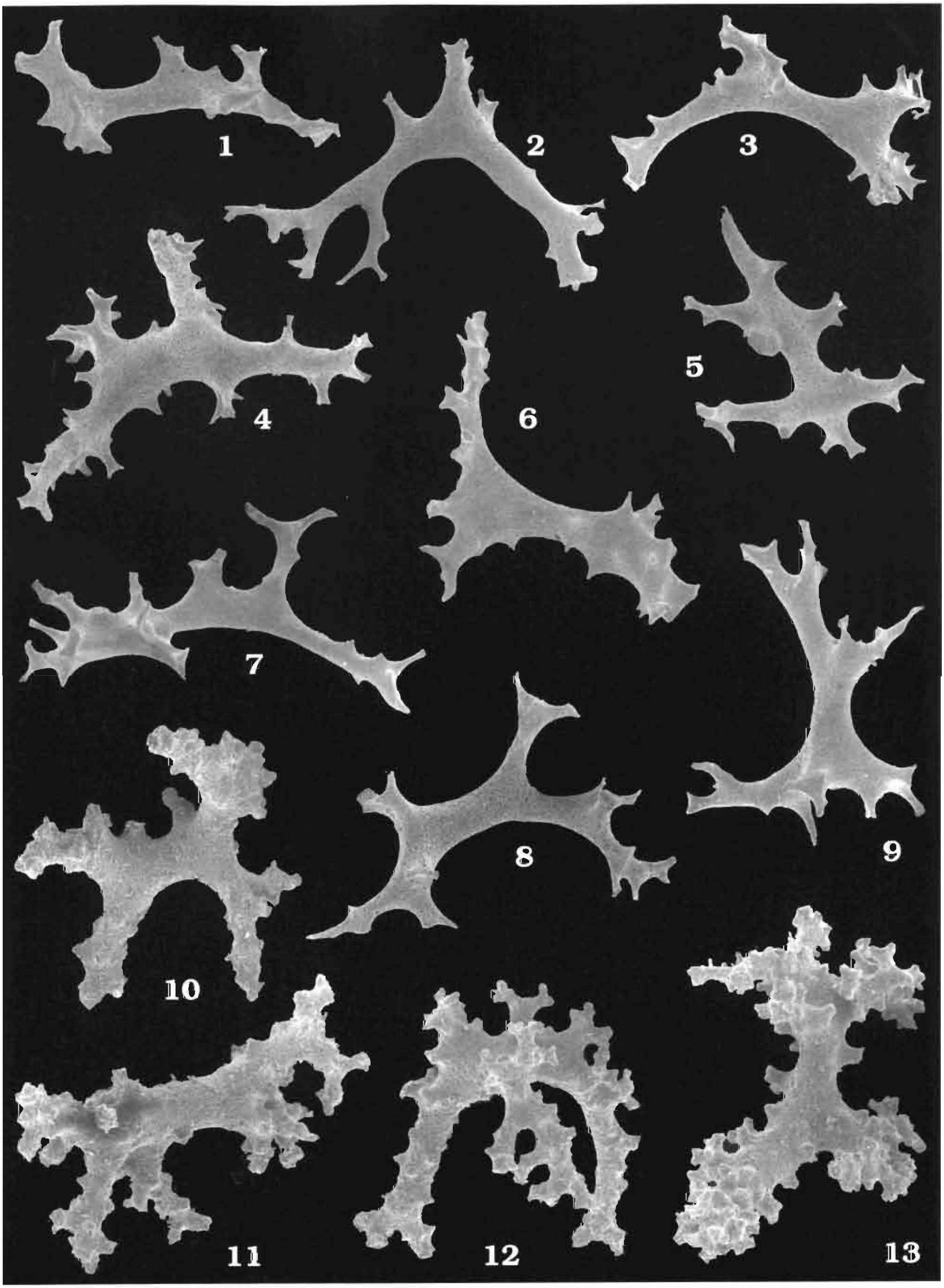

1
2
3
4
5
6
7
8
9
10
11
12
13

PLATE 45

Platychonia striata (SCHRAMMEN, 1937) 85

1–11. Variously shaped rhizoclones, specimen ZPAL Pf.VIII/319, Heuchstetten, Kimmeridgian limestones (Epsilon); *1–10* × 100; *11* articulated rhizoclones, × 93.

Lecanella pateraeformis ZITTEL, 1878 93

12–16. Variously shaped astroclones, specimen ZPAL Pf.VIII/322, Heuchstetten, Kimmeridgian limestones (Zeta); *12–15* × 88; *16* articulated spicules, × 67.

Dermal demosponge spicule 95

17. Discotriaen with incised margins, view from below, note very short pointed shaft, Gussenstadt, Kimmeridgian coral limestones (Zeta); × 80.

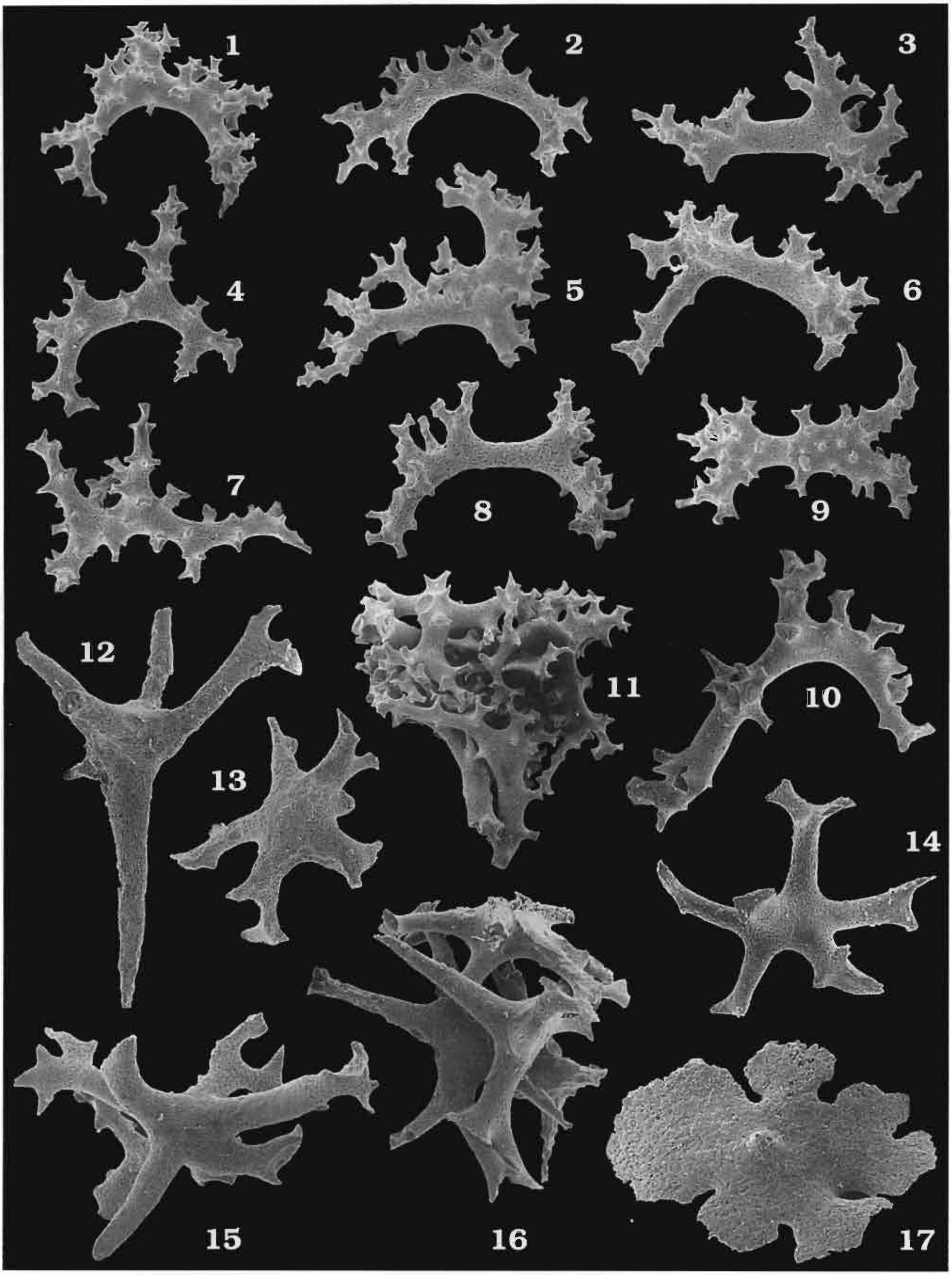
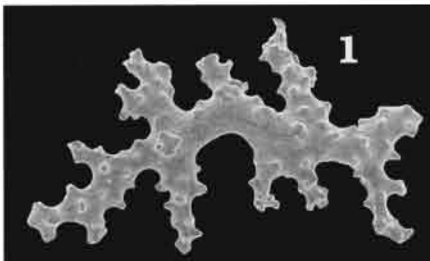

