

UDK 563.4:551.736(593)=20

Sponge assemblage of some Upper Permian reef limestones from Phrae province (Northern Thailand)

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Abstract

The sponge fauna of uppermost Permian reef or reefal limestones of the Phrae province in northern Thailand include representatives of hexactinellida, sclerospongia, "sphinctozoans", and "inozoans". The "sphinctozoans" and "inozoans" are described in detail. Following taxa are new:

"Sphinctozoans": *Phraethalamia tubulara* n. gen., n. sp., *Ambithalamia permica* n. gen., n. sp.

"Inozoans": *Bisiphonella tubulara* n. sp., *Solutossaspongia crassimuralis* n. gen., n. sp.

The genus name *Belyaevaspongia* nom. nov. is proposed for *Polysiphonella* Belyaeva, 1991 (in Boiko et al., 1991), non *Polysiphonella* Russo, 1981.

Geological setting

During recent mapping in Phrae province (northern Thailand, text-fig. 1) an outcrop of Upper Permian (Dorashamian) rocks, rich in sponges, was discovered. This outcrop is situated in a small creek, located approximately 650 m north of kilometer 17.5 on the highway from Phrae to Amphoe Long (text-fig. 2). According to Mickein (1922, unpublished) the creek follows a small syncline which trends NE-SW and that is disturbed by some minor NE-SW trending faults. The trough of the syncline is held up by a series of alternating fossiliferous limestones, shales, sandstones and volcanic rocks (text-fig. 3). Such alternating sequences are typical of the uppermost Permian in this part of Thailand (Chonglakmani, pers. comm. 1991).

The locality described here is located west of the "Nan-Uttaradit" suture, in that part of northern Thailand in which Triassic strata of the "Lampang Group" are widely distributed.

This interpretation does not fully explain the geological relationships of northern Thailand. The Early and Middle Permian of the region between Mae Hong Son and

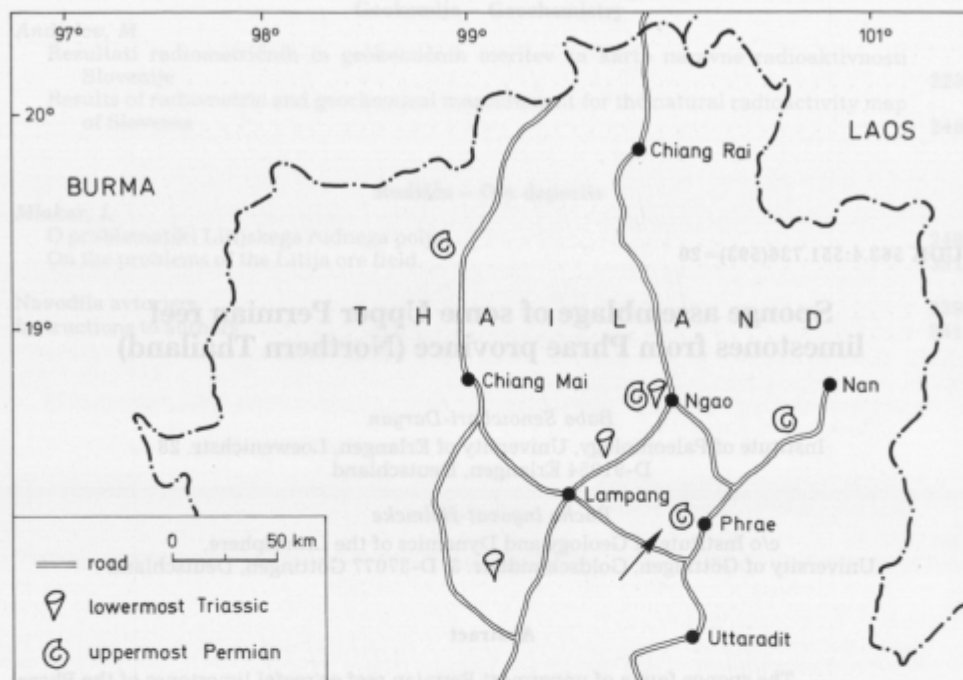


Fig. 1. Fossil localities of latest Permian and earliest Triassic age in northern Thailand. The new locality is indicated by an arrow

Pai in northwestern Thailand – far to the west of the Nan-Uttaradit suture and the described outcrop – have long been known (Konishi, 1953; Baum et al., 1970) to be composed of strata clearly indicative of subtropical paleolatitudes: oolitic and oncolithic limestones are a clear indication that these areas were not at all influenced by the Permian-Carboniferous Gondwana glaciations.

The Early Permian fusulinid faunas described from northern Thailand (Ingavat et al., 1980; Toriyama, 1984) also clearly contain arctic elements. These data indicate that the Nan-Uttaradit suture can not be the trace of the former ocean (Paleotethys) which was some thousand kilometers wide (separating the Gondwana facies from the tropical facies). Only a minor oceanic basin closed along the Nan-Uttaradit suture. This closure occurred in the Middle Permian, as proved by data from the Phetchabun fold and thrust belt (Helmcke & Lindenberg, 1983; Helmcke 1985, 1986; Ahrendt et al., 1991), from the Nan-Uttaradit suture itself (Barr & Macdonald, 1987), and from the region of Phrae (Lüddecke et al., 1991; Mickein, unpublished 1992). K/Ar data show that a tectonic-metamorphic event occurred in all of these regions at approximately 260 Ma.

The Late Permian sponge fauna described in this paper, therefore, did not live on a seamount in the Paleotethys or on the passive margin of a displaced terrane. There is growing evidence that many areas of Thailand were affected by extension after the cessation of Middle Permian contractional deformation (Helmcke, 1983; Cooper

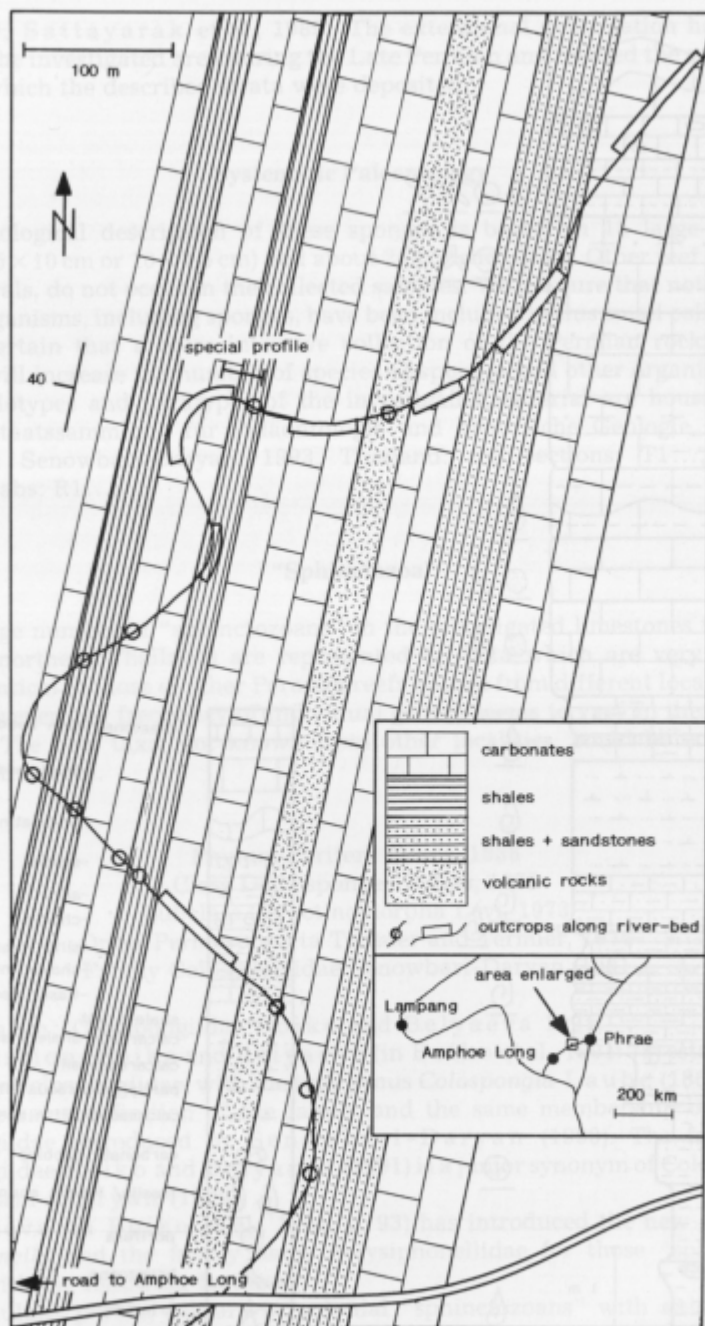


Fig. 2. Generalized sketch of geological relationship of the Upper Permian sequence along the highway from Phrae to Amphoe Long (kilometer 17.5)

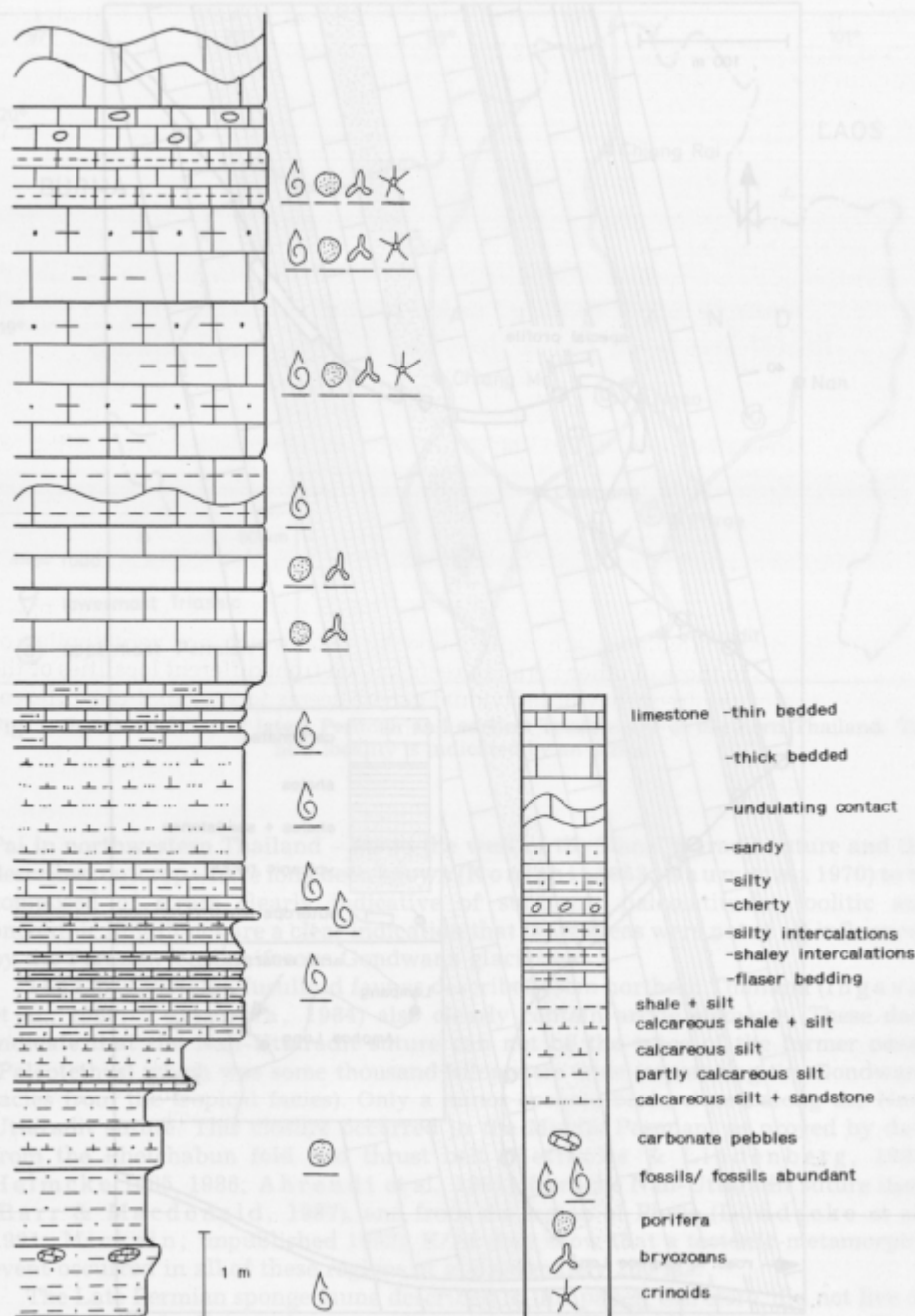


Fig. 3. Lithological section of the Upper Permian limestones which yielded the rich sponge fauna (approximately 650 m north of the highway from Phrae to Amphoe Long)

et al., 1989; Sattayarak et al., 1989). The extensional deformation had already started in the investigated area during the Late Permian and created the sedimentary basins in which the described strata were deposited.

Systematic Paleontology

Paleontological description of these sponges is based on 15 large-sized thin sections (15×10 cm or 10×7.5 cm) and about 20 polished slabs. Other reef organisms, such as corals, do not occur in the collected samples. We are sure that not all taxa of the reef organisms, including sponges, have been included in this small collection. We are also certain that a more intensive collection of the Permian rocks in Phrae province will increase the number of species of sponges and other organisms.

The holotypes and paratypes of the investigated material are housed in "Bayerische Staatssammlung für Paläontologie und historische Geologie, München" (inventory: Senowbari-Daryan, 1993, Thailand: thin-sections: T1..., rocks or polished slabs: R1...).

"Sphinctozoa"

The large number of "sphinctozoans" in the investigated limestones from Phrae province (northern Thailand) are represented by taxa which are very similar or almost identical to those of other Permian reefs known from different localities of the world. However, the frequency of individual genera seems to vary in these different localities. The new taxa, not known from other localities, could be endemic and limited to this area.

Phylum Porifera Grant, 1836

Class Demospongea Sollas, 1875

Subclass Ceractinomorpha Lévi, 1973

Order Permosphincta Termier and Termier, 1974

Family Colospongiidae Senowbari-Daryan, 1991

Synonym: Colospongiidae Boiko and Belyaeva 1991.

Discussion: Boiko and Belyaeva (in Boiko et al., 1991: 78) established the new family Colospongiidae, with the type genus *Colospongia* Laube (1865) and with almost the same definition of the family and the same membership of genera as Colospongiidae introduced by Senowbari-Daryan (1990). The family name Colospongiidae Boiko and Belyaeva (1991) is a junior synonym of Colospongiidae Senowbari-Daryan (1990).

Belyaeva (in Boiko et al., 1991, p. 93) has introduced the new genus name *Polysiphonella* and the family name Polysiphonellidae for those "sphinctozoan" sponges with the following features:

"Catenulate, porate, solitary or colonial "sphinctozoans" with axial canals of ambisiphonat or retrosiphonat type and with more or less numerous peripheral canals passing through couple of chambers. The chamber interior is hollow or filled with some spore-like filling structure".

Some remarks regarding the Role of International Zoological Nomenclature (RIZN) and the systematic affinity of sponges described as *Polysiphonella* by Belyaeva are necessary:

1. The genus name *Polysiphonella* is occupied by an inozoan genus introduced by Russo (1981) and therefore according to (RIZN) the name "*Polysiphonella*" Belyaeva is an invalid name. Because of the invalidity of the genus name the family name "Polysiphonellidae" Belyaeva (non Polysiphonellidae Wu (1991)) with the type genus *Polysiphonella* Russo (1981) is also invalid as well (our consideration of RIZN in this paper does not mean to justify the family name in the classification of sphinctozooid sponges by Wu, 1991).
2. The memberships of the family Intrasporocoeleidae Fan and Zhang (*Rhabdactinia* Yabe & Sugiyama, 1934, and *Intrasporocoeleia* Fan & Zhang, 1985) were moved from this family as Intrasporocoeleinae to the new family Polysiphonellidae by Belyaeva. Here the RIZN was not taken in consideration by the author. Consequently the representatives of the family Polysiphonellidae should be placed as Polysiphonellinae into the family Intrasporocoeleidae.
3. According to Belyaeva (in Boiko et al., 1991, p. 93) the sponge described as *Polysiphonella insolita* possesses several ambisiphonate or retrosiphonate axial spongocoels. The axial spongocoels can not be seen in specimen(s) illustrated by Belyaeva in pl. 20, fig. 1-3. Also the spore-like filling structure within the chamber interior, as mentioned by Belyaeva, can not be seen in the illustrated specimens of Belyaeva. The chamber interiors are filled either with micritic sediment showing partly geopetal structure or with sparry calcite cement. Some vesiculae occur within the chamber interiors.

The morphology, catenulate arrangement of the chambers, perforation of the chamber walls and the occurrence of vesiculae within the chamber interiors of sponges described as *Polysiphonella insolita* by Belyaeva and also in this paper are identical with *Colospongia* Laube. Large ostia within the chamber walls occur in the type species *Colospongia dubia* and also in some other species of *Colospongia* (see Senowbari-Daryan & Rigby, 1988, p. 183; Senowbari-Daryan, 1990, p. 64). However, these ostia or sieve-like plates are only on the exowall and not developed in the interwall. The ostia occurring in some species of *Colospongia* do not pass through a couple or several chambers as in "*Polysiphonella*" *insolita*. For this reason we accept the opinion of Belyaeva that a separate genus should be established for this sponge. Because of the invalidity of *Polysiphonella* Belyaeva 1991 (in Boiko et al., 1991) (non *Polysiphonella* Russo 1981) the genus name *Belyaevaspongia* nov. nom. is proposed. *Belyaevaspongia* is placed in the family Colospongiidae Senowbari-Daryan (1990).