1
2
3
4
5
6
7
8
9
12
11
10
13
14
15
16
17

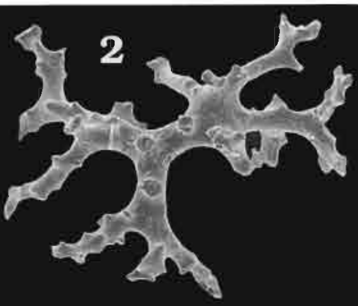
PLATE 46

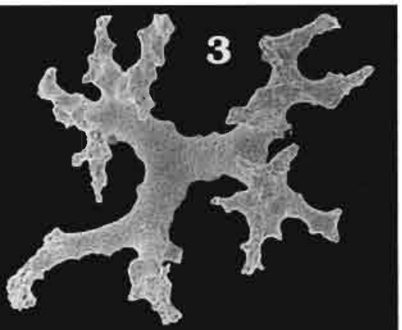
Dicranoclonella schmidti SCHRAMMEN, 1937 83

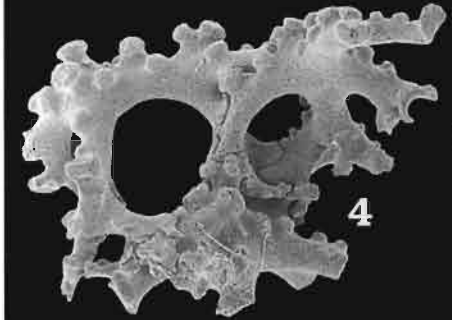
All from specimen ZPAL Pf.VIII/323, Heuchstetten, Kimmeridgian limestones (Epsilon).

1–3. Loose dicranoclone desmas resembling rhizoclones (in various orientation); × 120.
4. Three articulated typical dicranoclones from the subdermal region, side view; × 80.
5. Dicranoclone from deeper part of the skeleton, top view; × 80.
6. Top view of articulated skeleton from the subdermal portion; × 100.
7. Details of dicranoclones articulation, view from below; × 110.
8. Dichotriaenes in the dermal layer; × 87.
9. Specialized dermal dicranoclone; × 200.
10a. Dermal dichotriaenes (top centre), subdermal typical, massive, strongly tuberculated dicranoclones (bottom right) and specialized rhizoclone-like dicranoclones (top left); × 33.
10b. Detail of the previous fragment showing specialised subdermal dicranoclones resembling rhizoclones; × 66.
11. Dermal dichotriaenes felted with subdermal specialised rhizoclone-like dicranoclones; × 100.

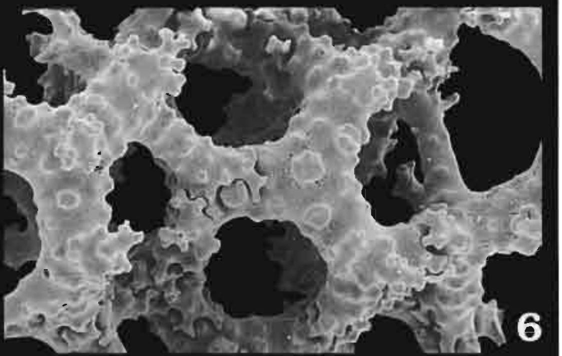

1

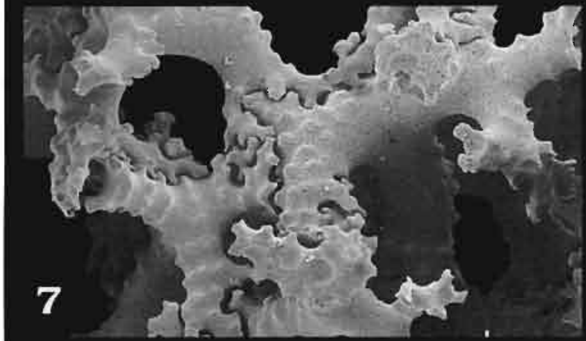

2

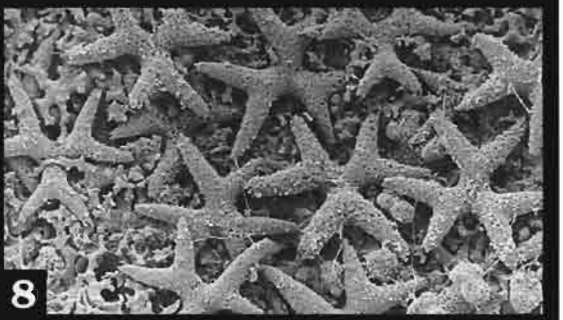

3

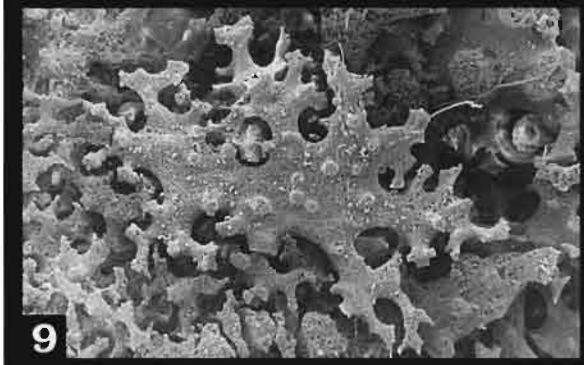

4

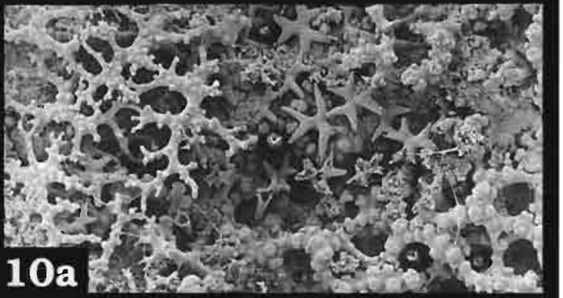

5

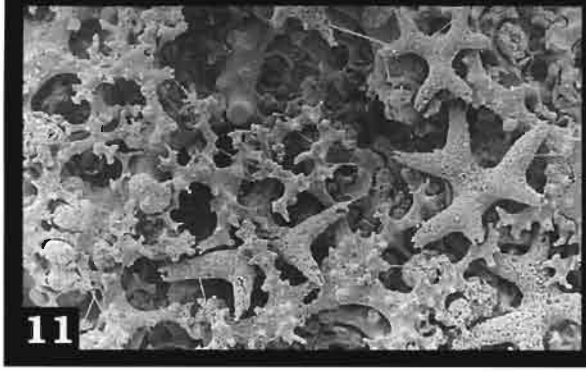

6


7


8


9


10a


11

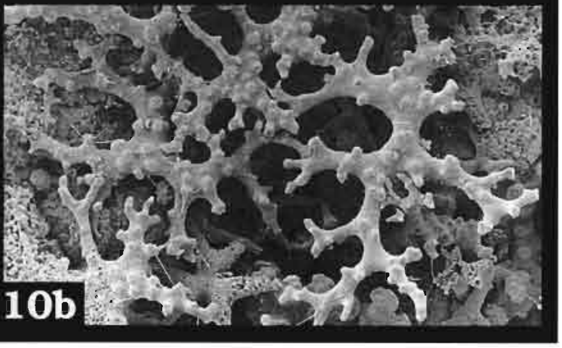

10b

PLATE 47

Polygonatium sphaeroides SCHRAMMEN, 1937 36

1. Choanosomal skeleton, SCHRAMMEN's collection, IGPTU; × 20.

Demosponge spicules 95

2. Anatetraene (pentactine), Gerstetten, Kimmeridgian coral limestones (Zeta); × 85.
3. Acanthocalthrop, Gerstetten, Kimmeridgian coral limestones (Zeta); × 200.
4. Criccalthrop, Gerstetten, Kimmeridgian coral limestones (Zeta); × 200.
5. Prodichotriaene, Heuchstetten, Kimmeridgian limestones (Epsilon); × 30.
6. Anadiaene, Gerstteten, Kimmeridgian coral limestones (Zeta); × 44.
9. Dicranoclone with four arms, Gussenstadt, Kimmeridgian coral limestones (Zeta); × 80.

10–12. Megaclones, Gussenstadt, Kimmeridgian coral limestones (Zeta); × 66.

Feifelia gigas SCHRAMMEN, 1937 37

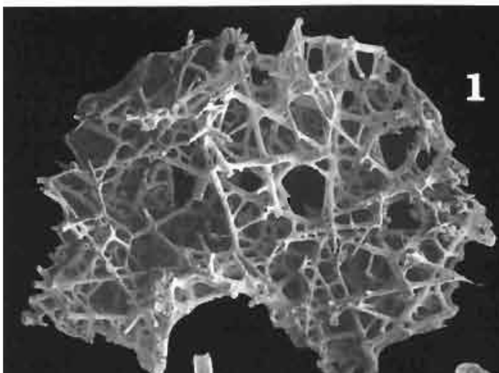
7. Choanosomal skeleton, SCHRAMMEN's collection, IGPTU; × 25.

Ramispongia ramosa QUENSTEDT, 1878 53

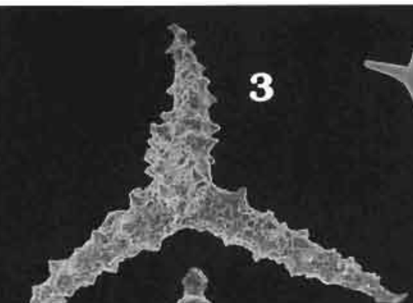
8. Choanosomal skeleton, SCHRAMMEN's collection, IGPTU; × 25.

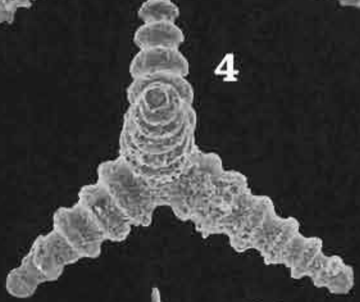
Pachycothon quenstedti (KOLB, 1910) 79

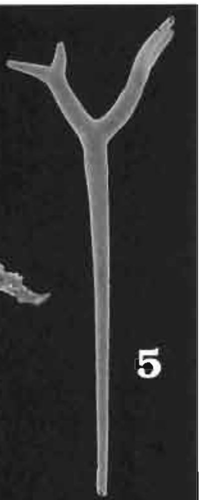
13. Specimen from SMNS collection; *a* general view showing skeleton composed of loosely felted heloclones and two dermal dichotriaenes, locality unknown, × 12; *b* close up of the Fig. 13a, two dermal dichotriaenes, × 53.

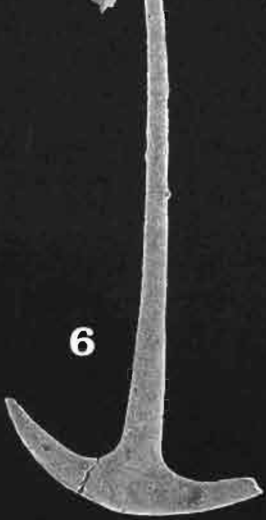

1

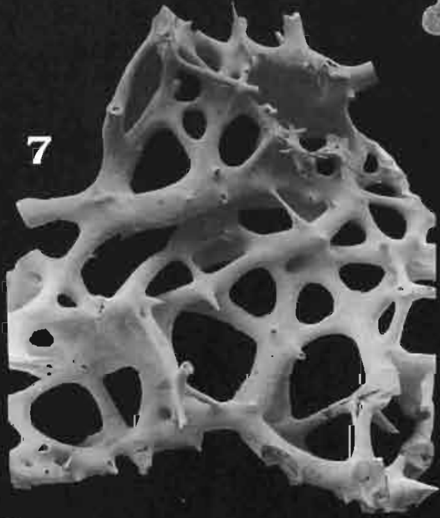

2

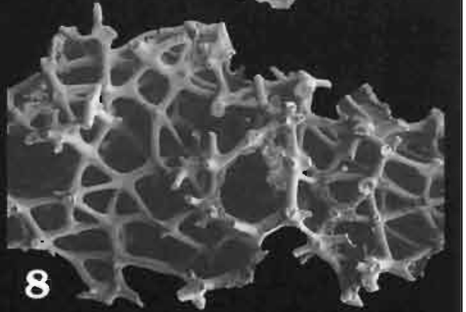

3

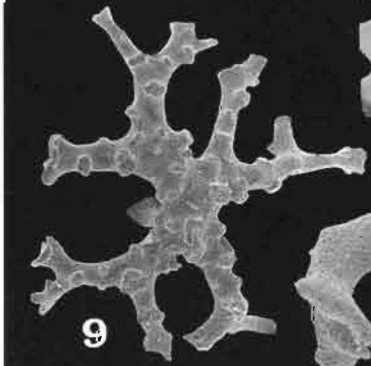

4

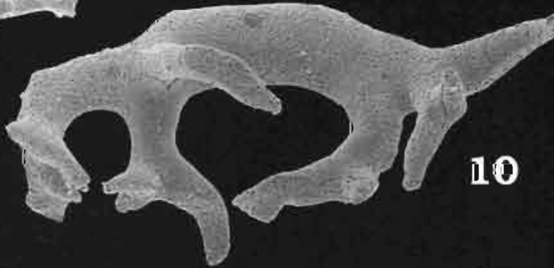

5

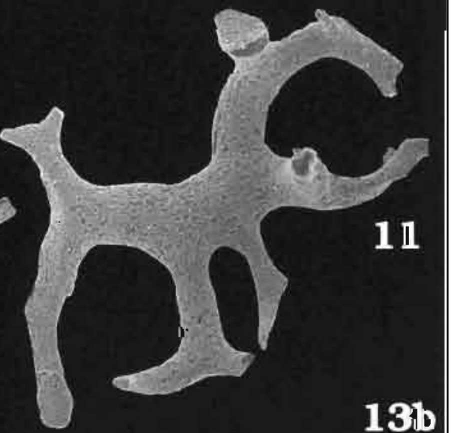

6


7

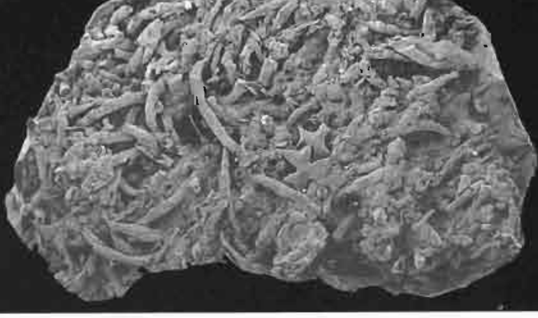

8


9


10


11


12


13a


13b

PLATE 48

Demosponge spicules 96

1–3. Tetractines (calthrops), Heuchstetten, Kimmeridgian limestones (Epsilon); *1* × 200; *2* × 87; *3* × 80.
4. Tetractine with one ray reduced to a knob, Gussenstadt, Kimmeridgian coral limestones (Zeta); × 60.
13. Massive tylostyle, Heuchstetten, Kimmeridgian limestones (Epsilon); × 121.

Cylindrophyma milleporata (GOLDFUSS, 1833) 90

5–12. Specimen ZPAL Pf.VIII/321, Gussenstadt, Kimmeridgian coral limestones (Zeta); *5* articulated spicules, × 80; *6, 7, 9, 10* isolated spicules resembling rhizoclones from the interior of the skeleton, displaying lack of developement or early stages of development of two globular centers characteristic of didymoclones; *6, 10* × 107; *7, 9* × 134; *8* two articulated spicules; one a typical didymoclone and one resembling a rhizoclone (in fact an early stage of didymoclone development), × 107; *11* strongly branched articulated didymoclone spicules, × 64; *12* typical tuberculated didymoclone spicule from the outer part of the skeleton; × 134.