Genus *Belyaevaspongia* nov. nom.

Derivatio nominis: Named for Dr. G. V. Belyaeva who described this sponge for the first time.

Diagnosis: Moniliforme, porate "sphinctozoan" sponge without a spongocoel but with numerous small tubes passing through one or two chambers. Interiors of the chambers are hollow or filled with vesiculae.

Type species: *Polysiphonella insolita* Belyaeva, 1991 (in Boiko et al., 1991).

Belyaevaspongia insolita (Belyaeva, 1991)
(Pl. 1, fig. 1–4, pl. 2, fig. 1–2, pl. 3, fig. 1/D, 2, 4)

1990 *Polysiphonella insolita* n. gen., n. sp. – Belyaeva (in Boiko et al., 1991), p. 93–95, pl. 20, fig. 1–3.

1993 "*Polysiphonella*" *insolita* Belyaeva. – Senowbari-Daryan & Ingavat-Helmcke, fig. 1/D, 4.

Description: The single or branched stems of this sponge reach a length of more than 100 mm. The sponge is composed of several spherical or hemispherical chambers arranged moniliforme, one above the other. Diameters of the chambers are usually greater than their heights. According to Belyaeva the height of the chambers is about 1/4 of the diameter. In our material diameters of the chambers range between 6.5 and 15 mm and heights of the chambers reach from 3.5 mm to 10 mm. The ratio of the chamber width/height is always more than 1 (text-fig. 4). Chambers at branching points are very wide (see text-fig 4, stars in circles).

Outer segmentation of the sponge is well developed. The relatively thick chamber wall of 0.5–1.2 mm is pierced by numerous single, unbranched pores about 0.2–0.3 mm in diameter (according to Belyaeva 0.25–0.35 mm).

Chamber interiors are either hollow and now filled with sparry calcite cement and/or sediment, or some vesiculae occur within the chamber interiors. Spore-like filling structures, as described by Belyaeva for the holotype from the Southern Pamir (but not recognizable in illustrated specimen(s) by the author), could not be observed in our material from Thailand.

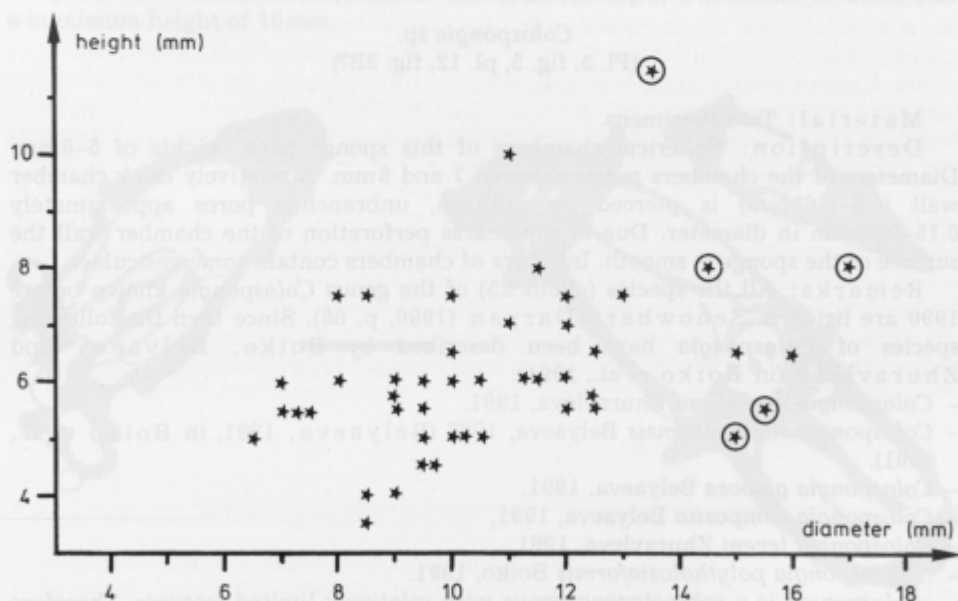


Fig. 4. Diagram showing the ratio of chamber height/chamber width in *Belyaevaspongia insolita* (Belyaeva) from Phrae province, northern Thailand. The stars in circles indicate the large diameter of the chambers on the branching points

An axial spongocoel that pass through the whole sponge is not developed (at least in our material). Very typical for this sponge are several small tubes pass through one or two chamber roofs. Chambers with 2 tubes were also be observed (pl. 1, fig. 2). These tubes are usually situated in interwalls between chambers (chamber roofs). Tubes in the outer wall (exowall) are rare but do occur (pl. 1, fig. 1). Outer diameters of the tubes range from 1.2 to 3mm, and inner diameters from 0.7 to 1.3mm. According to Belyaeva diameters of the tubes range from 1.2 to 2.0mm. These tubes are usually developed in the chamber wall at branching points (pl. 1, fig. 2-4). Walls of the tubes are also pierced with pores if the same size as those in the chamber walls. The tubes are of ambisiphonate type (sensu Seilacher, 1962).

Occurrence: *Belyaevaspongia insolita* (Belyaeva) is known from the type locality (Primoria, Far East) and now from the uppermost Permian of Phrae province, Thailand. It seems to be an endemic sponge limited to the Middle and Eastern Tethyan realm. It has not been observed in collection from the western part of the Tethys. *Belyaevaspongia insolita* is the most abundant sphinctozoan sponge within the investigated limestones of Phrae province in Thailand.

Genus *Colospongia* Laube, 1865

Diagnosis: see Senowbari-Daryan and Rigby, 1988.

Type species: *Manon dubium* Münster, 1841.

Colospongia sp.

(Pl. 5, fig. 5, pl. 12, fig. 3B?)

Material: Two specimens.

Description: Spherical chambers of this sponge have heights of 5-6mm. Diameters of the chambers range between 7 and 8mm. A relatively thick chamber wall (0.5-0.65mm) is pierced by uniform, unbranched pores approximately 0.15-0.20mm in diameter. Due to the coarse perforation of the chamber wall the surface of the sponge is smooth. Interiors of chambers contain some vesiculae.

Remarks: All the species (about 25) of the genus *Colospongia* known before 1990 are listed in Senowbari-Daryan (1990, p. 65). Since then the following species of *Colospongia* have been described by Boiko, Belyaeva and Zhuravleva (in Boiko et al., 1991):

- *Colospongia arakeljani* Zhuravleva, 1991.
- *Colospongia nachodkiensis* Belyaeva, 1987 (Belyaeva, 1991, in Boiko et al., 1991).
- *Colospongia globosa* Belyaeva, 1991.
- *Colospongia composita* Belyaeva, 1991.
- *Colospongia leveni* Zhuravleva, 1991.
- ? *Colospongia polytholosaformis* Boiko, 1991.

Colospongia is a sphinctozoan genus with relatively limited features. Therefore determination of individual species is not easy and most of them are confused. The genus *Colospongia*, like *Amblysiphonella*, should be revised carefully.

Determination of the *Colospongia* from Phrae province has not been carried to

species level because no completely preserved specimen was available. The two specimens illustrated in pl. 5, fig. 5 and pl. 12, fig. 3B could belong to different species.

Genus *Tristratocoelia* Senowbari-Daryan and Rigby, 1988

Diagnosis: see Senowbari-Daryan and Rigby, 1988.

Type species: *Tristratocoelia rhythmica* Senowbari-Daryan and Rigby, 1988.

Tristratocoelia rhythmica Senowbari-Daryan and Rigby, 1988

(Pl. 10, fig. 1–2, text-fig. 5)

1988 *Tristratocoelia rhythmica* n. sp. – Senowbari-Daryan and Rigby, p. 189–190, pl. 29, fig. 5–6, 9, text-fig. 10).

1991 *Tristratocoelia rhythmica* Senowbari-Daryan and Rigby. – Senowbari-Daryan and Rigby, p. 625, fig. 3.6, 3.7.

1993 *Tristratocoelia rhythmica* Senowbari-Daryan and Rigby, – Senowbari-Daryan and Ingavat-Helmcke, fig. 5/A.

Material: One branched or two separate specimen(s) were divided by cutting one of the samples. The sponges were investigated in two polished slabs.

Description: This tiny and curved sponge is at least 40mm long and is composed of 5 barrel-like chambers. The chambers have a diameter of 5mm and a maximum height of 10mm.

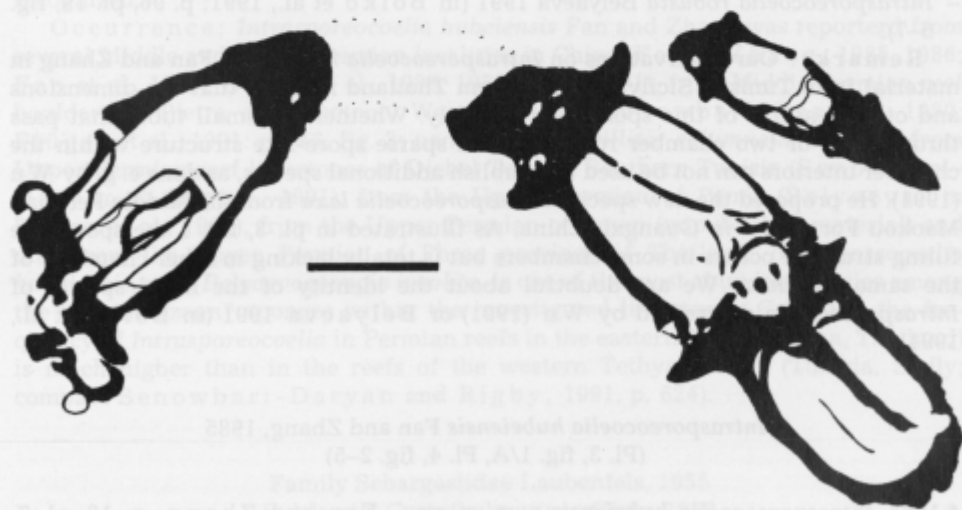


Fig. 5. Drawing of a section of *Tristratocoelia rhythmica* Senowbari-Daryan and Rigby, exhibiting the chambers with some vesiculae and the thick and ring-like chamber roofs pierced by pores (compare pl. 10, fig. 1). Scale 5 mm

The chamber walls are of varying thickness, in some areas up to 0.65 mm in others only 0.12 mm. Because of recrystallization of the chamber walls neither the pores nor the two-layered nature of the walls, as described by Senowbari-Daryan and Rigby (1991, p. 625), could be recognized. However, some large ostia up to 0.7 mm in diameter pierce the segment walls. The chamber roofs, called ring chambers (RC) in the original description by Senowbari-Daryan and Rigby (1988), are between 1.5 and 2.5 mm thick and are pierced by several large and branched openings. The chamber roofs are developed as a ring with a diameter that is larger than the chambers.

Interiors of the chambers are filled with vesiculae. Vesiculae run in some cases parallel to the chamber walls.

Occurrence: Until now *Tristratocoelia rhythmica* was known only from the Upper Permian reefs in Djebel Tebaga, Tunisia (Senowbari-Daryan & Rigby, 1988, 1991). In the type locality only three specimens were found. Within the investigated limestones of Phrae province only one branched(?) specimen or two individual specimens have been found.

Family Intrasporeocoeliidae Fan and Zhang, 1985

Genus *Intrasporeocoelia* Fan and Zhang, 1985

Diagnosis: see Fan and Zhang, 1985: 17.

Type species: *Intrasporeocoelia hubeiensis* Fan and Zhang, 1985.

Further species:

- *Intrasporeocoelia laxa* Wu (1991: p. 82, pl. 11, fig. 2, 5).
- *Intrasporeocoelia orientalis* Belyaeva 1991 (in Boiko et al., 1991: p. 95–96, pl. 19, fig. 3–5).
- *Intrasporeocoelia robusta* Belyaeva 1991 (in Boiko et al., 1991: p. 96, pl. 19, fig. 6–7).

Remarks: Our observations on *Intrasporeocoelia hubeiensis* Fan and Zhang in material from Tunisia, Sicily and now from Thailand indicate that the dimensions and other features of this sponge vary greatly. Whether the small tubes that pass through one or two chamber roofs, and the sparse spore-like structure within the chamber interiors can not be used to establish additional species, as done e. g. by Wu (1991). He proposed the new species *Intrasporeocoelia laxa* from the Middle Permian Maokou Formation in Guangxi, China. As illustrated in pl. 3, fig. 1 the spore-like filling structure occurs in some chambers but is totally lacking in other chambers of the same specimen. We are doubtful about the identity of the listed species of *Intrasporeocoelia* described by Wu (1991) or Belyaeva 1991 (in Boiko et al., 1991).

Intrasporeocoelia hubeiensis Fan and Zhang, 1985

(Pl. 3, fig. 1/A, Pl. 4, fig. 2–5)

* 1985 *Intrasporeocoelia hubeiensis* n. g., n. sp. – Fan and Zhang, p. 18, pl. 7, fig. 4, 8 (non 6).

1990 *Intrasporeocoelia hubeiensis* Fan and Zhang, – Senowbari-Daryan, p. 101, pl. 33, figs. 3–5 (see for complete synonymy).

- 1991 *Intrasporeocoelia hubeiensis* Fan and Zhang. – Senowbari-Daryan and Rigby, fig. 3.3–3.5.
- 1991 *Preverticillites columnella* Parona. – Flügel, Di Stefano and Senowbari-Daryan, pl. 46, fig. 3.
- 1991 *Intrasporeocoelia hubeiensis* Fan and Zhang, – Wu, p. 82, pl. 10, fig. 13, pl. 13, fig. 1.
- 1993 *Intrasporeocoelia hubeiensis* Fan and Zhang. – Senowbari-Daryan and Ingavat-Helmcke, fig. 4/A.

Description: Usually single or rarely branched (pl. 2, fig. 1) specimens of this cylindrical or subcylindrical sponge range in the material from Thailand to lengths of more than 170 mm and to diameters of 30 mm. However, large specimens up to 42 mm in diameter have been reported from Upper Permian reef limestones of Djebel Tebaga, Southern Tunisia (Senowbari-Daryan & Rigby, 1991, p. 623). Outer segmentation of the sponge is absent or poorly developed, but the internal segmentation is clearly recognizable.

The sponge is composed of several crescent-like chambers, each 3–10 mm high in the central part of the sponge.

Chamber walls are distinct from the internal filling structure in thin section and polished slabs. They appear dark and are massive. Chamber interwalls are usually 1–1.5 mm thick and pierced by equally distributed pores with diameters of 0.2–0.8 mm. Because younger chambers overlap older ones, the exowall is thicker than the endowall. It has a thickness of up to 2.5 mm (pl. 4, fig. 2, 4).

Chamber interiors are filled by densely packed spherical – appearing filling structures, called “spore-like” structures by Fan and Zhang (1985: 17–18) and described in detail from Chinese material by Rigby et al. (1988). Because of recrystallization of the filling structures, individual “spores” can not be easily recognized.

Occurrence: *Intrasporeocoelia hubeiensis* Fan and Zhang was reported from several Middle and Upper Permian localities in China (Fan & Zhang, 1985, 1986; Fan et al., 1987; Rigby et al., 1988, 1989; Wu, 1991), from Middle Permian reef boulders of Pietra de Salamone, Western Sicily (Senowbari-Daryan, 1990; Flügel et al., 1991: pl. 46, fig. 3; named *Preverticillites columnella* Parona), from Upper Permian reef limestones of Djebel Tebaga, Southern Tunisia (Senowbari-Daryan & Rigby, 1991), from the Upper Permian of Pamir (Belyaeva: in Boiko et al., 1991), from the Upper Permian of Oman (unpublished material) and now from the Upper Permian of Phrae province of Thailand. *Intrasporeocoelia hubeiensis*, with *Belyaevaspongia insolita*, is one of the most abundant species among the “sphinctozoan” sponges within the investigated limestones. Generally the frequency of *Intrasporeocoelia* in Permian reefs in the eastern Tethys (China, Thailand) is much higher than in the reefs of the western Tethyan realm (Tunisia, Sicily; compare Senowbari-Daryan and Rigby, 1991, p. 624).

Family Sebargasiidae Laubenfels, 1955

Subfamily Cystothalamiinae Girty, 1908

Genus *Discosiphonella* Inai, 1936

Diagnosis: see Senowbari-Daryan (1990, p. 56).

Type species: *Discosiphonella manchuriensis* Inai, 1936.

Remarks: The genera *Discosiphonella* Inai, *Cystauletes* King, *Ascosymplegma* Rauff and *Lichuanospongia* Zhang, and consequently the families Cystothalamiidae Girty (1908) and Stromatocoeliidae Fan and Zhang (1985) were synonymized with Sebargasiidae Steimann (1882) by Senowbari-Daryan (1990). Belyaeva (in Boiko et al., 1991, p. 102) introduced the new family Cystauletidae, with type genus *Cystauletes* King (1943). Wu (1991, p. 87) also introduced the family name *Cystauletidae* but without giving a diagnosis of the family and choosing a type genus.