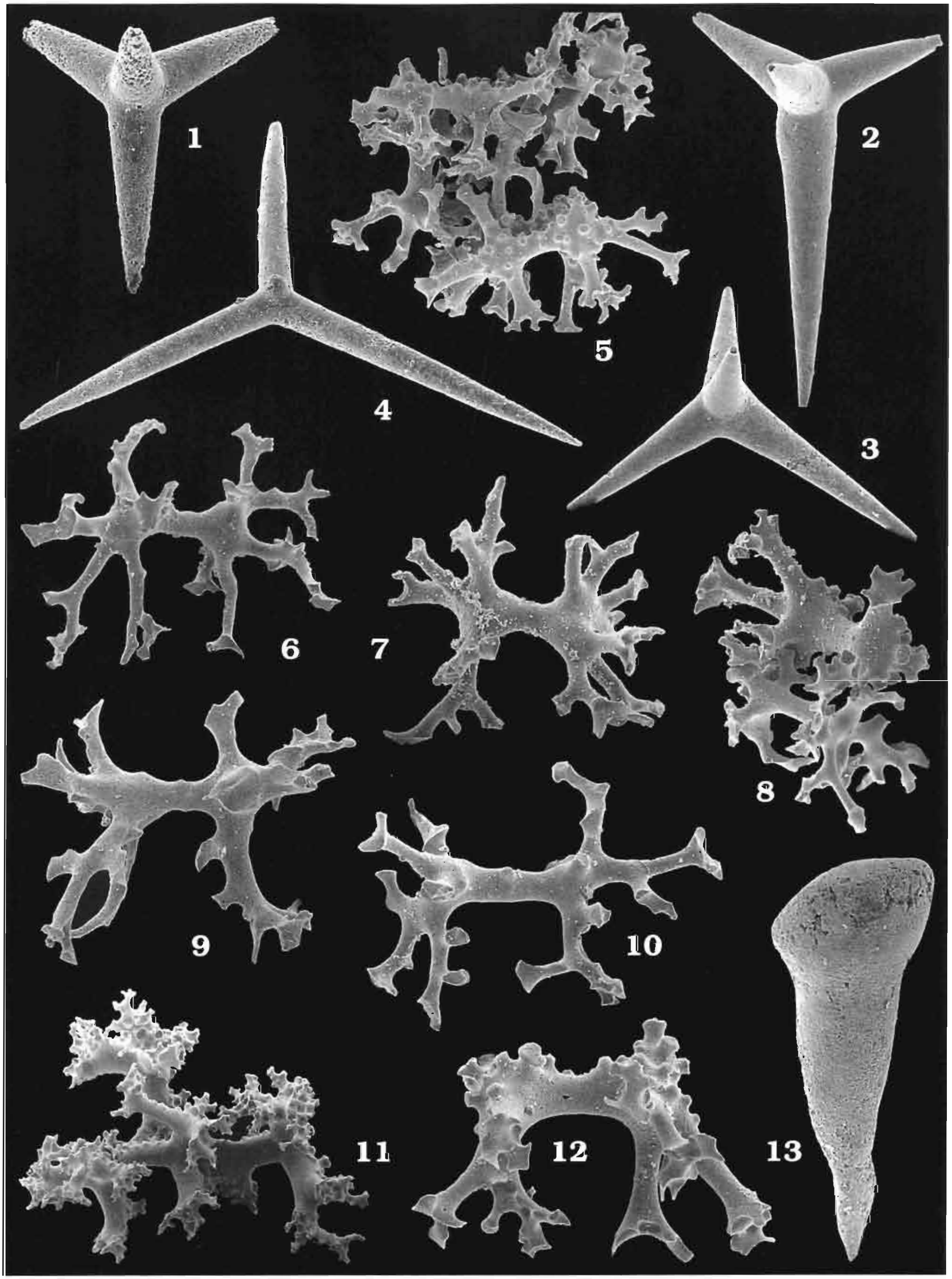

1
2
5
4
3
6
7
8
9
10
11
12
13

PLATE 49

Kalpinella cf. *pateraeformis* HINDE, 1883 81

1–10. Specimen ZPAL Pf.VIII/225, Heuchstetten, Kimmeridgian limestones (Epsilon); *1–9* tetraclone desmas; *1–5* × 80; *6* × 77; *8* × 80; *7* × 107; *9* × 153; *10* dermal dichotriaene, × 100.

Demosponge spicules 97

11. Kyphorabd (most probably from *Helminthophyllum*), Heuchstetten, Kimmeridgian limestones (Epsilon), × 80.

12–14. Heloclones (most probably *Pachycothon*); *12* Gussenstadt, Kimmeridgian coral limestones (Zeta), × 66; *13* Gussenstadt, Kimmeridgian coral limestones (Zeta), × 43; *14* Gerstetten, Kimmeridgian coral limestones (Zeta), × 60.

15–16. Two desmas resembling kyphorhabds but sculptured with short spines rather than rings; *15* Gerstetten, Kimmeridgian limestones (Zeta), × 140; *16* Gussenstadt, Kimmeridgian limestones (Zeta), × 80.

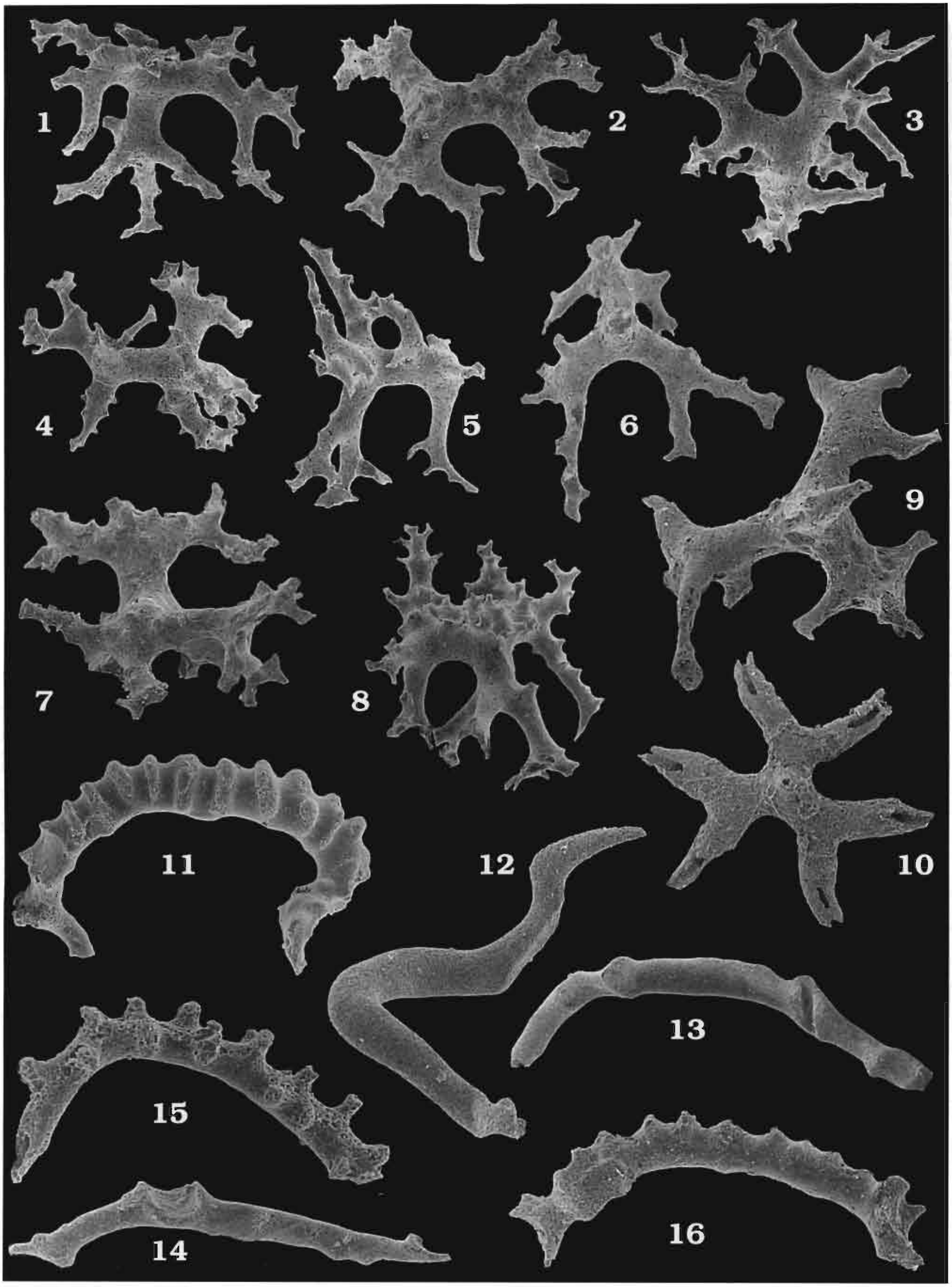

1
2
3
4
5
6
9
7
8
11
12
10
13
15
14
16

PLATE 50

Demosponge spicules 95

1, 3, 5, 7. Prodichotriaenes; *1* Heuchstetten, Kimmeridgian limestones (Epsilon), × 33; *3* Heuchstetten, Kimmeridgian limestones (Epsilon), × 57; *5* Gerstetten, Kimmeridgian coral limestones (Zeta), × 50; *7* Gerstetten, Kimmeridgian coral limestones (Zeta), × 66.

2. Long-shafted orthodichotriaene, Gussenstadt, Kimmeridgian coral limestones (Zeta); × 34.

4. Long shafted massive prodichotriaene, Gerstetten, Kimmeridgian coral limestones (Zeta); × 73.

6. Dichotriaene with very short shaft and slender straight clads (seen from below), Gerstetten, Kimmeridgian coral limestones (Zeta); × 80.

8. Massive dichotriaene with short clads and long shaft, side view, Gerstteten, Kimmeridgian coral limestones (Zeta); × 100.

9. Massive promesotriaene, Heuchstetten, Kimmeridgian limestones (Epsilon); × 80.

10. Massive prodichotriaene with short clads and shaft, Heuchstetten, Kimmeridgian limestones (Epsilon); × 107.

11. Massive dichotriaene with a very short conical schaft, seen from below, Heuchstetten, Kimmeridgian limestones (Epsilon); × 178.

17. Sphaeroclone, Heuchstetten, Kimmeridgian limestones (Epsilon); × 200.

18. Rhizoclone?, Gerstetten, Kimmeridgian coral limestones (Zeta); × 90.

12–16. Rhizoclones of a sponge infesting *Dicranoclonella schmidti* SCHRAMMEN, ZPAL Pf.VIII/323, Heuchstetten, Kimmeridgian limestones (Epsilon); × 100.