First we want to give the name Cystauletidae Belyaeva (non Cystauletidae Wu) priority because she named the type genus and defined the family Cystauletidae. However, the genus *Cystauletes* King (1943) was synonymised with *Discosiphonella* Inai (1936) by Senowbari-Daryan (1990).

Concerning establishment of the family Cystauletidae and its membership (see Senowbari-Daryan, 1990; Belyaeva, in Boiko et al., 1991; the new genus *Squamella* established by Belyaeva seems to be identical with the genus *Imbricatocoelia* Rigby et al., 1989) could exist differences of opinion but we think that relationships of genera within the family Sebargasiidae and "Cystauletidae" (*sensu* Belyaeva) are very close and that they should be included in a single family. Of course the classification of Senowbari-Daryan (1990) is used in this paper.

All the species of the genera *Discosiphonella* (including *Ascosymplegma* Rauff 1938, *Cystauletes* King 1943 and *Lichuanospongia* Zhang, 1983) are listed in Senowbari-Daryan (1990, p. 57). Belyaeva (in Boiko et al., 1991) has described two (three) new species of the genus "*Cystauletes*" as "*C.*" *primoriensis* (p. 105), ? "*C.*" *squamilis* (p. 104) and "*C.*" *bzhebsi* (p. 165–166). In addition a new species of the genus "*Lichuanospongia*" ("*L.*" *primorica*" was established by the same author.

Within the investigated limestones of Phrae province, the genus *Discosiphonella* is represented by a small and poorly preserved species described below:

Discosiphonella sp.

(Pl. 2, fig. 5–6, pl. 6, fig. 2/B?, 3)

1993 *Discosiphonella* sp. – Senowbari-Daryan and Ingavat-Helmcke, fig. D/C.

Description: Stems of this sponge have a maximum diameter of 3–4 mm. The small spherical chambers, with diameters of 1–2 mm, are arranged in one layer around an axial spongocoel, which is up to 1 mm in diameter. Chamber interiors are hollow and no vesiculae were observed. The specimen illustrated in pl. 6, fig. 3 shows that the chambers are connected to the axial spongocoel by large openings, about 0.12 mm in diameter. The chamber walls, as well as the wall of spongocoel, are relatively thick (0.2–0.3 mm). Because almost all the specimens are recrystallized perforations of the wall can not be recognized and exact sizes of pores in the chamber wall can not given. This sponge is not abundant in the investigated limestones.

Remarks: Representatives of the genus *Discosiphonella* (including the genera *Cystauletes*, *Ascosymplegma* and *Lichuanospongia*) with their dimensions and other morphological features are listed in Senowbari-Daryan (1990, p. 58). Our species from Phrae province is differentiated from all other known species listed in Senowbari-Daryan (1990) by the extremely small dimensions of the sponge, its chambers and other elements.

Dimensions of the specimens from Thailand are almost the same as those of ?*Cystauletes squamilis* and *Cystauletes primoriensis* described by Belyaeva (in Boiko et al., 1991, p. 104–106) and perhaps represent one of those species.

Subfamily Cystothalamiinae Girty, 1990

Genus *Cystothalamia* Girty, 1908

Diagnosis: see Senowbari-Daryan (1990, p. 54).

Type species: *Cystothalamia nodulifera* Girty, 1908.

Cystothalamia? sp.

(Pl. 2, fig. 3)

Description: As illustrated in pl. 2, fig. 3, this sponge is composed of numerous spherical chambers in a polyglomerate (in several layers) arrangement around a spongocoel(?). The sponge has a length of 15 mm and a diameter of 5 mm in its upper part. Individual chambers have inner diameters of 0.25–0.8 mm. The chamber walls are 0.05–0.1 mm thick. Chamber interiors are hollow; no vesiculae nor other filling structures are developed. Because of recrystallization of the sponge skeleton, no pores could be recognized in the chamber walls. It is also possible that this sponge belongs to the aporate sphinctozoans (*Glomocystospongia*). Only one specimen of this sponge has been found.

Family Deningeriidae Boiko (in Boiko et al., 1991)

Discussion: Boiko (in Boiko et al., 1991) established the family Deningeriidae with the following diagnosis:

"Colonies catenulate, chambers subspherical, filling skeleton reticular, formation of the siphon is asiphonate or retrosiphonate".

Engeser (1986) had earlier proposed the family Solenolmiidae for all segmented sponges with a reticular filling skeleton and the retrosiphonate type of siphon (see Senowbari-Daryan, 1990). It would be practical to limit the family Deningeriidae to those genera without any spongocoel but with a reticular filling skeleton. The following described sponge is without siphon but possesses a filling skeleton of reticular type.

Genus *Ambithalamia* n. gen.

Derivatio nominis: Ambiguus (lat. =) indistinct. Because of poor and indistinct segmentation.

Diagnosis: Cylindrical, seldom branching sponge without a spongocoel. Outer as well as internal segmentation is poorly developed. Chamber roofs(?) or the growth lines(?) are marked by very thin and fine perforated lines. The interior of the chambers or the internal skeleton of the sponge is composed of relatively regular fibers of reticular type.

Type species: *Ambithalamia permica* n. sp.

Ambithalamia permica n. sp.

(Pl. 5, fig. 4/C, pl. 6, fig. 4/C, pl. 7, fig. 1/B, 3/B, 4, pl. 10, 1/C, 2/B, pl. 11, fig. 1, 2/C, 3/B, 4, pl. 12, fig. 2/A, 3/A, pl. 13, fig. 3/B, 4/A, 5/B)

1993 "Inozoa"? gen. et. sp. indet. – Senowbari-Daryan and Ingavat-Helmcke, fig. 5/A/d.

Derivatio nominis: Named for the occurrence of the sponge in Permian limestones.

Holotype: As holotype we choose the specimen marked with "H" in pl. 7, fig. 4. (R6).

Locus typicus: Outcrop in the small creek, located approximately 650 m north of the highway between Phrae and Amphoe Long, northern Thailand (see text-fig. 1–2).

Stratum typicum: Upper Permian (Dorashamian).

Material: Numerous specimens in several polished slabs.

Diagnosis: See diagnosis of the genus.

Description: This cylindrical and rarely branched sponge reaches a length of more than 25 mm and usually has a diameter of 3–4 mm. The sponge displays indistinct segmentation which is developed poorly in some specimens (e. g. pl. 7, fig. 3/B, pl. 11, fig. 3/B), but relatively well in others (e. g. pl. 7, fig. 4, pl. 11, fig. 1–2). Both outer and internal segmentation is hardly recognizable.

The holotype (pl. 7, fig. 4/H) is represented by an oblique section which, like other specimens in pl. 7, fig. 4, shows relatively well developed segmentation. Chambers range in shape from crescent-like to hemispherical. The segment roofs, which look like a thin cortex, are very thin (approximately 0.05 mm) and pierced by very small pores about 0.05 mm in diameter. Heights of segments range in the holotype from 0.5 to 1.3 mm, but has greater variation in other specimens. Interiors of the segments are filled with relatively regular reticular fiber structures. The fibers are approximately 0.1 mm thick.

Some specimens (e. g. pl. 7, fig. 3, 4; in the middle part, pl. 12, fig. 3) exhibit large, spongocoel-like, "openings" that have a peripheral position. We interpret these openings as activities of boring organisms.

Occurrence: *Ambithalamia permica* n. gen., n. sp. is one of the most abundant sphinctozan sponges in the investigated limestones. More than 100 specimens have been cut in several polished slabs.

Family Phragmocoliidae? Ott, 1974

Thalamid sponge gen. et sp. indet

(Pl. 10, fig. 1/B, pl. 12, fig. 1/A)

Material: Three specimens in polished slab R7.

Description: The largest specimen (pl. 12, fig. 1/A; in the right corner) reaches a maximum diameter of 2 mm and a length of 10 mm. It is composed of 5 chambers with heights between 1.5 and 2.5 mm. A spongocoel, with a diameter to 1.2 mm, passes through the sponge. Chamber walls are 0.05 mm thick, but because of strong recrystallization the pores or ostia in the walls are not preserved. The most charac-

teristic feature of the sponge is the sept-like filling structure subdividing chamber interiors into bubble-like small units.

Remarks: This sponge is most probably a representative of a new genus, but we describe it here only as gen. et sp. indet. Only three poorly preserved specimens are available. The most characteristic feature of this tiny sponge are the sept-like elements within the chamber interiors, like those occurring within the family Phragmocoeliidae Ott (1974). Only two genera have been placed into this family: the Devonian genus *Radiothalamos* Pickett and Rigby (1983) and the Triassic genus *Phragmocoelia* Ott (1974). Sponges with radially arranged and sept-like elements within chamber interiors have not been known from Permian deposits until now.

Suborder Aporata Seilacher, 1962

Family Thaumastocoeliidae Ott, 1967

Subfamily Thaumastocoeliinae Senowbari-Daryan, 1990

Genus *Sollasia* Steinmann, 1882

Diagnosis: see Senowbari-Daryan (1990).

Type species: *Sollasia ostiolata* Steinmann, 1882.

Further species: All species of *Sollasia*, known before 1990, are listed in Senowbari-Daryan (1990: p. 128). Since then only one species – *S. arta* – has been described by Belyaeva, 1991 (in: Boiko et al., 1991) from the Upper Permian of the Far East.

Sollasia ostiolata Steinmann, 1882

(Pl. 3, fig. 1/C, pl. 4, fig. 1/B, pl. 6, fig. 4/A, 6, pl. 12, fig. 1/B)

1882 *Sollasia ostiolata* n. sp. – Steinmann, p. 151–152, pl. 7, fig. 3.

1990 *Sollasia ostiolata* Steinmann. – Senowbari-Daryan, p. 128, pl. 43, fig. 7, pl. 45, fig. 4, 8, pl. 56, fig. 9, text-fig. 47 (synonymy-list).

1991 *Sollasia ostiolata* Steinmann. – Wu, p. 85, pl. 10, fig. 1, pl. 11, fig. 4.

1991 *Sollasia ostiolata* Steinmann. – Belyaeva (in Boiko et al., 1991), p. 62, pl. 7, fig. 2–4, pl. 8, fig. 1–5, pl. 9, fig. 1–3.

Description: Diameter of this moniliform sponge ranges greatly. In the investigated material diameters of specimens range between 3 and 8 mm, but larger specimens, up to 15 mm are known from Permian reefs of Djebel Tebaga, Tunisia (Senowbari-Daryan & Rigby, 1988). The individual chambers are spherical or barrel-shaped and reach heights of up to 7 mm. Exowalls and endowalls of chambers are pierced by large ostia (pl. 6, fig. 4, 6). Diameters of ostia depend on diameters of the sponges. Usually the small specimens have small ostia and larger specimens have relatively larger ones. Vesiculae were not observed within chamber interiors.

Occurrence: *Sollasia ostiolata* Steinmann is a cosmopolitan thalamid sponge, occurring in several Carboniferous and Permian localities in Western Tethys (Spain, Sicily, Slovenia, Tunisia, Oman) and Eastern Tethys (the Far East, China, Kamotscha), as well as in the Guadalupe Mountains in Texas and New Mexico (Senowbari-Daryan, 1990). In Sicily (Senowbari-Daryan & Di Stefano, 1988)

and especially in Djebel Tebaga, Tunisia (Senowbari-Daryan & Rigby, 1988) it is a very abundant thalamid sponge. In the investigated limestone from Phrae province, however, *Sollasia* is a relatively rare sponge.

Sollasia spheroida Rigby, Fan and Zhang, 1989

(Pl. 2, fig. 7, pl. 5, fig. 1?, 2, 4, pl. 7, fig. 2/B)

1989a *Sollasia spheroida* n. sp. – Rigby, Fan & Zhang, p. 438, fig. 19.7–19.9, 20.7–20.9).

Description: Diameters of this species range between 5 and 11 mm and thicknesses of chamber walls range between 0.5 and 0.7 mm. The chamber wall is pierced by large ostia 0.35–0.5 mm in diameter. Interiors of chambers are filled with vesiculae.

Subfamily Enoplocoeliinae Senowbari-Daryan, 1990

Genus *Girtyocoelia* Cossman, 1909

Diagnosis: see Senowbari-Daryan, 1990: 130.

Type species: *Heterocoelia beedei* Girty, 1908.

Girtyocoelia beedei (Girty, 1908)

(Pl. 7, fig. 1, pl. 8, fig. 3? pl. 9, fig. 2)

1908 *Heterocoelia beedei* n. sp. – Girty, S. 248, Taf. 14, fig. 1–8.

1990 *Girtyocoelia beedei* (Girty). – Senowbari-Daryan, p. 130–131, pl. 45, fig. 1–3, 5–7, text-fig. 48 (synonymy-list).

? 1991 *Girtyocoelia* cf. *beedei* (Girty). – Belyaeva (in Boiko et al., 1991), p. 61, pl. 6, fig. 1–3, pl. 7, fig. 1.

Description: Only two (three?) specimens of this certainly very rare sponge were found within the investigated limestones. Both of them are 5.5 mm in diameter, a little smaller than the diameter of this species from other localities (compare Senowbari-Daryan & Di Stefano, 1988). The axial spongocoel has an inner diameter of 1 mm. Chamber walls, as well as the wall of the spongocoel, are 0.22–0.4 mm thick and are pierced by ostia with an inner diameter of 0.3 mm. Ostia typically display the short exaules, as known in *Girtyocoelia beedei* from other localities.

Occurrence: *Girtyocoelia beedei* is known from numerous Carboniferous and Permian localities in the USA (Guadalupe- and Glass Mountains in Texas and New Mexico), and from several localities of the Western and Southern Tethys (Europe: Sicily, Spain, Alps; Africa: Tunisia; Oman, the Far East). The genus *Girtyocoelia* has not been reported from the Permian reefs of southeastern Asia (China or other localities). Sponges, described as *Girtyocoelia markamensis* by Deng (1982) from the Permian reefs of China, has perforated chamber walls and does not belong to the genus *Girtyocoelia* (see Senowbari-Daryan, 1990, p. 131). The discovery of *Girtyocoelia beedei* in Phrae province indicates an occurrence of the genus and species within the Permian reef limestones of the eastern part of the Tethys.

Genus *Phraethalamia* n. gen.

Derivatio nominis: From Phrae province and thalamos (= chamber).

Diagnosis: Aporate thalamid sponge with two or more axial spongocoels and ring-like chambers. Numerous, occasionally dichotomous, branched tubes extend from the spongocoel wall into the hollow chambers. Chamber interiors without vesiculae and filling structure.

Type species: *Phraethalamia tubulara* n. sp.

Discussion: The chamber shape, arrangement of the chambers and, perhaps, also the ostia on the chamber wall in the new genus are similar or identical to *Girtyocoelia* Cossman. *Phraethalamia* differs, however, from *Girtyocoelia* by possession of two or more axial spongocoels and by the distinct tubes which run from the spongocoel wall into the hollow chambers. Such tubes are known from the Permian demospongid genus *Pseudoamblysiphonella* Senowbari-Daryan and Rigby (1988) and from the calcispongid sponge *Barroisia lehmanni* described from Cretaceous deposits of northern Germany by Hilmer and Senowbari-Daryan (1986). Both of those genera belong to the porate sphinctozoans and both of them have perforated walls. However, a sponge like *Phraethalamia* is not known within the aporate sphinctozoans.

Phraethalamia tubulara n. sp.

(Pl. 3, fig. 1/B, pl. 4, fig. 1, pl. 11, fig. 2/A, 3/A, text-fig. 6)

1993 *Girtyocoelia*? sp. – Senowbari-Daryan and Ingavat-Helmcke, fig. 4/A.

Derivatio nominis: Named for the distinct tubes that extend from the spongocoel wall into the chamber interiors.

Holotype: Longitudinal section illustrated in pl. 3, fig. 1/B and the enlargement from the same specimen illustrated in pl. 4, fig. 1.

Locus typicus: Small creek ca. 650 m north of the highway between Phrae and Amphoe long (see text-fig. 1-2).

Stratum typicum: Upper Permian (Dorashamian).

Diagnosis: See diagnosis of the genus.

Material: Two or four (?) specimens.

Description: The holotype of *Phraethalamia tubulara* n. gen., n. sp. is weathered out in the sample illustrated in pl. 3, fig. 1. An enlargement of it is shown in pl. 4, fig. 1 (see text-fig. 6). The specimen has a length of 45 mm and a diameter of 7 mm. It is composed of 6 spherical chambers with lengths of 7–8 mm. Two relatively wide axial tubes (spongocoels), with diameters of 1.25 or 1.6 mm, run vertically through the whole sponge. These tubes are connected to others by large openings, as shown in text-fig. 6. Connection between axial canals and surrounding chambers are made by some small tubes that may branch dichotomously within the chambers (see text-fig. 6). The diameter of the tubes is approximately 0.35 mm in diameter.

One of the paratypes (pl. 11, fig. 3/A) seen in a longitudinal section is composed of three (four) globular and ring-like chambers with diameters of 5.5–7.5 mm. Chambers have heights of 6–7 mm. All other features of this specimen correspond completely to

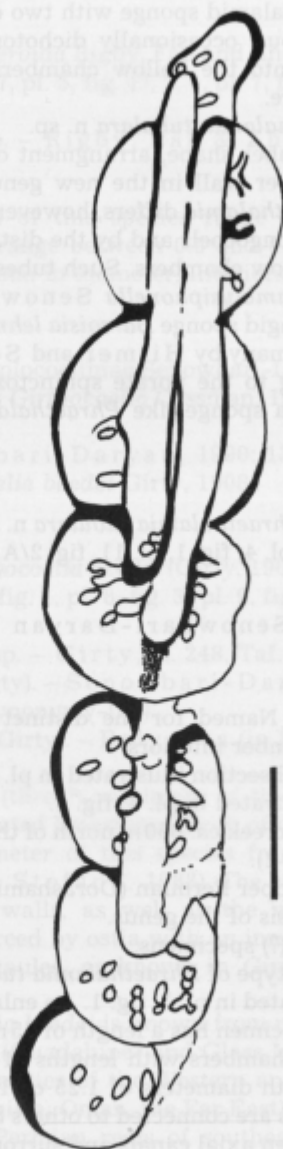


Fig. 6. Drawing of a thin section of *Phraethalamia tubulara* n. gen., n. sp. The spherical chambers exhibit imperforate walls. Some tubes extend from the spongocoel wall into the chamber interiors. Two, relatively wide and axial spongocoels pass vertically through the sponge. Scale 5mm

those of the holotype. Interiors of the spongocoels show additionally secreted skeleton which were not observed in the holotype.

Two other paratypes (pl. 11, fig. 2/A), which can not be identified with certainty, are only seen in cross or oblique sections.

"Inozoa"

The term "Inozoa" was introduced by Steinmann (1882) for those fossil sponges which have a calcareous rigid skeleton and – in contrast to "sphinctozoa" – no segmentation. Most post-Triassic inozoans have a spicular skeleton of primary calcite composition (Hurcewicz, 1975). In representatives of Triassic and Paleozoic inozoans no such spicular skeleton has been found to date. The group of sponges, called the "inozoa", is – like "sphinctozoa" – of polyphyletic nature. It seems likely that the Triassic and Paleozoic inozoans belong to a completely different group than the post-Triassic representatives.

The classification of post-Triassic "inozoan" sponges is based on the composition, shape and arrangement of the spicular skeleton (Wagner, 1964; Hurcewicz, 1975; Müller, 1984). However, a generally accepted classification for Triassic and pre-Triassic "inozoan" sponges is still needed. The classifications of Dieci et al. (1968), Russo (1981), Bizzarini and Russo (1986) is based on the canal system for water circulation and has included only a part of known Triassic "inozoans". This classification scheme was used by Rigby et al. (1989b) to describe the Permian inozoan sponges from China. Wu (1991) was influenced by the classification of Rigby et al. (1989) and used the outline of that classification to propose a new classification for inozoan sponges. This classification is also based only on a part of the Permian material (Permian "inozoans" of China), is to much too theoretical, and does not take consider relationship of closely related genera into consideration. For example, "inozoans" described from other localities, were not included by Wu. The mineralogic composition (calcite, Mg-calcite, or aragonite) and the microstructure of the rigid skeleton were also disregarded. Taxa described by Wu (1991) are poorly documented and his description and illustrations of almost all species make it difficult for other workers. Despite efforts by Wu (1991) the classification of Dieci et al. (1968), which is based on the type of canal system and which was followed by others (especially Rigby et al., 1989, and Wu 1991) seems to be most useful in classifying the "inozoan" sponges.

"Inozoa" in the investigated limestones from Phrae province are limited to only a few genera. However, they are the second most important reef builders in the investigated limestones, following the "sphinctozoans".

Order Pharetronda Zittel, 1878

Suborder Inozoa Steinmann, 1882

Family Peronidellidae Wu 1991

Genus *Peronidella* Hinde, 1893

(pro *Peronella* Zittel, 1878)

Diagnosis: see Zittel, 1878: 120.

Type species: *Spongia pistilliformis* Mouroux, 1821

Peronidella sp.

(Pl. 3, fig. 3, pl. 6, fig. 5, 7/B, pl. 9, fig. 3–4)

Description: Single specimens of this species range in diameter from 2 to 6 mm. An axial spongocoel, with diameters of 1–2 mm (30–40% of the whole sponge), passes through each sponge. The relatively loose reticular fibrous structure has elements approximately 0.2–0.3 mm thick. The skeleton is strongly recrystallized.

Peronidella is not abundant in the investigated limestones.

Remarks: More than 30 species of *Peronidella* have been described in the literature (see Zittel, 1878; Hurcewicz, 1975). Most of these description concern Triassic to Cretaceous taxa. The following species of *Peronidella* have been described from Permian strata:

- *Peronidella baloghi* Flügel, 1973
- *Peronidella beipeiensis* Rigby, Fan and Zhang, 1989
- *Peronidella gravida* Wu, 1991
- *Peronidella labiaformis* Wu, 1991
- *Peronidella minicoeliaca* Wu, 1991
- *Peronidella recta* Hinde, 1893 (in Wu 1991)
- *Peronidella recta grossa*, Wu 1991
- *Peronidella regulara* Rigby, Fan and Zhang, 1989
- *Peronidella rigbyi* Senowbari-Daryan (= pro *Peronidella parva* Rigby, Fan and Zhang, non *Peronidella parva* Nutzubidze 1964, see Senowbari-Daryan, 1991).

Most of these species, especially those described by Wu (1991), are described using only one or two cross sections and without emphasizing the differences from the other known *Peronidella* of Permian age. A complete revision of the genus *Peronidella* is necessary.

Genus *Bisiphonella* Wu, 1991

Diagnosis: see Wu (1991, p. 60).

Type species: *Bisiphonella cylindrata* Wu, 1991.

Bisiphonella tubulara n. sp.

(Pl. 5, fig. 2/C, 3; pl. 6, fig. 1, 2/A, 7/A, pl. 7, fig. 1/C, 2/A, 3/A, pl. 8, fig. 1–2, 4–6, pl. 11, fig. 2/B? pl. 12, fig. 2/C, 3/C, pl. 13, fig. 2/B, 3/A, 8)

1993 "Inozoa"? gen. et. sp. indet. – Senowbari-Daryan and Ingavat-Helmcke, fig. 5/A/C.

Derivatio nominis: Named for the short tubes (exaulos-like) which pass from the spongocoel wall into the interior of the chambers (see pl. 8, fig. 2).

Holotype: Longitudinal section in pl. 8, fig. 2A (half of the holotype is figured in pl. 8, fig. 4/B and is connected by lines with fig. 2/A of the same plate).

Locus typicus: Small creek, approximately 650 m north of kilometer 171.5 on the highway between Phrae and Amphoe Long (see text-fig. 1–2).

Stratum typicum: Upper Permian (Dorashamian).

Material: Several thin sections and polished slabs.

Diagnosis: Cylindrical sponge with two spongocoels of the same size that extend vertically through the axial region of the sponge. The spongocoels possess their own walls, but there is a common wall between the two spongocoels. A loose fibrous structure is developed between the outer wall and the wall of the spongocoels. Numerous openings with short tube-like walls lead to the spongocoels from the surrounding and loosely packed fibrous skeletal structure. The outer surface of the sponge is rough and has a spiny appearance.

Differential diagnosis: Follows description of the species.

Description: This cylindrical and single sponge reaches a length of more than 35 mm and a diameter of up to 6 mm. The holotype in the polished slab (pl. 8, fig. 1/A-4/B) has a length of 35 mm and a diameter of 4 mm. Two spongocoels of the same size, each approximately 1 mm in diameter, pass vertically through the sponge. The diameter of the spongocoels is relatively constant. In paratypes it ranges between 0.75 and 1.1 mm. The spongocoels have their own walls that are approximately 0.15–0.2 mm thick. The common wall between the spongocoels has the same thickness. The space between the outer wall of the sponge and the wall of the spongocoels is filled with loose radially arranged fibrous structures. The space between the radially arranged fibers appears to be small tubes that extend from the walls of the spongocoels (pl. 8, fig. 2). The spongocoels and interspaces between the surrounding fibrous structures are connected by openings with diameters of approximately 0.1–0.2 mm. Such openings show short exaulos-like tubes (pl. 6, fig. 2). The outer surface of the sponge is rough and appears to be covered by spine-like elements in the thin section (see pl. 5, fig. 1–2, 7, pl. 6, fig. 4).

Remarks: *Bisiphonella tubulara* is the most abundant inozoan sponge in the investigated limestones of Phrae province. More than 50 specimens were observed in the polished slabs and thin sections.

Bisiphonella tubulara n. sp. differs from the type species of the genus – *Bisiphonella cylindrata* Wu (it seems that two sponges with different fibrous skeletal structures have been included to the same species by Wu) – by the type of fibrous skeletal structure (reticular in *B. cylindrata*, but radial in *B. tubulara*), by the spongocoels having its own wall, by openings with exaulos like tubes within the wall, and by the rough (in thin section spiny appearing) surface of the sponge. In addition to these, the wall between the spongocoels in the type species is relatively thick and has the same reticular fiber structure as the surrounding wall, however in the new species the wall is thin and massive (not porous like in the type species) (see pl. 5, fig. 7. pl. 6, fig. 2, 5).

Family uncertain

Genus *Solutossaspongia* n. gen.

Derivatio nominis: *Solutus* (lat. =) loose, *ossa* (lat. =) skeleton. Because of the loose fiber skeleton in the interior of the sponge.

Diagnosis: Cylindrical and unbranched sponges, each with a distinct thick outer wall. The skeleton interior of each sponge is composed of loose reticular fibers. Sponge lacks a spongocoel.

Discussion: Wu (1991) established the superfamily Acoelioidea and the family Acoeliidae for those Chinese Permian inozoan sponges which have neither distinct

inhalant and exhalant canals nor a spongocoel. He did not take into consideration other known inozoan sponges without canals.

The type genus of the family Acoeliidae, *Acoelia* Wu and the type species *A. rudia* Wu, were described using only one thin section, which could also be a marginal section of any number of other inozoid sponges. Also, the description of the genus, *Ramospongia* Wu, which belongs to the same family, is documented using with a section which could be a piece of other inozoid sponge, as well. Because of the totally insufficient descriptions and illustrations of both genera we are not able to follow the author in describing our sponges. The genus described here differs from Wu's acoeliid "genera" by its distinct thick outer wall and by the loosely packed fibrous skeletal structure in the inside of the sponge.

Solutossaspongia crassimuralis n. sp.

(Pl. 5, fig. 2/D, pl. 7, fig. 1/C, 3/C, pl. 12, fig. 2/B, 4, pl. 13, fig. 2/A, 3/C, 5/A, 6, 7)

Derivatio nominis: Named for the thick outer wall of the sponge.

Holotype: Longitudinal section in pl. 13, fig. 3 (R5).

Locus typicus: Outcrop in the small creek, located approximately 650 m north of kilometer 17.6 on the highway between Phrae and Amphoe Long (see text-fig. 1-2).

Stratum typicum: Upper Permian (Dorashamian).

Material: Numerous specimens in several polished slabs.

Diagnosis: See diagnosis of the genus.

Description: The stems of this sponge usually have diameters of 3-5 mm and lengths of up to several centimeters. The holotype (pl. 13, fig. 3) has a diameter of 4 mm and a length of 15 mm. The most characteristic feature of this sponge is the thick outer wall, which has a thickness of 1 mm in the holotype and ranges between 0.4 mm and 1.3 mm in the paratypes. The outer wall is pierced by large openings which can be observed in only some of the specimens (pl. 13, fig. 2A). The diameter of the openings is approximately 1 mm. The interior of the sponge is characterized by a loosely packed fibrous structure of reticular type. The thickness of the fibers is approximately 0.3 mm. An orientation of the fibers parallel to the axis of the sponge can be observed in some specimens (pl. 12, fig. 4).

Remarks: The fiber structure of *Solutossaspongia crassimuralis* n. gen., n. sp. is similar to that of *Bisiphonella tubulara*. Marginal sections of *Bisiphonella tubulara* could be mistaken for longitudinal sections of *S. crassimuralis*, but they may be distinguished by the thick outer wall in the latter sponge.

Inozoan sponge gen. et sp. indet

(Pl. 11, fig. 4, pl. 12, fig. 1/D, pl. 13, fig. 1)

Material: Numerous specimens in several polished slabs.

Description: The stems of this inozoan are single or branched dichotomously (pl. 13, fig. 1), and they reach diameters of up to 10 mm and lengths of more than 50 mm. Stems are composed of relatively regularly arranged fibrous skeleton of reticular type. The thickness of the fibers is approximately 0.08 mm. Fibers on the exterior surface are finer than those in the interior of the sponge. A spongocoel and inhalant and exhalant canals are absent. Cross sections of some specimens, however,

show some radially arranged small canals that are produced by the radial arrangement of the fiber structures (pl. 11, fig. 11).

Remarks: This sponge includes the largest inozoan sponge in the investigated limestones. It has an appearance similar to *Ambithalamia permica* n. gen., n. sp., but differs from it by a lack of coarse segmentation, by having fine and regular fibrous skeletal structure and by its large dimensions.

Sclerospongia

After the "sphinctozoans" and "inozoans", the sclerosponges are the third most abundant sponges as well as the third-most important reef organisms in the investigated limestones. A detailed determination of the sclerosponges was not carried out because:

- a) most of them are poorly preserved and,
- b) a generally accepted classification of Permian sclerosponges (chaetetids) has not been established.

The most abundant genus of sclerosponges is illustrated in pl. 5, fig. 1/B, 5/B, pl. 9, fig. 5-7, pl. 12, fig. 1/C. This sponge is characterized by tubes with diameters of 0.3-0.5 mm, that diverge from the axis toward the periphery of the stems. Internal parts of nearly all of the specimens are recrystallized (pl. 5, fig. 1/B, pl. 9, fig. 6-7).

Hexactinellida

Hexactinellid sponges are not abundant in the investigated limestones. Most of them were either largely destroyed or the silicification of the sediment between the hexactinellid lattice caused the disappearance of that skeletal structure. Only a few specimens are relatively well preserved where the hexactinellid lattice can be recognized (pl. 6, fig. 4/B, pl. 9, fig. 7). However, the determination of hexactinellids to genus or other categories is not possible in our thin sections.

Other organisms

In addition the sponges noted above, some bryozoans (the genus *Polypora* is most abundant), algae? (some red algae are preserved, but green algae were not found), abundant echinoderms, gastropods, brachiopods, *Tubiphytes obscurus* Maslov, and small foraminifers were found. It should be emphasized that corals and fusulinid foraminifers, as well as encrusting organisms, are completely missing. *Archaeolithoporella*, an encrusting organism (binder) which is usually abundant in other Permian reefs or reefal limestones, is also completely absent in the investigated limestones. The small foraminifers are represented by *Geinitzina* ex. gr. *G. postcarbonica*, *Geinitzina* cf. *G. taurica*, *Geinitzina* sp., *Protonodosaria* sp., *Hemigordius* sp., and *Colaniella* ex. gr. *C. parva*. According to Jenney-Deshusses and Baud (1989) the occurrence of *Colaniella* ex gr. *parva* indicates an uppermost Permian age (Dorashamian) for the investigated limestones.

Microfacies types

Matrix between organisms in the investigated samples is micritic. Abundant organic detritus is imbedded in the micritic sediment. All of the limestones are bafflestones in which sponges and some bryozoans functioned as bafflers. The complete absence of spary matrix, green algae (e. g. dasycladaceans), as well as of fusulinid foraminifers, indicates relatively deep water for the environment of accumulation (deeper than wave-base, maybe deeper than the photic zone). The absence of encrusting organisms, like *Archaeolithoporella*, could indicate that the rate of sedimentation was too high and that these organisms could not exist in this environment.

Comparison

Compared to other Permian reef or reefal limestones of the world, we conclude that the diversity of organisms of the investigated Upper Permian limestones of Phrae province in northern Thailand is not high, but, as mentioned above, we are sure that intensive field collection will greatly increase the number of taxa.

The most important organisms in the reefal limestones of Phrae province are the sponges. The most important group is the "sphinctozoans", followed by "inozoans" and sclerosponges, respectively.

Belyaevaspongia insolita is the most abundant sphinctozoid sponge. It has been described before now only from the Permian of the Far East by Belyaeva (in Boiko et al., 1991). The lack of *Belyaevaspongia* in relatively well investigated Permian localities in the western part of the Tethys (Tunisia, Sicily, Alps) indicates that this sponge is limited to the eastern parts of the Tethyan realm.

The next most abundant genus is *Intrasporeocoelia*, which also occurs in Permian reefs of the Western Tethys (Sicily, Tunisia, Oman), but it is apparently a more abundant sponge in Permian reefs in China. *Intrasporeocoelia* is an endemic sponge of Middle and Upper Permian reefs and its present ranges is limited to the Tethyan realm. It is not known from the Permian reefs of the Guadalupe Mountains in North America.

The genera *Sollasia*, *Girtyocoelia* and *Discosiphonella* are cosmopolitan sponges and they occur with abundances that vary in many Carboniferous and Permian localities of the world. The absence of *Amblysiphonella* is remarkable, but it is a cosmopolitan sponge like *Sollasia* or *Girtyocoelia* which occur in nearly all Carboniferous or Permian reef localities of the world. Certainly *Amblysiphonella* seems to be a most abundant sphinctozoan sponge in Permian reefs in the eastern part of the Tethys (China), but is lacking in Phrae province. The two new described genera – *Phraethalamia* and *Ambithalamia* – are not yet known from other localities.