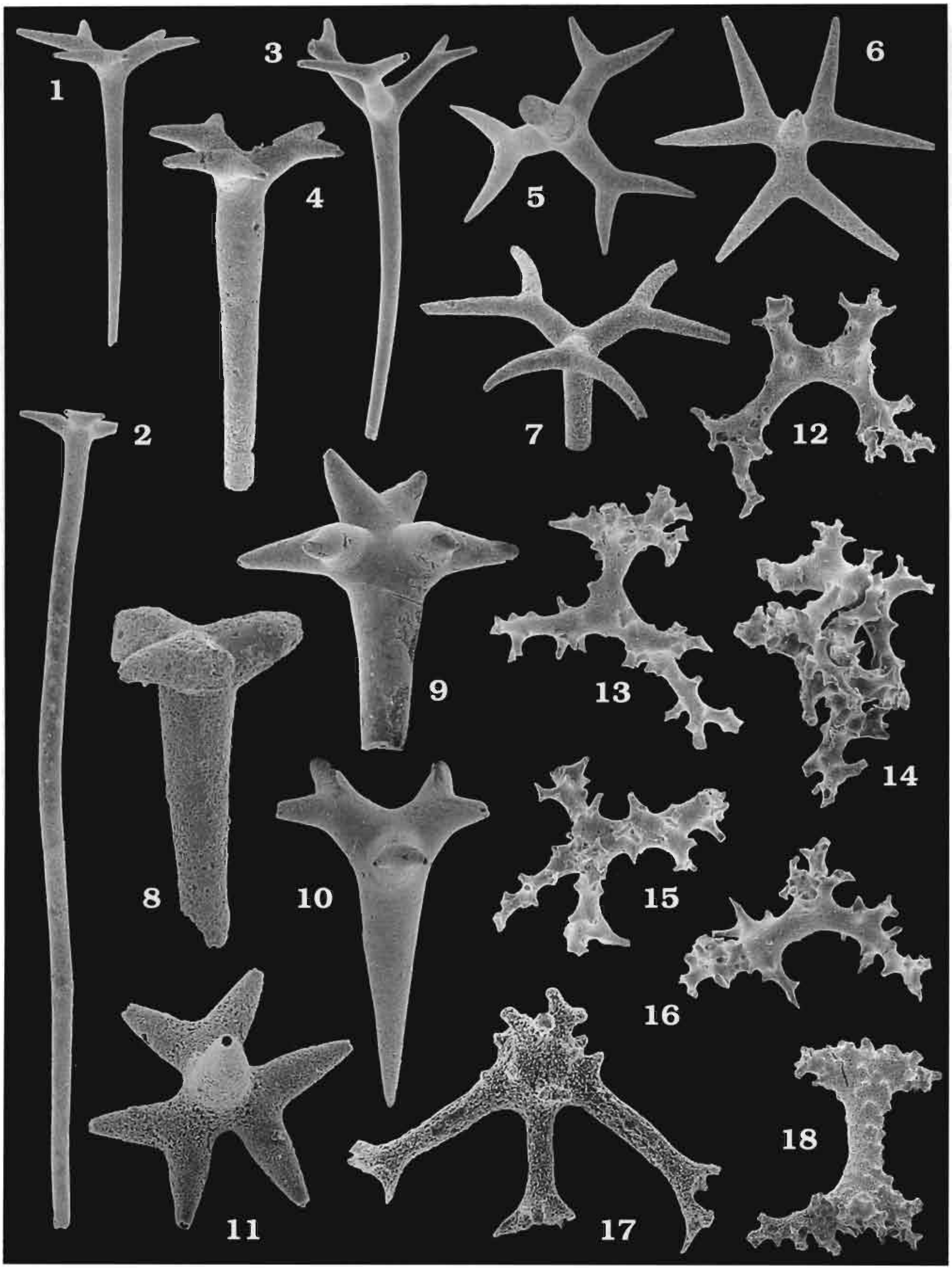

1
3
6
4
5
7
12
2
9
13
14
8
10
15
16
18
11
17

PLATE 51

1–2. Sinous oxeas, *1* Gussenstadt, Kimmeridgian coral limestones (Zeta), × 40; *2* Heuchstetten, Kimmeridgian limestones (Epsilon), × 27.

3–8. Oxeas; *3* Gussenstadt, Kimmeridgian coral limestones (Zeta), × 28; *4* Gerstetten, Kimmeridgian coral limestones (Zeta), × 27; *5* Gussenstadt, Kimmeridgian coral limestones (Zeta), × 67; *6* Heuchstetten, Kimmeridgian limestones (Epsilon), × 80; *7* Heuchstetten, Kimmeridgian limestones (Epsilon), × 100; *8* Heuchstetten, × 27.

9. Exotylostyle, Gussenstadt, Kimmeridgian coral limestones (Zeta); × 33.

10–11. Prodichostylotriaene (trachelotrieane), Heuchstetten, Kimmeridgian limestones (Epsilon); *10* × 63; *11* × 60.

12–14. Tylostyles, Gerstetten, Kimmeridgian coral limestones (Zeta); *12* × 80; *13* × 66; *14* × 74.

15. Megastyle, Gerstetten, Kimmeridgian coral limestones (Zeta), × 27.

16. Massive orthotriaene, Gussenstadt, Kimmeridgian coral limestones (Zeta); × 26.

17–18, 25–26. Trachelotriaenes; *17* Heuchstetten, Kimmeridgian limestones (Epsilon); × 39; *18* Heuchstetten, Kimmeridgian limestones (Epsilon); × 40; *25* Gerstetten, Kimmeridgian coral limestones (Zeta); × 60; *26* Gussenstadt, Kimmeridgian coral limestones (Zeta); × 52.

19–20. Cricostyles, Heuchstetten, Kimmeridgian limestones (Epsilon); *19* × 33; *20* × 30.

21–24. Tylostyles; *21* Heuchstetten, Kimmeridgian limestones (Epsilon); × 27; *22* Gussenstadt, Kimmeridgian coral limestones (Zeta); × 33; *23* Heuchstetten, Kimmeridgian limestones (Epsilon); × 40; *24* Gerstetten, Kimmeridgian coral limestones (Zeta); × 60.

27. Tylostyle, Gerstetten, Kimmeridgian coral limestones (Zeta); × 47.

28–29. Procriccotriaenes; *28* Gussenstadt, Kimmeridgian coral limestones (Zeta); × 66; *29* Heuchstetten, Kimmeridgian coral limestones (Epsilon); × 62.