Among the "inozoans" the genus *Bisiphonella* is the most abundant genus within the investigated limestones, followed by *Solutossaspongia* and *Peronidella*. *Bisiphonella*, described first from the Upper Permian reefs of China, occurs also in the Permian reefs in western Tethys (unpublished material). *Peronidella*, however, is a cosmopolitan sponge and occurs in many Carboniferous and Permian reefs in the western Tethyan realm. The number of "inozoan" genera in the investigated limestones seems to be lower than in the Permian reefs of China. The majority of the "inozoan" genera described by Deng (1982b, 1982c), Rigby et al. (1989b), and Wu

(1991) were not found in Thailand. This is also true for the "hydrozoans" described by Fan et al. (1991). This could indicate that only some of the sponges could exist under the limited environmental conditions which prevailed during the sedimentation of the reefal limestones in Phrae province, Thailand.

Conclusions

The investigation of the sponge fauna of a few samples of Upper Permian reef or reefal limestones of the Phrae province in northern Thailand documents a high diversity of sponges. The sponge fauna is represented by "sphinctozoans", "inozoans", sclerosponges and hexactinellida. "Sphinctozoans" are the most abundant and diverse sponges, followed by inozoans.

The genus name *Belyaevaspongia* nom. nov. is proposed for *Polysiphonella* Belyaeva, 1991 (in Boiko et al., 1991, non *Polysiphonella* Russo 1981). *Belyaevaspongia insolita* (Belyaeva) is the most abundant "sphinctozoan" sponge species, followed by *Intrasporeocoelia hubeiensis* Fan and Zhang. *Amblysiphonella*, a most abundant "sphinctozoan" genus in other Permian reefs of the world, especially in Middle and Upper Permian reefs in the Eastern Tethys (China), was not found in the Phrae province faunas in northern Thailand. The genera *Phraethalamia* and *Ambithalamia* and the species *Phraethalamia tubulara* and *Ambithalamia permica* are described for the first time.

Phraethalamia, a *Girtyocoelia*-like thalamid sponge is placed into the family Thaumastocoeliidae. *Ambithalamia* represents a poorly segmented sponge which belongs to the family Deningeriidae.

Among the "inozoans" the following taxa are described for the first time: *Bisiphonella tubulara* n. sp. and *Solutossaspongia crassimuralis* n. gen., n. sp.. *Bisiphonella tubulara* is the most abundant species among the inozoan sponges.

The reef or reefal limestones of Phrae province are generally developed as bafflestones. Encrusting organisms, like *Archaeolithoporella*, an abundant encrusting organism in other Permian reef limestones, are totally absent. The absence of *Archaeolithoporella* could be indicative of the high rate of sedimentation. The occurrence of *Colaniella* ex. gr. *parva* indicates an uppermost Permian (Dorashmian) age for the investigated limestones.

The "sphinctozoan" and "inozoan" fauna of the investigated limestones show little similarities to other known Permian reefs. In addition to the cosmopolitan sponges, e. g. *Sollasia*, *Girtyocoelia*, *Colospongia*, *Peronidella*, no endemic sponges occurring in Phrae province, are known from other Permian localities of the world. It should be emphasized that *Amblysiphonella*, an abundant sphinctozoan sponge in other Permian reefs, especially in China, did not occur in the investigated limestones from the Phrae province.

Acknowledgments

This paper contains results of the cooperative program between the Department of Mineral Resources, Bangkok, and the Institute of Geology and Dynamics of the Lithosphere, Göttingen, on the geodynamic evolution of northern Thailand. The investigations, reported here, were carried out in the Institute for Paleontology,

University of Erlangen-Nürnberg, within the research project of priority program "global and regional controls on biogenic sedimentation" supported by the "Deutsche Forschungsgemeinschaft" in cooperation with Institute of Geology and Dynamics of the Lithosphere, University of Göttingen. We thank the National Research Council of Thailand, Bangkok, and the German Research Foundation (DFG), Bonn-Bad Godesberg for financial support. Special thanks are due to Dr. C. Chonglakmani for valuable information about the Late Permian rocks in northern Thailand and to Dipl. Geol. A. Mickein who provided us with the necessary data to draw Figure 2 and to describe the regional setting of the locality. Prof. Dr. J. Keith Rigby (Brigham Young University, Provo) provided a very helpful review of the manuscript.

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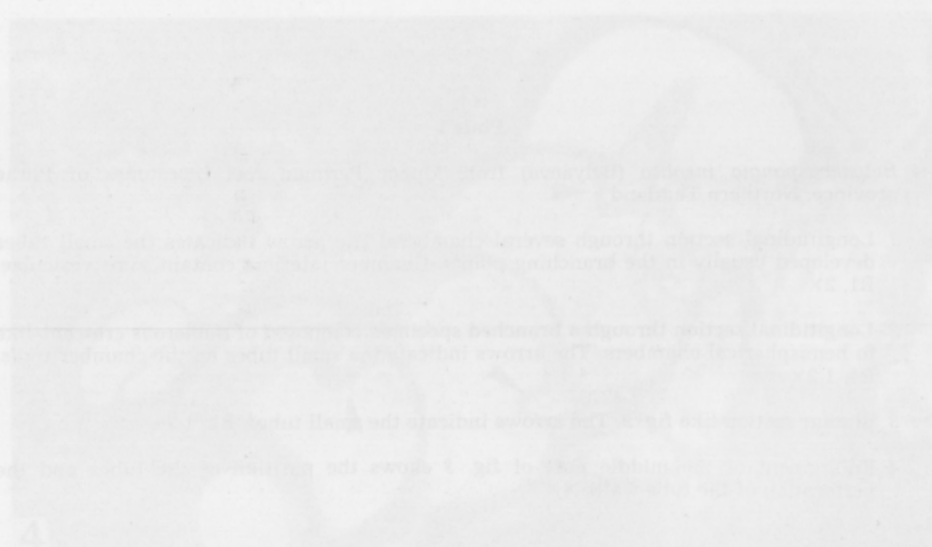


Plate 1

1-4 *Belyaevaspongia insolita* (Belyaeva) from Upper Permian reef limestones of Phrae province, Northern Thailand

- 1 Longitudinal section through several chambers. The arrow indicates the small tubes developed usually in the branching points. Chamber interiors contain some vesiculae. R1, 2×
- 2 Longitudinal section through a branched specimen composed of numerous crescent-like to hemispherical chambers. The arrows indicate the small tubes on the chamber roofs. R4, 1.2×
- 3 Similar section like fig. 2. The arrows indicate the small tubes. R2, 1.2×
- 4 Enlargement of the middle part of fig. 3 shows the position of the tubes and the perforation of the tube walls. 4×

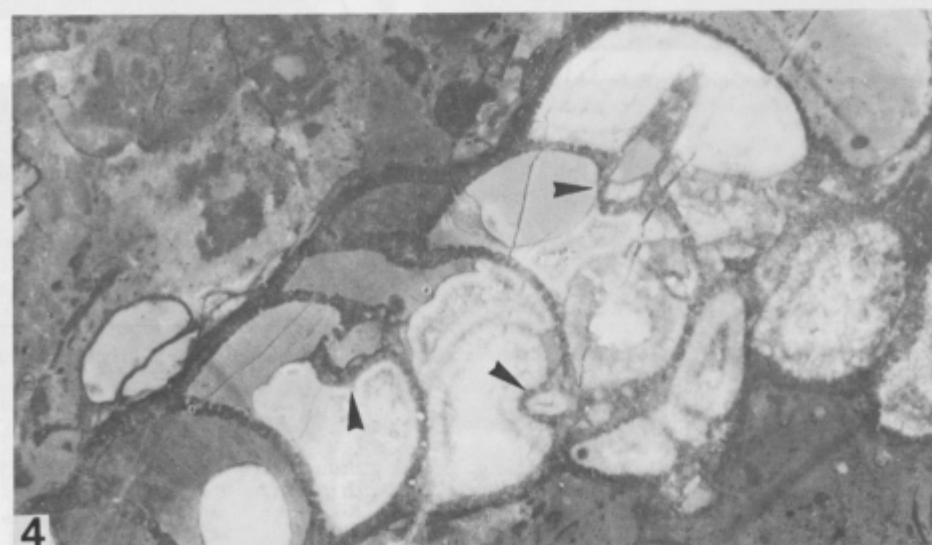
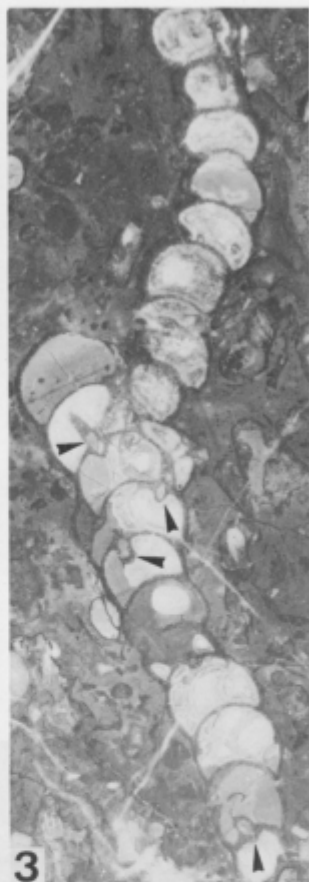




Plate 2

- 1 *Belyaevaspongia insolita* (Belyaeva). Longitudinal section through two or three(?) specimens. The arrows indicate the small tubes in the chamber walls. Natural weathered rock surface. R3, 1×
- 2 Enlargement of one specimen from fig. 1 (lower part) exhibits the small tube and perforation of the chamber walls, as well as the wall of the tube. R3, 3×
- 3 *Cystothalamia?* sp. or *Glomocystospongia?* sp. Section through glomerate chambers arranged in layers around the spongocoel. T1/2, 5×
- 4 *Sclerospongea* gen. et sp. indet. T5/1, 2.4×
- 5 *Discosiphonella* sp. Longitudinal- and transverse cross-section through two poorly preserved specimens. T1/2, 4×
- 6 *Discosiphonella* sp. Similar longitudinal section like fig. 5. T1/2, 8.5×
- 7 *Sollasia spheroida* Rigby, Fan and Zhang. Section through two chambers of a poorly preserved specimen. The chamber interiors are filled with vesiculae. T1, 3.2×

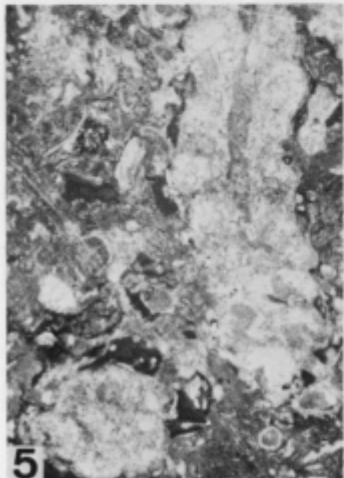
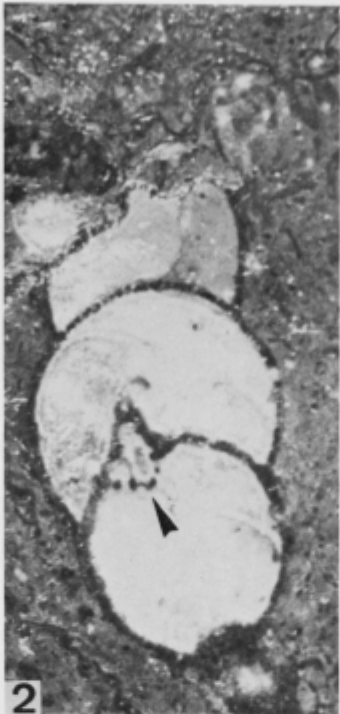




Plate 3

- 1 A) *Intraporeocoelia hubeiensis* Fan and Zhang. Longitudinal section through three specimen of different size. The specimen on the left side of the picture is branched. The two specimens on the right side exhibit some chambers with and some without spore-like filling structure
- B) *Phraethalamia tubulara* n. gen., n. sp. (holotype, compare pl. 4, fig. 1)
- C) Longitudinal and transverse cross sections of *Sollasia ostiolata* Steinmann
- D) Section through three chambers of a specimen of *Belyaevaspongia insolita* (Belyaeva). Natural weathered rock surface. R8, 0.7×
- 2 *Belyaevaspongia insolita* (Belyaeva). Section through a recrystallized specimen, 2×
- 3 Cross- and oblique-sections of *Peronidella* sp.. T4/2, 8×
- 4 *Belyaevaspongia insolita* (Belyaeva). Section through a branched specimen. The interior of some chambers (lower part) show some vesiculae. Natural weathered rock surface. T3, 0.7×

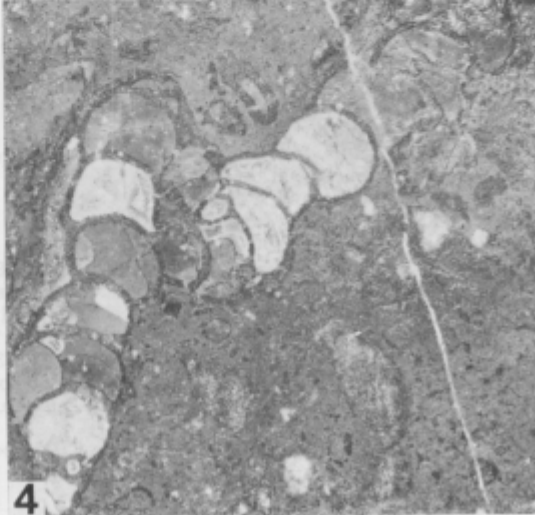
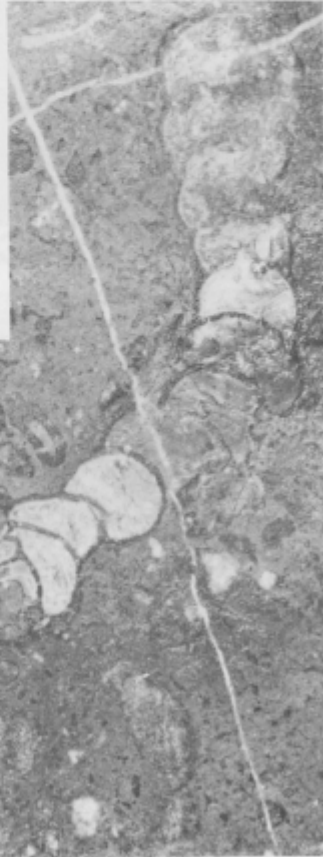
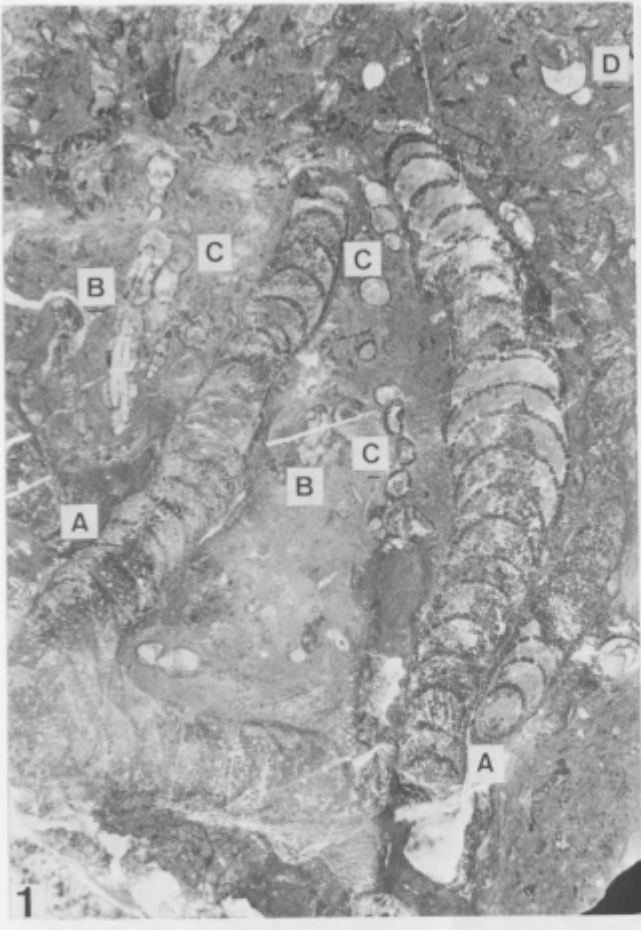




Plate 4

1 Enlargement from pl. 3, fig. 1

- A) *Phraethalamia tubulara* n. gen., n. sp. (holotype). Longitudinal section through several chambers and the two wide axial canals
 B) *Sollasia ostiolata* Steinmann
 C) Thalamid sponge indet. R8, 2×

2–5 *Intrasporeocoelia hubeiensis* Fan and Zhang, 1985

- 2 Longitudinal section through several crescent-like chambers. The chamber walls are characterized by their massive appearance and dark color. The chamber interiors are filled with recrystallized spore-like filling structure. T9, 2.5×
- 3 Similar section like fig. 2. Thin section. T1/2, 3×
- 4 Enlargment of three chambers from fig. 2 (upper part) exhibit the thin interwalls, thick exowalls of the chamber and the filling structure within the chamber interiors. Thin section. T9, 4×
- 5 Similar section as fig. 4. Thin section. T6/1, 3×

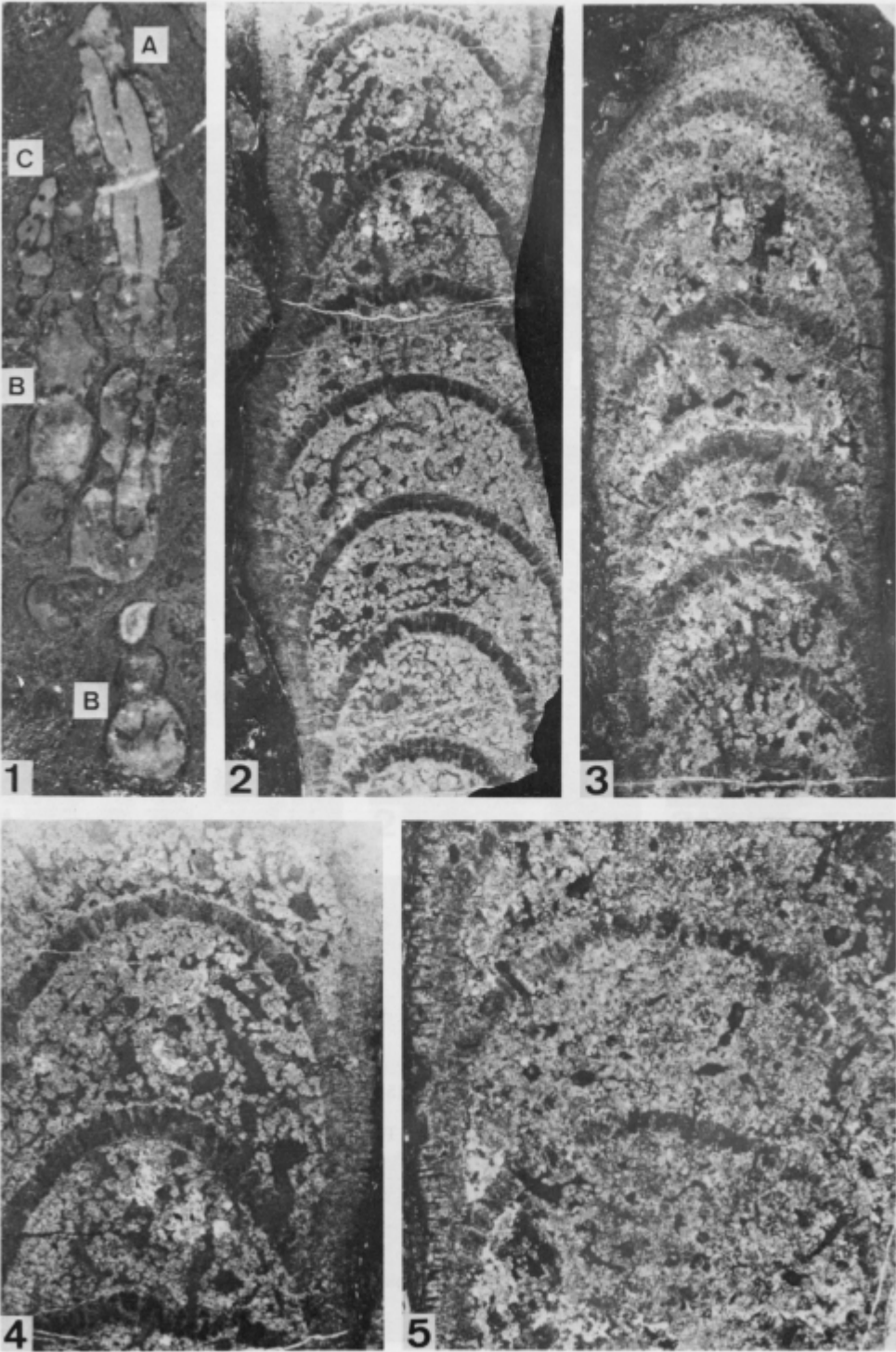
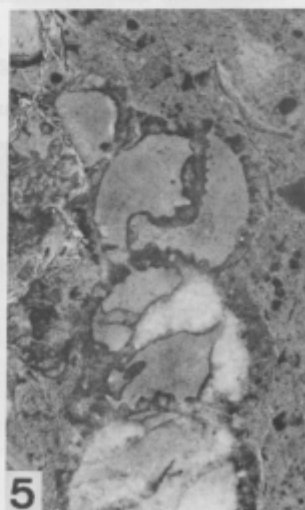
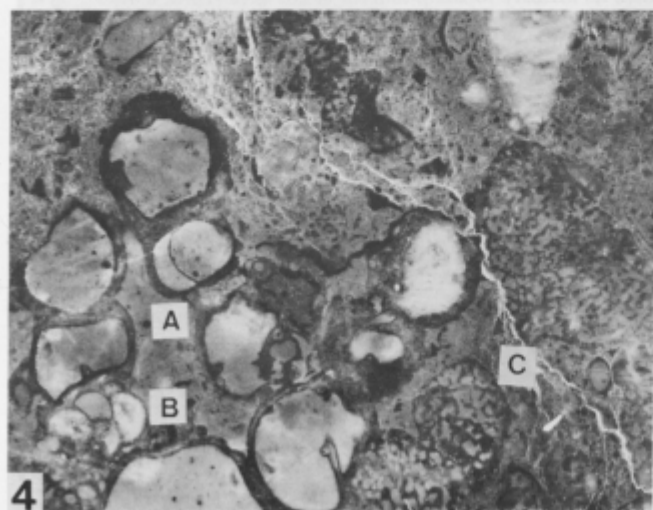
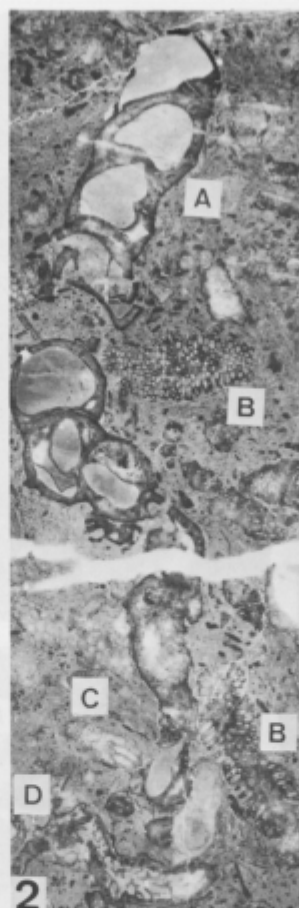
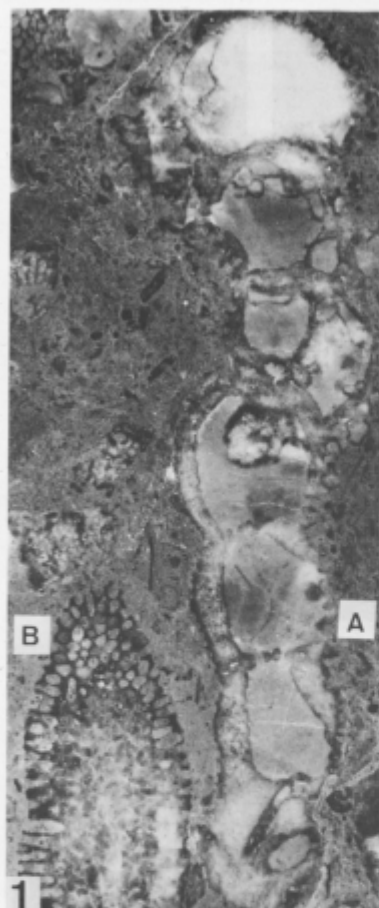




Plate 5

- 1 A) ? *Sollasia spheroida* or *Colospongia*?. Because of the perforation of the segment roofs the affinity to *Sollasia* is uncertain and the specimen could belong to *Colospongia*
 B) *Sclerosponge* gen. et sp. indet. R6, 4×
- 2 A) *Sollasia spheroida* Rigby et al. Longitudinal section through several chambers. The chamber interiors are partly filled with vesiculae
 B) *Sclerosponge* gen. et sp. indet
 C) *Bisiphonella tubulara*. Oblique section
 D) *Solutossaspongia crassimuralis* n. gen., n. sp. R5, 1.7×
- 3 *Bisiphonella tubulara* n. sp. Longitudinal section. The two spongocoels are cut in the lower part. R9, 3.2×
- 4 A) *Sollasia spheroida* Rigby et al. Section through several chambers
 B) A few chambers of *Discosiphonella* sp.
 C) *Ambithalamia permica* n. gen., n. sp. R6, 4×
- 5 *Colospongia* sp. Section through three spherical chambers. R9, 3×



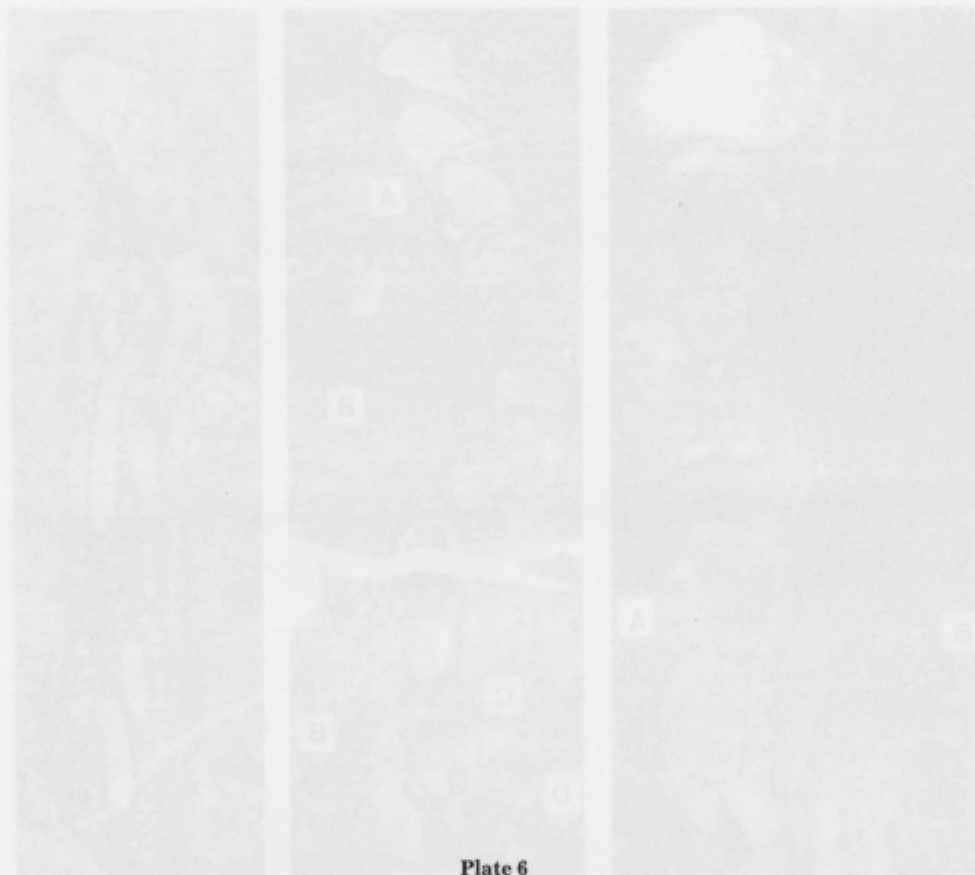


Plate 6

- 1 *Bisiphonella tubulara* n. sp. Longitudinal and transverse cross section. The cross section exhibits four canals and therefore its affinity to *Bisiphonella* is not sure. T6/2, 2.3×
- 2 A) *Bisiphonella tubulara* n. sp. Longitudinal to oblique section
B) Section through several glomerate chambers of *Discosiphonella* sp. T5/2, 2.7×
- 3 *Discosiphonella* sp. Longitudinal section through glomerate chambers around the axial spongocoel. T5/2, 5.4×
- 4 A) *Sollasia ostiolata* Steinmann
B) Section through an undetermined hexactinellid sponge
C) Several sections through an "inozoan" sponge. T3, 2.5×
- 5 *Peronidella* sp. Oblique- and transverse cross-sections through two specimens. T5/1, 2.7×
- 6 *Sollasia ostiolata* Steinmann. Section through three chambers. An ostium is cut in the wall of the youngest chamber. T4, 7×
- 7 A) *Bisiphonella tubulara* n. sp. Cross section exhibits the two spongocoels surrounded by a reticular fiber structure
B) *Peronidella* sp. Cross-section
C) Diverse and undetermined thalamid sponges. T2/1, 4×

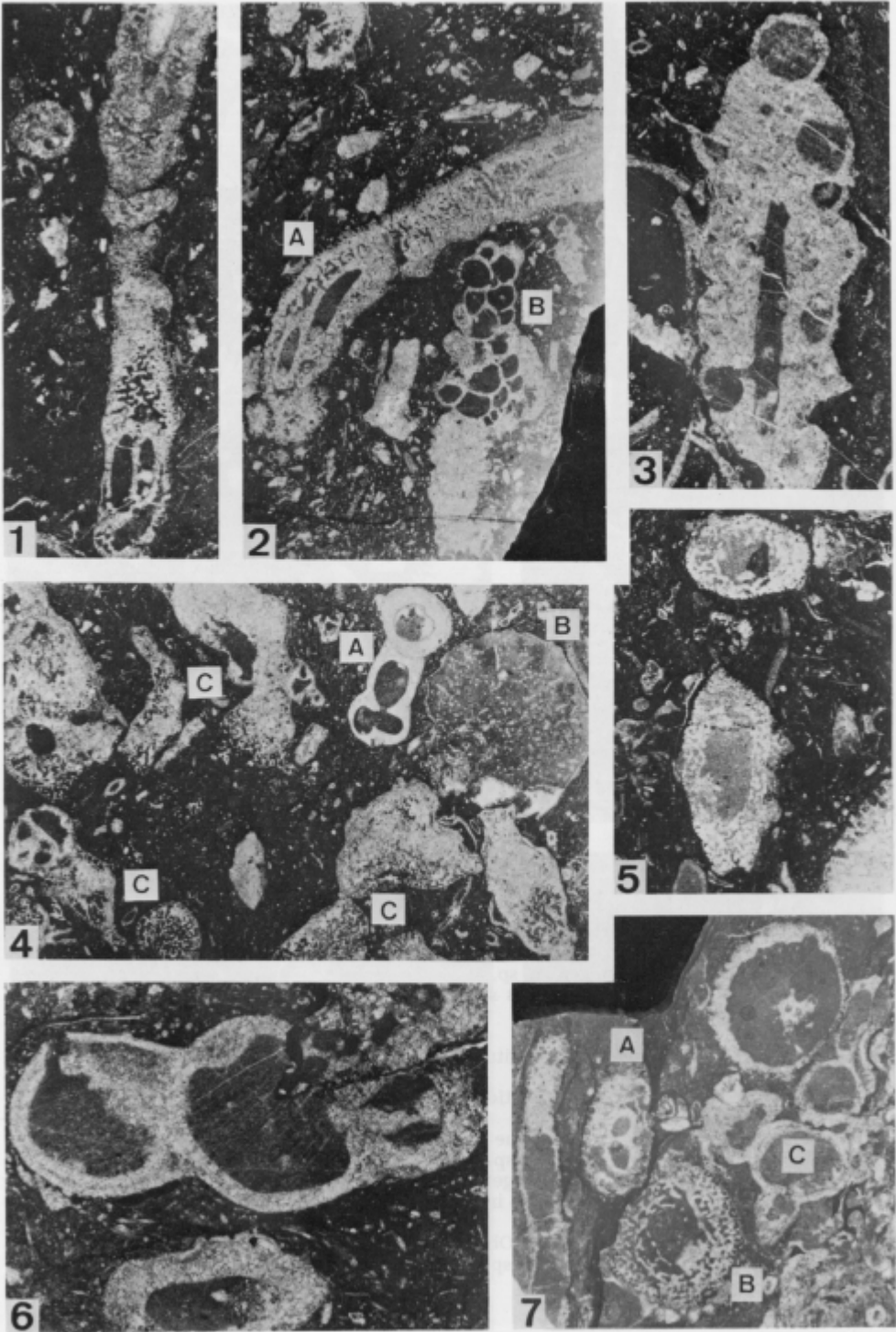




Plate 7

- 1 A) *Girtyocoelia beedei* (Girty). Longitudinal section. The spongocoel is cut in the upper part of sponge
 B) *Ambithalamia permica* n. gen., n. sp.
 C) *Bisiphonella tubulara* n. sp. Cross sections. In one specimen the two spongocoels can be seen. R7, 2×
- 2 A) *Bisiphonella tubulara* n. sp. Longitudinal section. The two spongocoels are cut in the upper part of the sponge
 B) *Sollasia spheroida* Rigby et al. Section through three chambers. R6, 4×
- 3 A) *Bisiphonella tubulara* n. sp. Oblique section
 B) *Ambithalamia tubulara* n. gen., n. sp.
 C) *Solutossaspongia crassimuralis* n. gen., n. sp. Cross section exhibits the thick outer wall and the loose fiberous structure of the interior of the sponge. R6, 4×
- 4 *Ambithalamia tubulara* n. gen., n. sp. Oblique section through several specimens exhibit the poorly developed segmentation of the sponge. R6, 4×