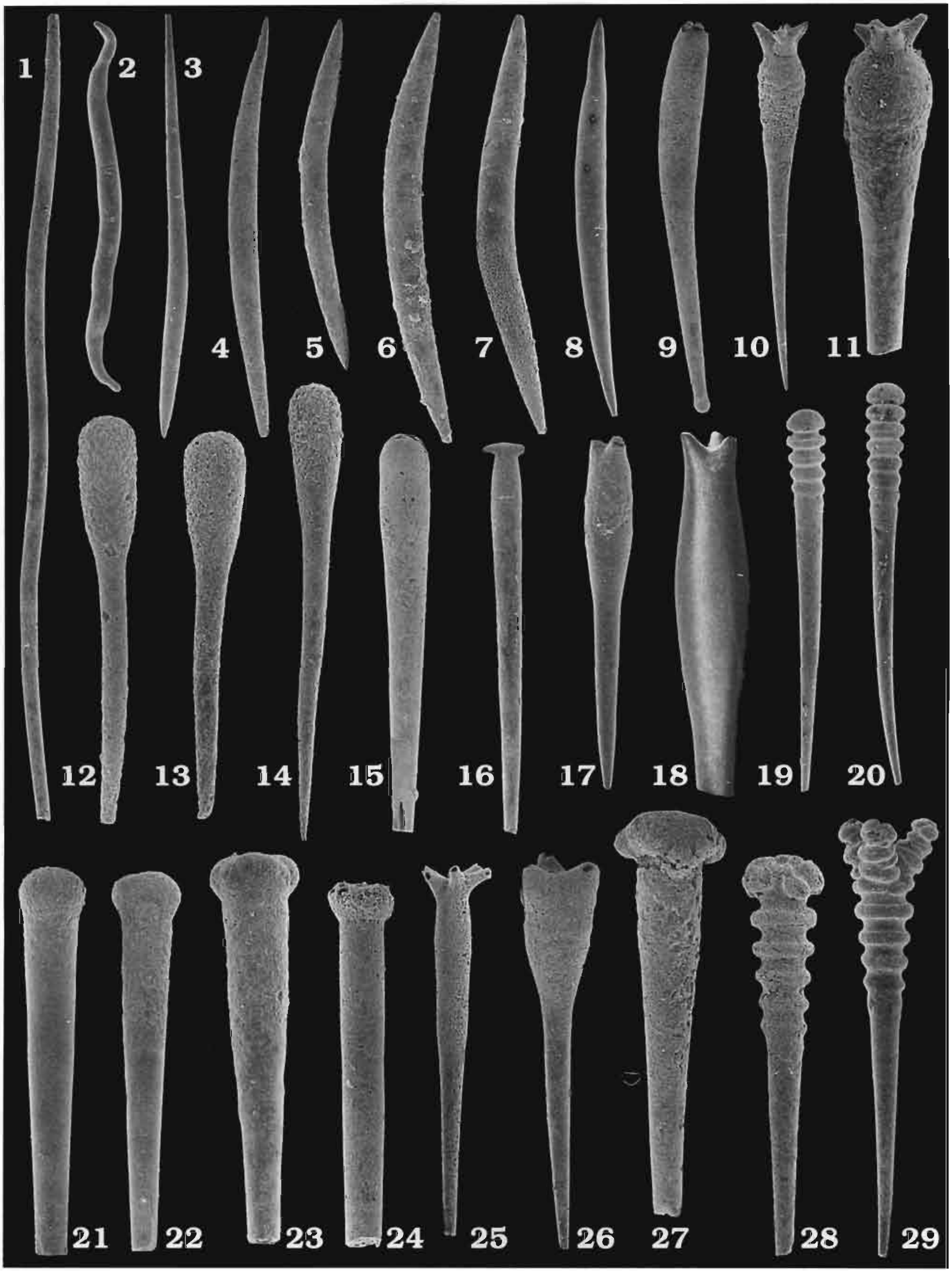

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

PLATE 52

Demosponge dermalia 95

1–3, 7. Dermal phyllotriaenes, *1–2* view from above, Gerstetten, Kimmeridgian coral limestones (Zeta), × 85; *3* view from below, Gerstetten, Kimmeridgian coral limestones (Zeta), × 53; *7* view from below, Gerstetten, Kimmeridgian coral limestones (Zeta), × 66.

4–5. Dermal phyllotriaenes whose clads were articulated, Gerstetten, Kimmeridgian coral limestones (Zeta); *4* × 73; *5* × 80.

6, 8–10, 15–16. Dermal phyllotriaenes; *6* Hechstetten, Kimmeridgian limestones (Epsilon), × 73; *8* Gerstetten, Kimmeridgian coral limestones (Zeta), × 100; *9* Gerstetten, Kimmeridgian coral limestones (Zeta), × 134; *10* Gerstetten, Kimmeridgian coral limestones (Zeta), × 80; *15* Heuchstetten, Kimmeridgian limestones (Epsilon), × 113; *16* Heuchstetten, Kimmeridgian limestones (Epsilon), × 100.

11, 13–14. Dermal discotriaenes with incised margins, Kimmeridgian coral limestones (Zeta); *11* × 134; *13* × 115; *14* × 127.

12. Dermal discotriaene, Heuchstetten, Kimmeridgian limestones (Epsilon); × 100.

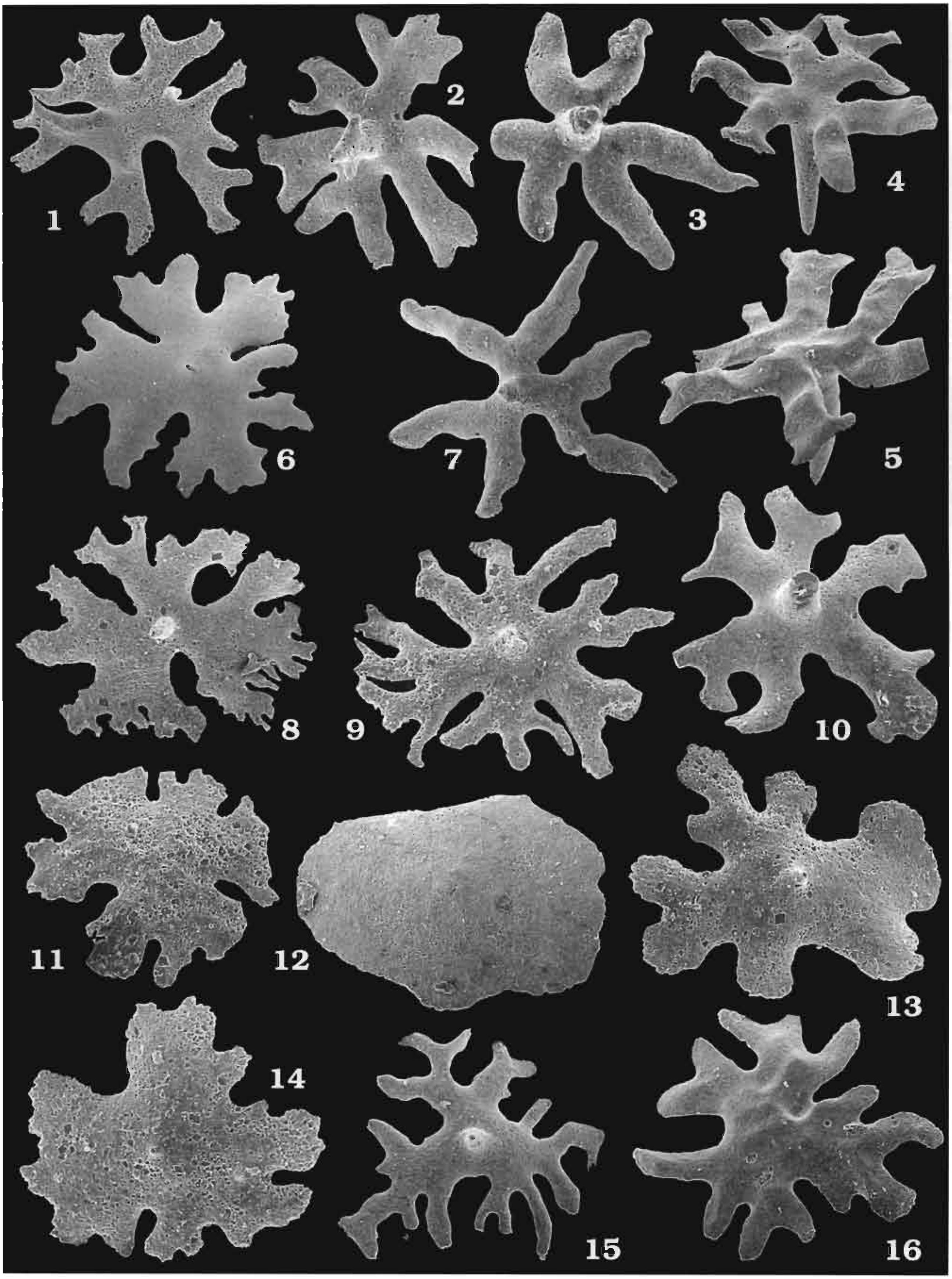

1
2
3
4
6
7
5
8
9
10
11
12
13
14
15
16

PLATE 53

Demosponge spicules 94

1\. Amphistyl, Heuchstetten, Kimmeridgian limestones (Epsilon); × 174.

2–3, 6–7. Amphistrongyle, Gerstetten Kimmeridgian coral limestones (Zeta); *2* × 268; *3* × 333; *6* × 200; *7* × 134.

4–5. Microxeas; *4* Gerstetten, Kimmeridgian coral limestones (Zeta), × 200; *5* Heuchstetten, limestones of the Kimmeridgian (Epsilon), × 148.

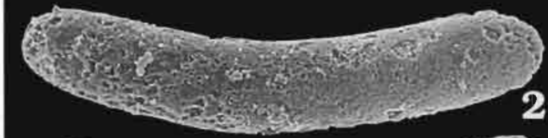
8–12. Criccorhabds; *8* Gerstetten, Kimmeridgian coral limestones (Zeta), × 266; *9* Heuchstetten, Kimmeridgian limestones (Epsilon), × 242; *10* Gerstetten, Kimmeridgian coral limestones (Zeta), × 233; *11–12* Gerstetten, Kimmeridgian coral limestones (Zeta), × 265.

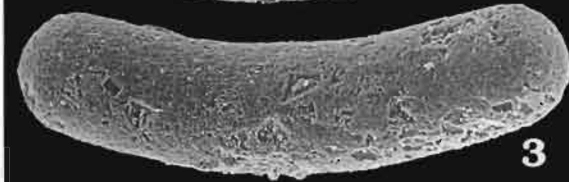
13–14. Oxyasters with various numbers of rays, Heuchstetten, Kimmeridgian limestones (Epsilon); *13* × 200; *14* × 253.

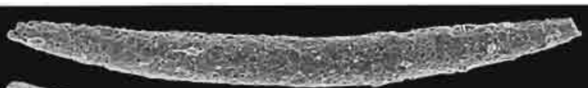
15–17. Variously developed oxyspherasters; *15* Gerstetten, Kimmeridgian coral limestones (Zeta), × 266; *16* Gerstetten, Kimmeridgian coral limestones (Zeta), × 300; *17* Heuchstetten, Kimmeridgian limestones (Epsilon), × 335.