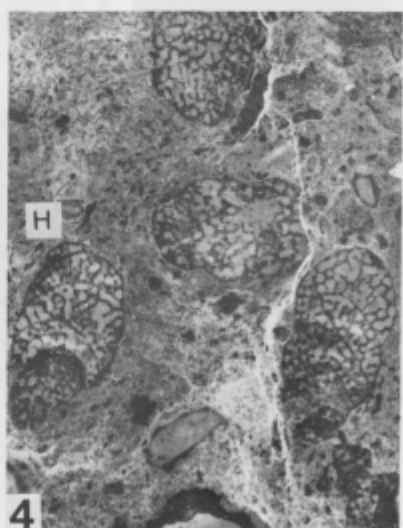
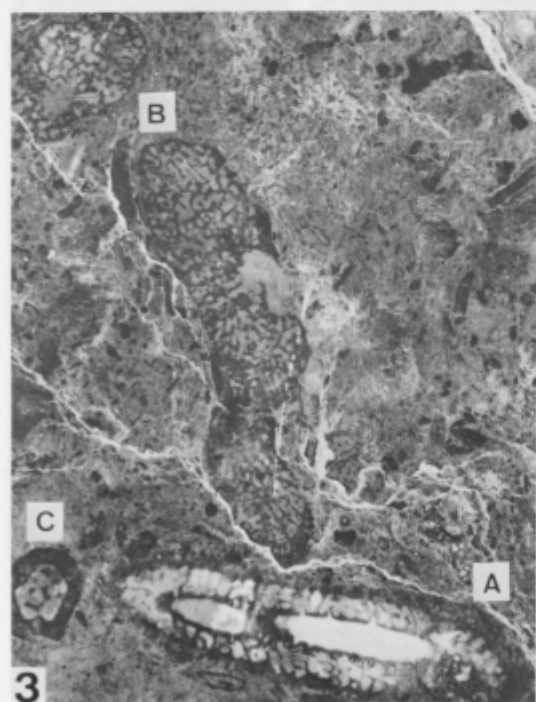
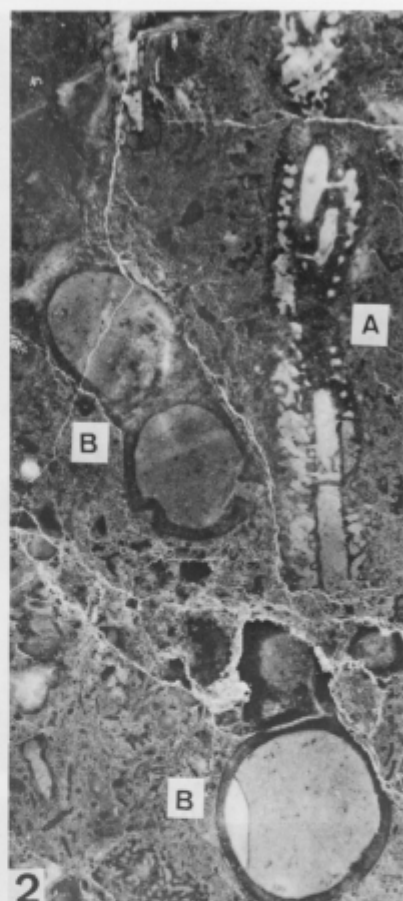
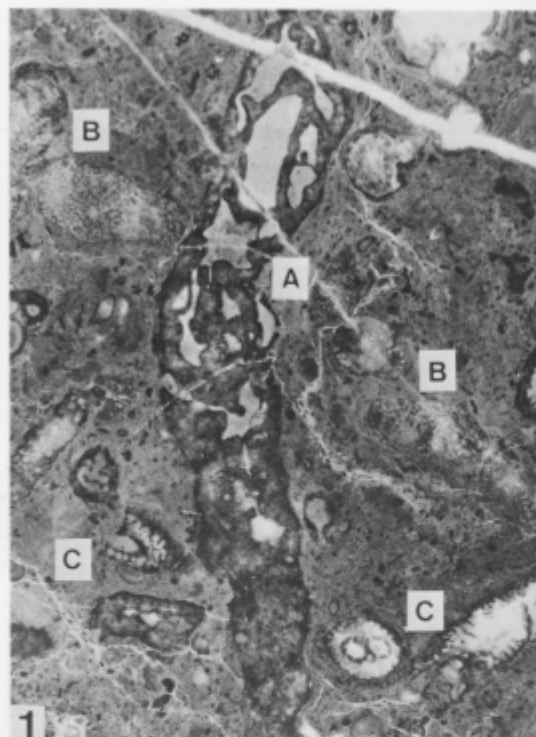
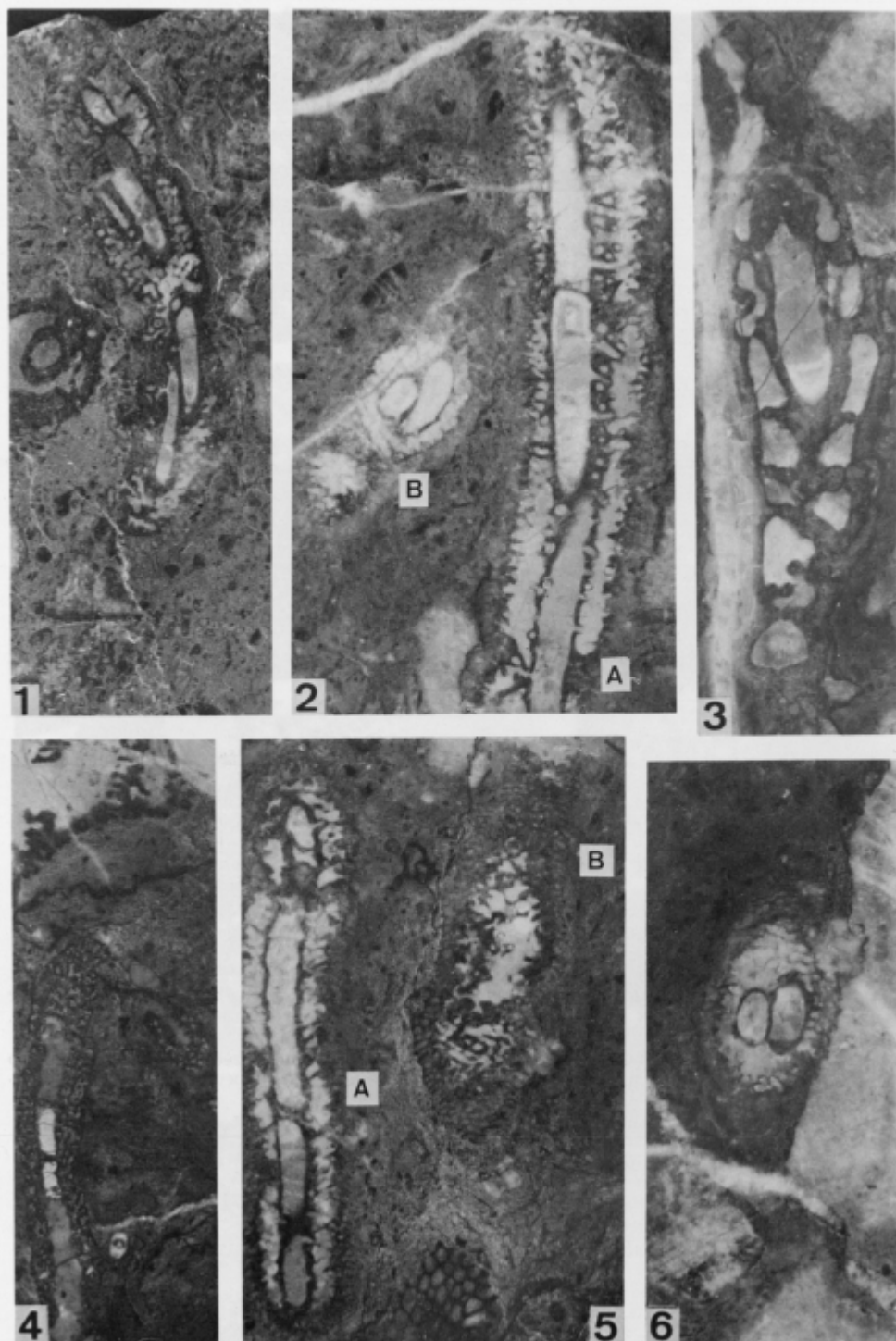




Plate 8

1, 2, 4-6 *Bisiphonella tubulara* n. sp. from Upper Permian reefal limestones of Phrae Province, northern Thailand

- 1 Peripheral section through the fiber skeleton exhibits the arrangement of the fibers. R4, 4×
- 2 A) Longitudinal section through holotype exhibits the two spongocoels, the pores on the spongocoel wall and the space between the wall of the spongocoels and the outer wall of the sponge
B) Cross section through a paratype exhibits the wide spongocoels. R1, 5×
- 4 Longitudinal section exhibits only one spongocoel in the axial part and a reticular fibrous structure around the spongocoel. The affinity of this sponge to *Bisiphonella tubulara* is uncertain. R1, 3×
- 5 A) Longitudinal section through a specimen exhibits one of the canals and the surrounding fiber structure
B) The basal part of the holotype. R1, 5×
- 6 Cross section exhibits the two wide spongocoels. R1, 6×
- 3 *Girtyocoelia* sp. Section through several ring-like chambers. The chambers are different in size. The spongocoel is cut in the middle part. R12, 6×



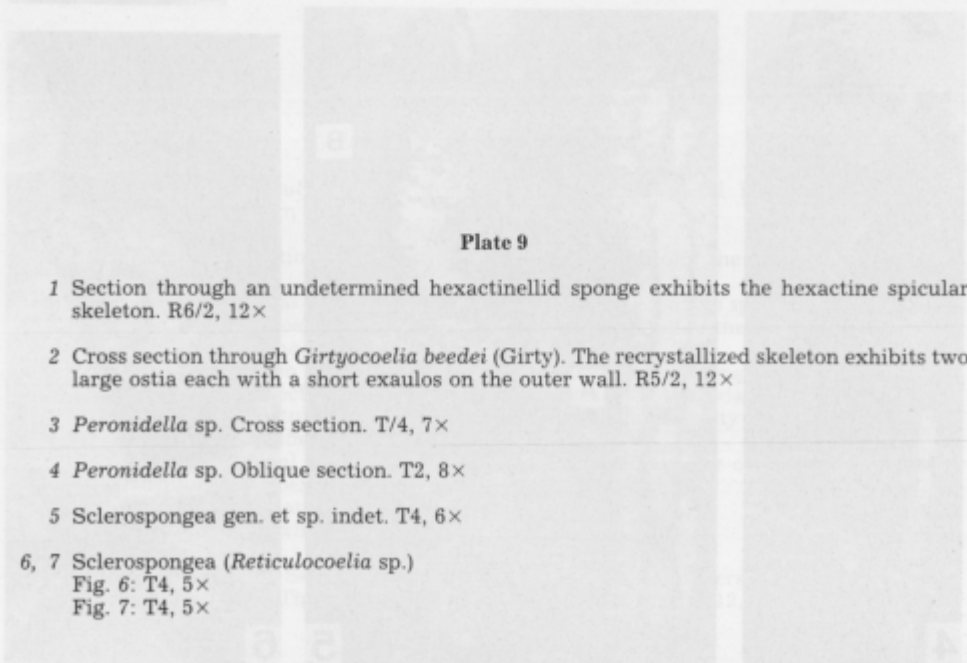
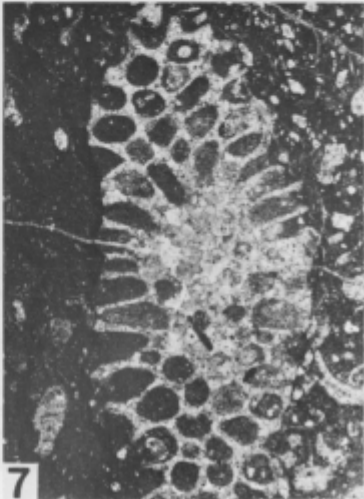
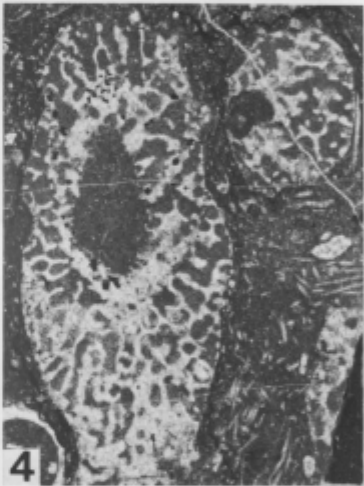
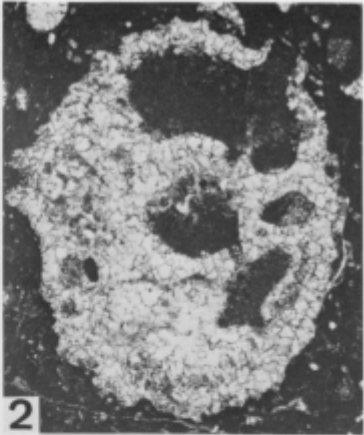
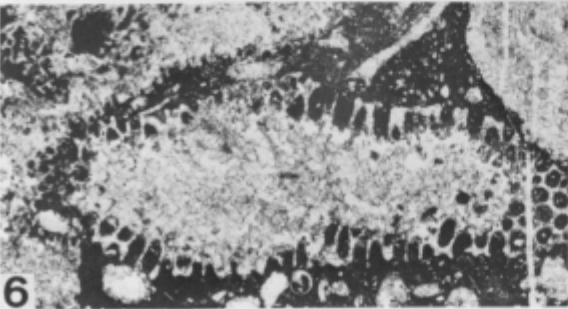
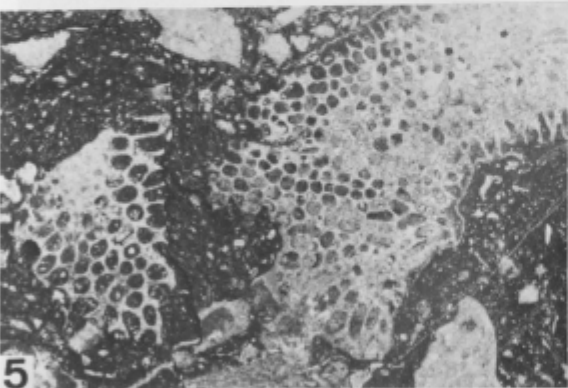
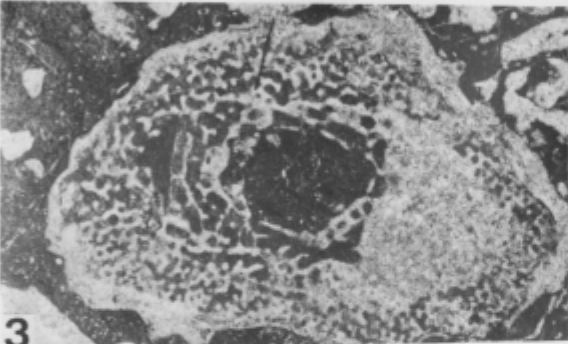
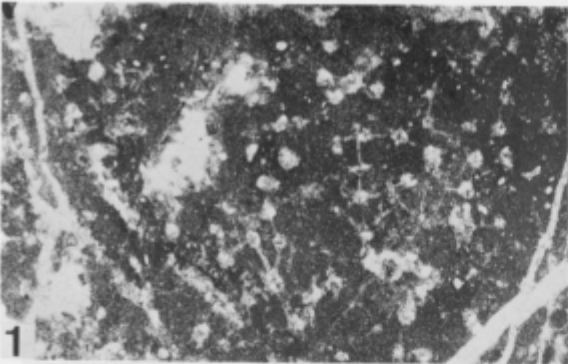


Plate 9

- 1 Section through an undetermined hexactinellid sponge exhibits the hexactine spicular skeleton. R6/2, 12×
- 2 Cross section through *Girtyocoelia beedei* (Girty). The recrystallized skeleton exhibits two large ostia each with a short exaulos on the outer wall. R5/2, 12×
- 3 *Peronidella* sp. Cross section. T/4, 7×
- 4 *Peronidella* sp. Oblique section. T2, 8×
- 5 *Sclerospongea* gen. et sp. indet. T4, 6×
- 6, 7 *Sclerospongea (Reticulocoelia)* sp.)
 Fig. 6: T4, 5×
 Fig. 7: T4, 5×



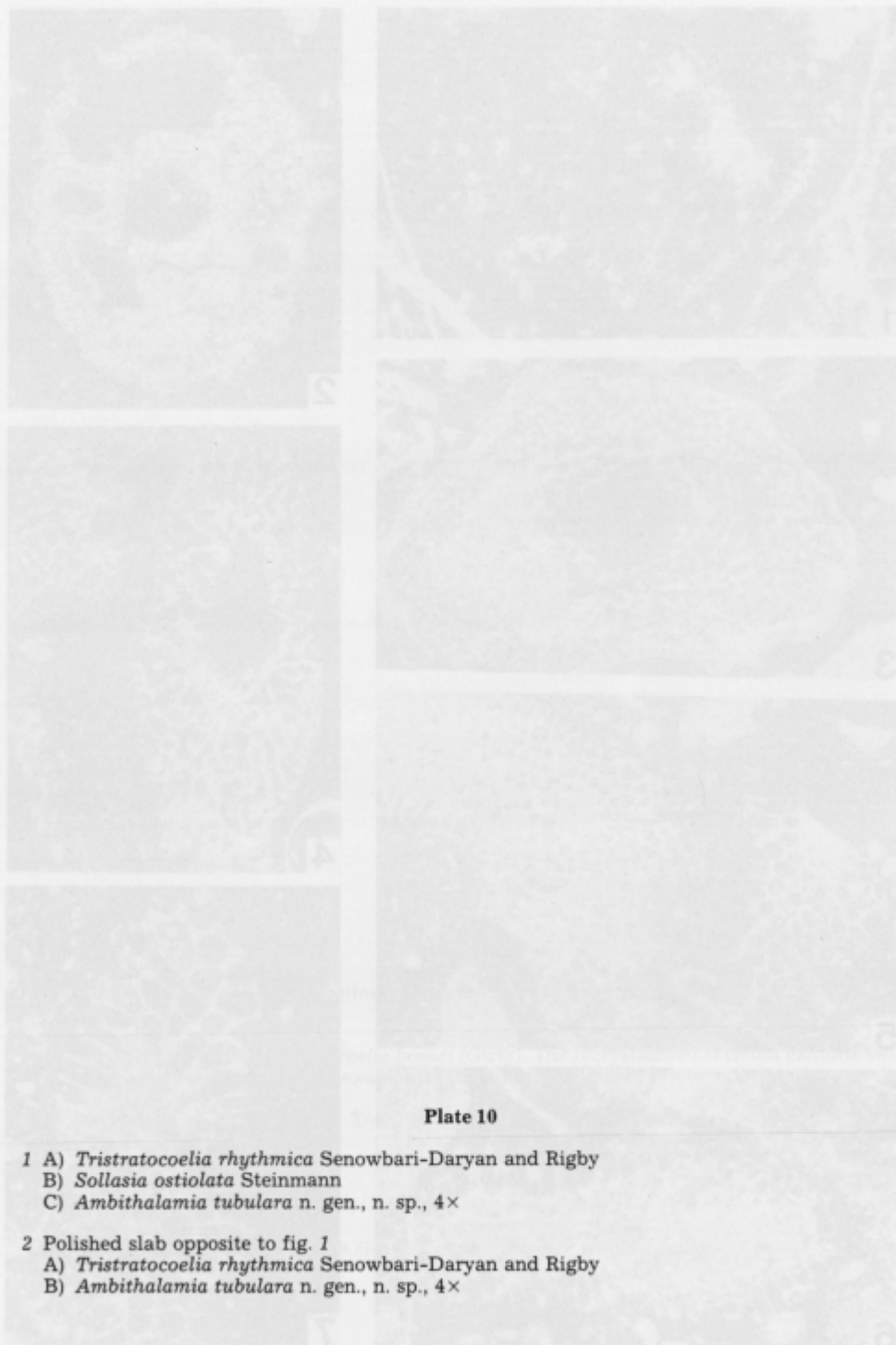


Plate 10

- 1 A) *Tristratocoelia rhythmica* Senowbari-Daryan and Rigby
 B) *Sollasia ostiolata* Steinmann
 C) *Ambithalamia tubulara* n. gen., n. sp., 4×
- 2 Polished slab opposite to fig. 1
 A) *Tristratocoelia rhythmica* Senowbari-Daryan and Rigby
 B) *Ambithalamia tubulara* n. gen., n. sp., 4×

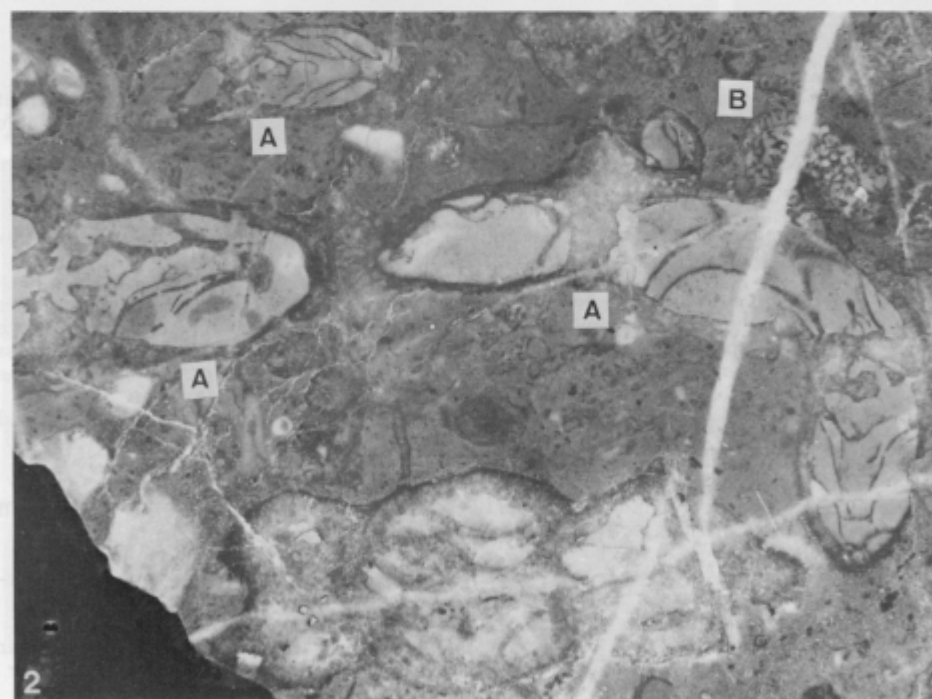




Plate 11

- 1 *Ambithalamia permica* n. gen., n. sp. Longitudinal and transverse cross sections exhibit the relatively easily recognizable segmentation of the sponge. The cross section (in the middle part of the picture) shows an axial cavity (spongocoel? or boring?). R4, 3,5×
- 2 A) *Phraethalamia tubulara* n. gen., n. sp.
 B) ? *Bisiphonella tubulara* n. sp. Marginal section?
 C) *Ambithalamia permica* n. gen., n. sp. The oblique section exhibits well developed segmentation. R14, 3,5×
- 3 A) *Phraethalamia tubulara* n. gen., n. sp. Longitudinal section through four chambers exhibiting the dichotomously branched tubes passing from the wall of the spongocoel into the interior of the chambers. Some vesiculae-like structure occur in the spongocoels. A cross section of a chamber of the same specimen (?) or an other specimen (?) is cut on the right in the picture
 B) *Ambithalamia permica* n. gen., n. sp. Longitudinal section exhibits the poorly developed segmentation
 C) Sphinctozoa gen. et sp. indet. R13, 2,3×
- 4 Inozoan sponge gen. et sp. indet. Cross sections through two specimens exhibit the fine and relatively regular reticular fibers. R17, 3,5×
- 5 *Ambithalamia permica* n. gen., n. sp. Oblique section exhibits the poorly developed segmentation and the regular fiber structure. R16, 3×
- 6 *Solutossaspongia crassimuralis* n. gen., n. sp. Longitudinal section exhibiting the thick outer wall and loose internal skeleton of the sponge. R9, 3,5×

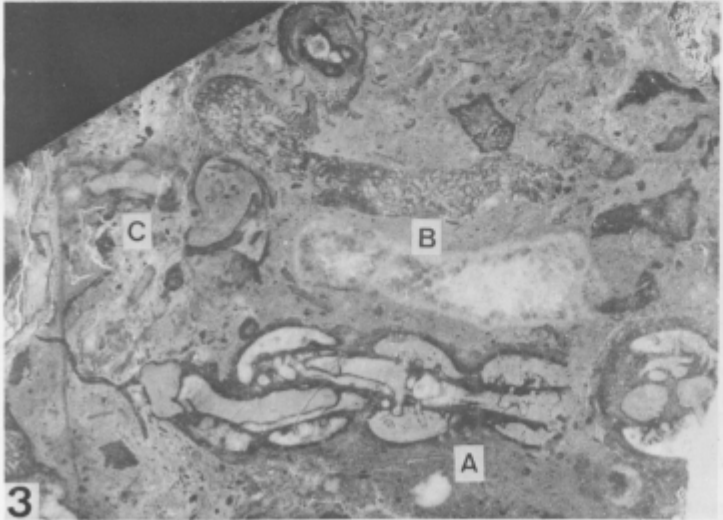
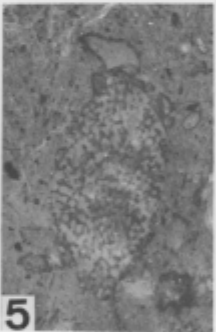
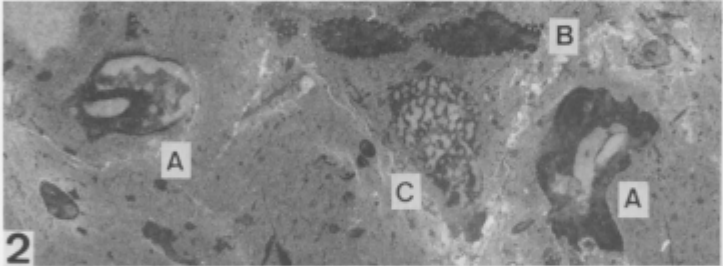
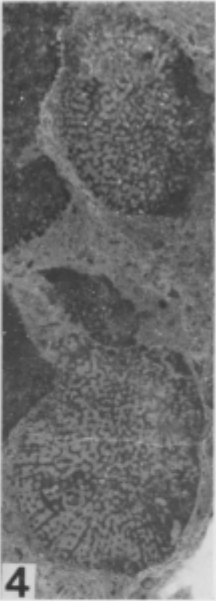
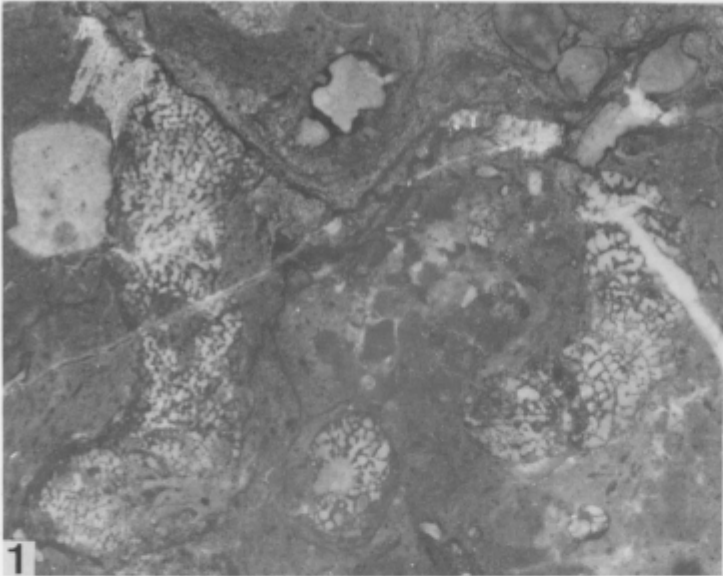




Plate 12

- 1 A) Thalamid sponge gen. et sp. indet.
 B) *Sollasia ostiolata* Steinmann
 C) *Slcerospongea* gen. et sp. indet
 D) Inozoan sponge gen. et sp. indet. R7, 4×
- 2 A) *Ambithalamia permica* n. gen., n. sp.
 B) *Solutossaspongia crassimuralis* n. gen., n. sp.
 C) *Bisiphonella tubulara* n. gen., n. sp. R6, 4×
- 3 A) *Ambithalamia permica* n. gen., n. sp.
 B) *Colospongia* sp.
 C) *Bisiphonella tubulara* n. sp. R7, 2×
- 4 *Solutossaspongia crassimuralis* n. g., n. sp. R6, 3×

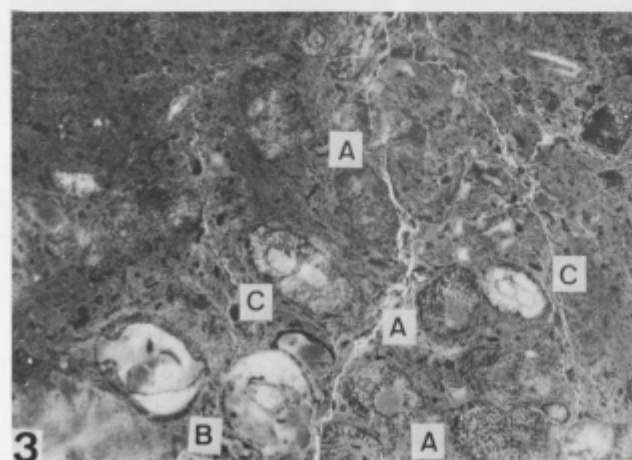
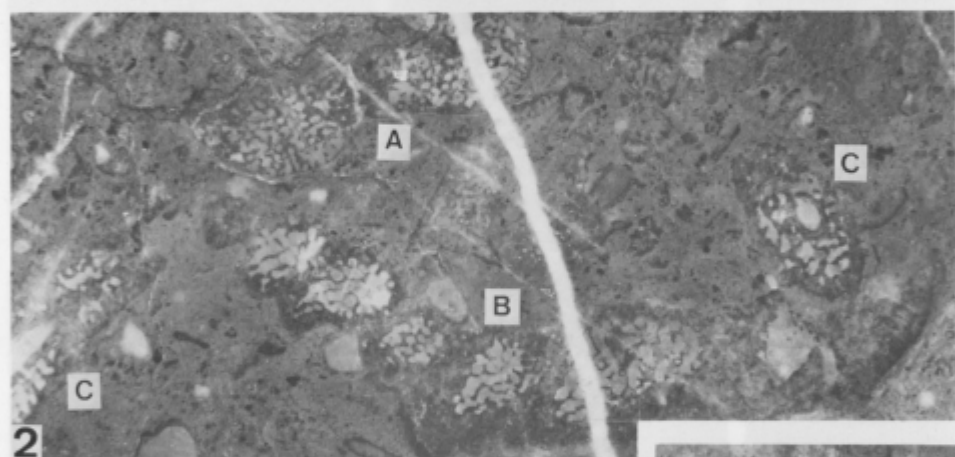
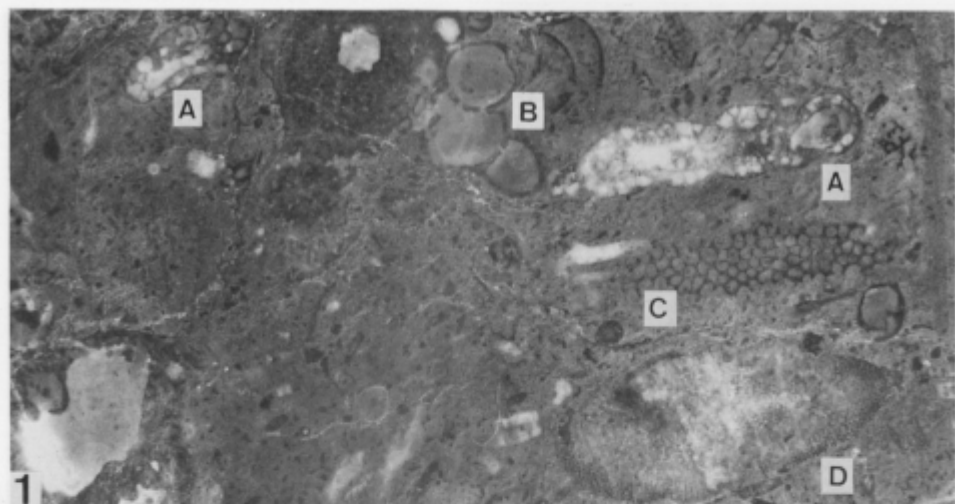




Plate 13

- 1 Inozoan sponge gen. et sp. indet. Longitudinal section through a branched specimen. R13, 3×
- 2 A) *Solutossaspongia crassimuralis* n. gen., n. sp.
B) *Bisiphonella tubulara* n. gen., n. sp. Cross sections through two specimens. R10, 3,5×
- 3 A) *Bisiphonella tubulara* n. sp.
B) *Ambithalamia permica* n. gen., n. sp.
C) *Solutossaspongia crassimuralis* n. gen., n. sp., R15, 3,5×
- 4 A) *Ambithalamia permica* n. gen., n. sp.
B) *Rhabdactinia* cf. *columnaria* Yabe and Sugiyama. Longitudinal section through some chambers. The chamber walls exhibit both small and large openings. R11, 3×
- 5 A) *Solutossaspongia crassimuralis* n. gen., n. sp. Longitudinal section of a specimen exhibiting the thick outer wall and the loose fibrous structure in the sponge
B) ?*Ambithalamia permica* n. gen., n. sp. R10, 3,5×
- 6 *Solutossaspongia crassimuralis* n. gen., n. sp. Cross section. R7, 3,5×
- 7 *Solutossaspongia crassimuralis* n. gen., n. sp. Section through a branched (?) specimen exhibits the thick outer wall and the loose fibers in the interior of the sponge. R6, 3,5×
- 8 *Bisiphonella tubulara* n. sp. Oblique to longitudinal section exhibits the two axial canals and the surrounding net-like fiber skeleton. R13, 3,5×