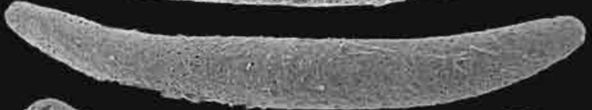
18–20. Selenasters; *18* Heuchstetten, Kimmeridgian limestones (Epsilon), × 300; *19* Gerstetten, Kimmeridgian coral limestones (Zeta), × 268; *20* Heuchstetten, Kimmeridgian limestones (Epsilon), × 468.

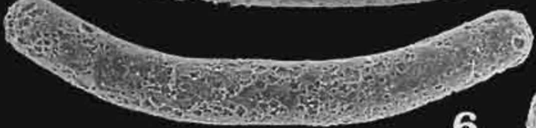

1

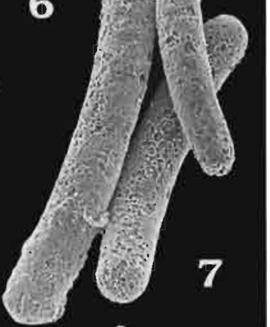

2


3

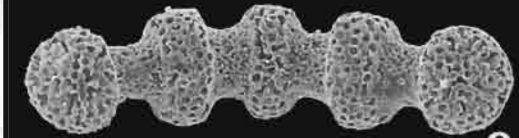

4

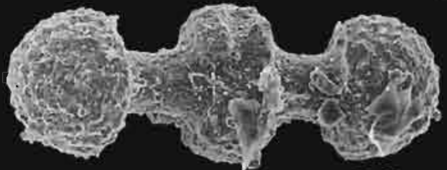

5

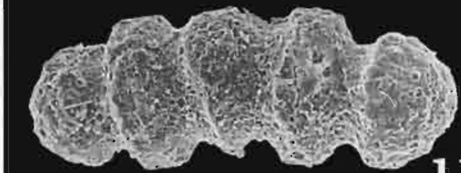

6

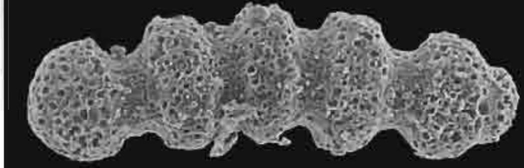

7

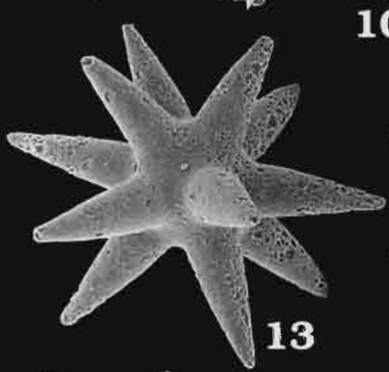

8

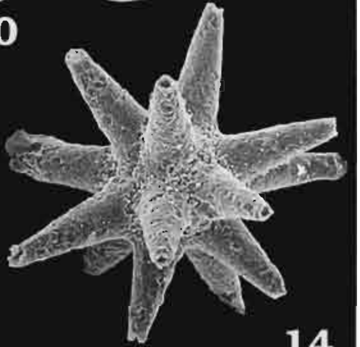

9

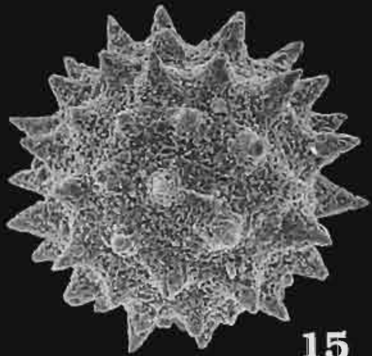

10

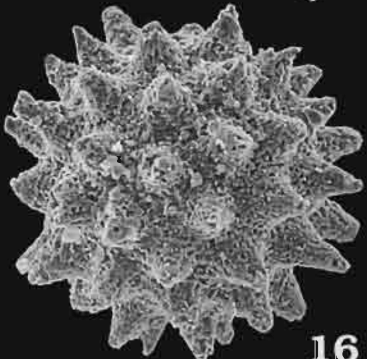

11

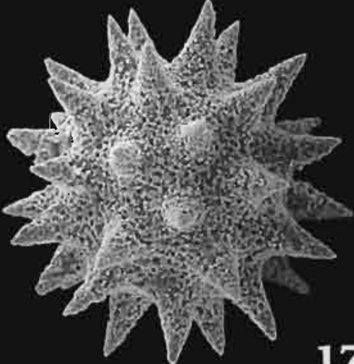

12

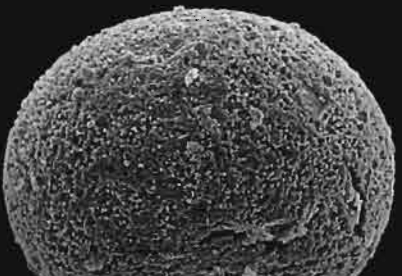

13

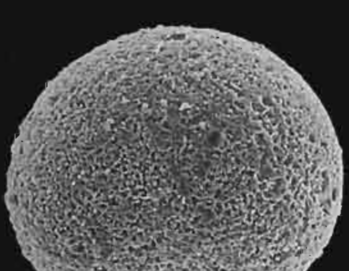

14


15


16


17


18


19

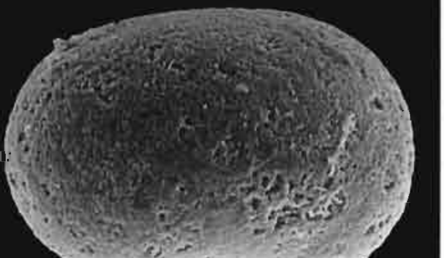
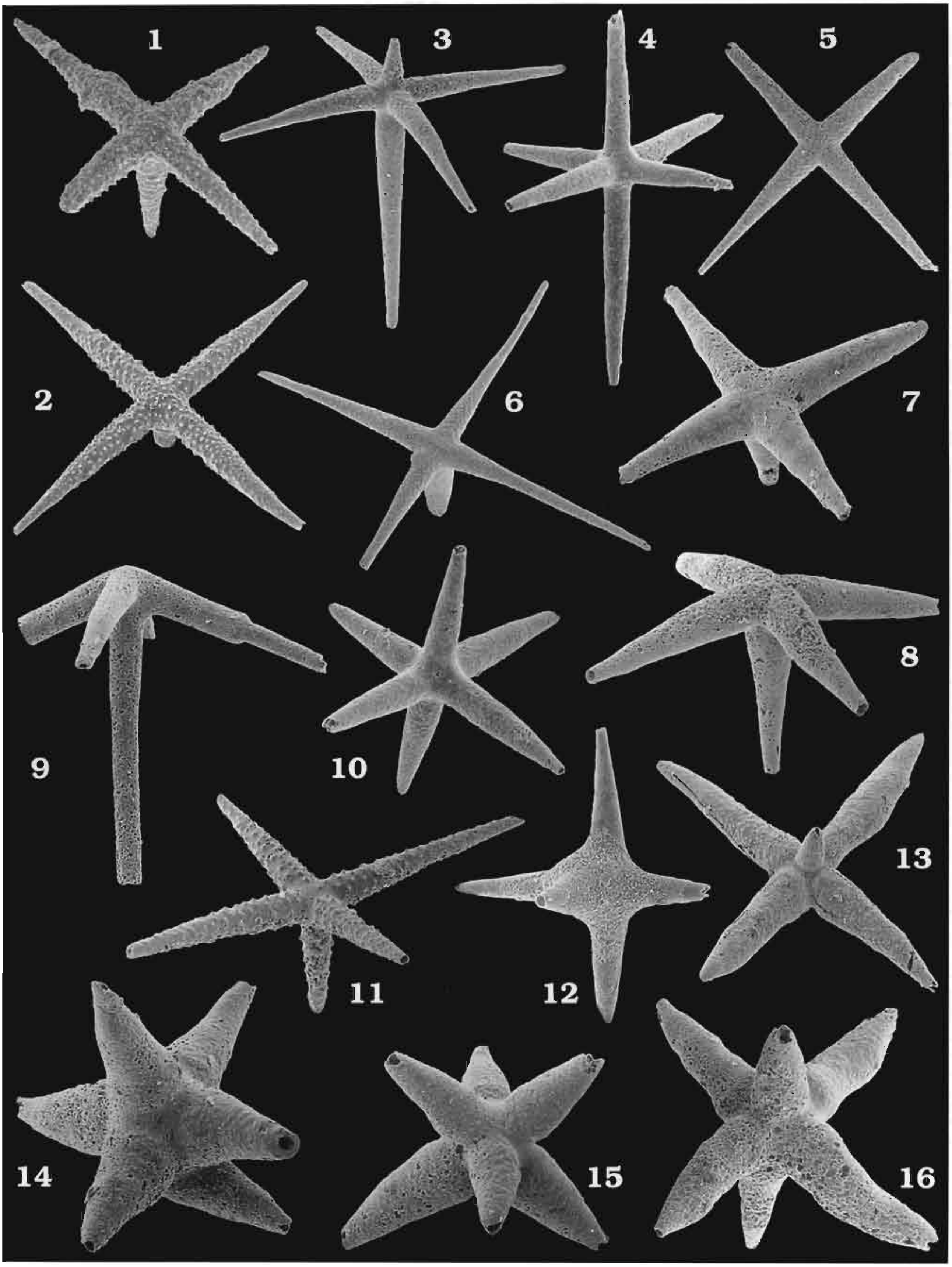

20

PLATE 54

1–2, 6, 11. Dermal acanthopentactines; *1* Heuchstetten, Kimmeridgian limestones (Epsilon), × 80; *2* Gerstetten, Kimmeridgian coral limestones (Zeta), × 134; *6* Heuchstetten, Kimmeridgian limestones (Epsilon), × 32; *11* Gerstetten, Kimmeridgian coral limestones (Zeta), × 73.
3. Dermal hexactine with very short outer ray, Heuchstetten, Kimmeridgian limestones (Epsilon), × 80.
4, 10. Loose hexactines, Gerstetten, Kimmeridgian coral limestones (Zeta); *4* × 93; *10* × 87.
5. Dermal? stauractine, Gerstetten, Kimmeridgian coral limestones (Zeta); × 40.
7–9. Masssive dermal pentactines; Gerstetten, Kimmeridgian coral limestones (Zeta); *7* × 66; *8* × 73; *9* × 126.
12. Pentactine, Heuchstetten, Kimmeridgian limestones (Epsilon); × 120.
13–16. Massive hexactines, Gerstetten, Kimmeridgian coral limestones (Zeta); *13* × 47; *14–15* × 80; *16* × 66.


1
3
4
5
2
6
7
9
10
8
11
12
13
14
15
16

INDEX OF GENERIC AND SPECIFIC NAMES

No. 32, 1975 — Wacław Bałuk. Lower Tortonian Gastropods from Korytnica, Poland. Part I. 186 pp., 5 text-figs, 21 plates.
No. 33, 1975 — Zofia Kielan-Jaworowska. (Editor). Results of the Polish-Mongolian Paleontological Expeditions. Part VI. 200 pp., 44 text-figs, 44 plates.
No. 34, 1976 — Aurelia Barbulescu. Considérations Stratigraphiques Concernant les Formations Coralligène Néojurassiques de la Dobrogea Centrale (Roumanie). 1–15 pp., 3 text-figs.
Ewa Roniewicz. Les Scleractiniaires du Jurassique Supérieur de la Dobrogea Centrale, Roumanie. 17–121 pp., 9 text-figs, 34 plates.
No. 35, 1976 — Aleksander Nowiński. Tabulata and Chaetetida from the Devonian and Carboniferous of Southern Poland. 125 pp., 21 text-figs, 27 plates.
No. 36, 1977 — Marian Książkiewicz. Trace Fossils in the Flysch of the Polish Carpathians. 208 pp., 45 text-figs, 29 plates.
No. 37, 1977 — Zofia Kielan-Jaworowska. (Editor). Results of the Polish-Mongolian Paleontological Expeditions. Part VII. 165 pp., 38 text-figs, 37 plates.
No. 38, 1979 — Zofia Kielan-Jaworowska. (Editor). Results of the Polish-Mongolian Paleontological Expeditions. Part VIII. 121 pp., 30 text-figs, 37 plates.
No. 39, 1979 — Andrzej Baliński. Brachiopods and Conodonts from the Frasnian of the Dębnik Anticline, Southern Poland. 1–95 pp., 23 text-figs, 23 plates.
Cyprian Kulicki. Ammonite Shell: Its Structure, Development and Biological Significance, 97–142 pp., 10 text-figs, 25 plates.
No. 40, 1979 — Maria Różkowska. Contribution to the Frasnian Tetracorals from Poland. 1–56 pp., 13 text-figs, 10 plates.
Ewa Olempska. Middle to Upper Devonian Ostracoda from the Southern Holy Cross Mountains, Poland. 57–162 pp., 5 text-figs, 22 plates.
No. 41, 1980 — Danuta Peryt. Planktic Foraminifera Zonation of the Upper Cretaceous in the Middle Vistula River Valley, Poland. 3–101 pp., 2 text-figs, 23 plates.
Ryszard Wrona. Upper Silurian–Lower Devonian Chitinozoa from the Subsurface of Southeastern Poland. 103–165 pp., 11 text-figs, 14 plates.
No. 42, 1981 — Zofia Kielan-Jaworowska. (Editor). Results of the Polish-Mongolian Paleontological Expeditions. Part IX. 182 pp., 37 text-figs, 45 plates.
No. 43, 1982 — Gertruda Biernat and Wanda Szymańska (Editor). Palaeontological Spitsbergen Studies — Part. I. 140 pp., 24 text-figs, 46 plates.
No. 44, 1983 — Barbara Zbikowska. Middle to Upper Devonian Ostracods from North Western Poland and the Stratigraphic Significance. 3–108 pp., 7 text-figs, 26 plates.
Andrzej Gaździcki. Foraminifers and Biostratigraphy of Upper Triassic and Lower Jurassic of the Slovakian and Polish Carpathians. 109–169 pp., 21 text-figs, 15 plates.
No. 45, 1984 — Jerzy Dzik. Phylogeny of the Nautiloidea. 203 pp., 72 text-figs, 47 plates.
No. 46, 1984 — Zofia Kielan-Jaworowska (Editor). Results of the Polish-Mongolian Palaeontological Expeditions. Part X. 183 pp., 41 text-figs, 31 plates.
No. 47, 1986 — Barbara Studencka. Bivalves from the Badenian (Middle Miocene) Marine Sandy Facies of Southern Poland. 3–128 pp., 7 text-figs, 18 plates.
Piotr Mierzejewski. Ultrastructure, Taxonomy and Affinities of Some Ordovician and Silurian Organic Microfossils. 129–220 pp., 23 text-figs, 19 plates.
No. 48, 1987 — Jerzy Fedorowski. Upper Palaeozoic Rugose Corals from Southwestern Texas and Adjacent Areas; Gaptank Formation and Wolfcampian Corals, Part I. 271 pp., 87 text-figs, 43 plates.
No. 49, 1987 — Andrzej Gaździcki (Editor). Palaeontological Results of the Polish Antarctic Expeditions. Part I. 168 pp., 53 text-figs, 44 plates.
No. 50, 1990 — Ryszard Marcinowski and Jost Wiedmann. The Albian Ammonites of Poland. 94 pp., 27 text-figs, 25 plates.
No. 51, 1991 — Aleksander Nowiński. Late Carboniferous to Early Permian Tabulata from Spitsbergen. 74 pp., 23 text-figs, 4 tables, 23 plates.
No. 52, 1992 — Eugenia Gawor-Biedowa. Campanian and Maastrichtian Foraminifera from the Lublin Upland, Eastern Poland. 187 pp., 4 text-figs, 3 tables, 39 plates.
No. 53, 1994 — Jerzy Dzik, Ewa Olempska and Andrzej Pisera. Ordovician Carbonate Platform Ecosystem of the Holy Cross Mountains, Poland. 307 pp., 104 text-figs, 67 plates.
No. 54, 1995 — Andrzej Baliński. Brachiopods and Conodont Biostratygraphy of the Famennian from the Dębnik Anticline, Sothern Poland. 88 pp., 24 text-figs, 22 plates.
No. 55, 1996 — Andrzej Gaździcki (Editor). Palaeontological Results of the Polish Antarctic Expeditions. Part II. 192 pp., 60 text-figs, 45 plates.
No. 56, 1997 — Adam Urbanek and Lech Teller (Editors). Silurian Graptolite Faunas in the East European Platform: Stratigraphy and Evolution. 272 pp., 88 text-figs, 34 plates.

PALAEONTOLOGIA POLONICA is indexed in *Polish Scientific Journals Contents – Agric. & Biol. Sci.* available in Internet under URL (Uniform Resource Locator) address: http://www.paleo.pan.pl/pp/pp.htm; http://saturn.ci.uw.edu.pl/psjc/ or http://ciuw.warman.org.pl/alf/psjc/.

All inquiries regarding delivery terms of
"Palaeontologia Polonica" should be directed to:

Instytut Paleobiologii PAN
00-818 Warszawa, ul. Twarda 51/55, Poland
or
Foreign Trade Enterprise "Ars Polona"
00-068 Warszawa, ul. Krakowskie Przedmieście 7, Poland

ISBN 83-01-04754-2
ISSN 0078-8562