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Sponge assemblage from the Permian reefal limestones of Kuh-e Bagh-e Vang, Shotori Mountains (eastern Iran)

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Abstract: An association of sphinctozoid and inozoid sponges and the problematic organism *Lercaritubus problematicus* are described from the Permian Jamal Formation exposed in Kuh-e Bagh-e Vang, south of the town of Shirgesht, in the Shotori Mountains, eastern Iran. The sponge taxa described, are: "**Sphinctozoida**": *Amblysiphonella rigbyi* nov. sp., *Baghevangia minima* nov. gen., nov. sp., *Shotorispongia permica* nov. gen., nov. sp., *Shotorispongia biserialis* nov. sp., *Thaumastocoelia*? cf. *Th. irregularis* Weidlich & Senowbari-Daryan, *Sollasia ostiolata* Steinmann, *Sollasia cylindrica* nov. sp., *Girtyocoelia beedei* (Girty), and *Lemonea cylindrica* (Girty); "**Inozoida**": *Peronidella recta grossa* Wu, *Bicoelia spinosa* nov. sp., *Heptatubispongia symmetrica* Rigby & Senowbari-Daryan, *Maeandrostia kansasensis* Girty, *Maeandrostia radiata* nov. sp., *Solutossaspongia tabasensis* nov. sp. **Problematic organism:** *Lercaritubus problematicus* Flügel, Senowbari-Daryan & Di Stefano. The sponge fauna of the Permian Jamal Formation of Kuh-e Bagh-e Vang is represented by at least 7 sphinctozoan genera (2 new) and 9 species (3 new) and 5 inozoan genera with 6 species (3 new). Among the documented genera *Amblysiphonella rigbyi* nov. sp. seems to be the most abundant species, followed by the inozoid species *Maeandrostia kansasensis* Girty and *Heptatubispongia symmetrica* Rigby & Senowbari-Daryan. The sponge fauna of Kuh-e Bagh-e Vang is similar to sponge faunas described by Senowbari-Daryan & Di Stefano (1988) from the Lower Permian reef boulders of Sosio Valley, western Sicily, and from the Permian reefal limestones of Oman. The sponge-bearing reefal carbonates of Kuh-e Bagh-e Vang can be classified as sponge-*Tubiphytes*-*Archaeolithoporella*-boundstones.

Key words: Permian, Iran, Shotori Mts, sponges, sphinctozoans, inozoans, problematica.

Introduction

Coralline sponges ("Sphinctozoida", "Inozoida", and "Chaetetida") are the most abundant reef builders in the late Paleozoic and Triassic reefs of the world. Hexactinellida are also known from Permian reefs of Texas (e.g. Finks 1960) and Triassic reefs of China (e.g. Wu & Xiao 1989; Rigby et al. 1999a; Wu 1990), the Pamir region (Boiko et al. 1991), Iran (Senowbari-Daryan & Hamedani 1999), and the Alps (Keupp et al. 1989), but their abundance and diversity is much lower than the coralline representatives. The number of coralline sponge taxa in some Permian reefs is very high, and locally exceeds 50 species (e.g. in Djebel Tebaga, Tunisia: Termier & Termier: in Termier et al. 1977; Senowbari-Daryan & Rigby 1988; Rigby & Senowbari-Daryan 1996; or in China: Deng 1981, 1982a,b; Rigby et al. 1989a,b, 1994; Fan & Zhang 1985; Fan et al. 1991, 2002; Zhang 1983; Wu 1991). The sponge fauna of the Permian Jamal Formation in Kuh-e Bagh-e Vang is rich in individuals, but has low diversity.

The foraminiferal assemblage of Kuh-e Bagh-Vang was described by Leven & Vaziri Moghaddam (2004). According to these authors the age of the sponge-bearing beds of the Jamal Formation in Kuh-e Bagh-e Vang is dated as Early Permian (Bolorian = Kungurian).

Sponges from the Permian Jamal Formation of Iran have not been previously described in detail. *Amblysiphonella iranica* was reported from the Permian deposits outcropping near Mount La Kaftari, north of Esfahan, by Senowbari-Daryan & Hamedani (2002), and the new wewokellid sponges *Iranospongia circulara* and *Regispongia fluegeli* by Rigby, Senowbari-Daryan & Hamedani. (2005) from the same locality.

The following sponge taxa from the Permian of Kuh-e Bagh-e Vang (Shotori Mts) are described in this paper:

— "**Sphinctozoida**": *Amblysiphonella rigbyi* nov. sp., *Baghevangia minima* nov. gen., nov. sp., *Girtyocoelia beedei* (Girty) 1908a, *Lemonea cylindrica* (Girty) 1908b, *Shotorispongia permica* nov. gen., nov. sp., *Shotorispongia biserialis* nov. sp., *Sollasia ostiolata* Steinmann, 1882, *Sollasia cylindrica* nov. sp., *Thamastocoelia*? cf. *Th. irregularis* Weidlich & Senowbari-Daryan, 1996.

— "**Inozoida**": *Bicoelia spinosa* nov. sp., *Heptatubispongia symmetrica* Rigby & Senowbari-Daryan, 1996, *Maeandrostia kansasensis* Girty, 1908a, *Maeandrostia radiata* nov. sp., *Slutossaspongia tebagensis* nov. sp.

— **Problematic organism** (sponge?): *Lercaritubus problematicus* Flügel, Senowbari-Daryan & Di Stefano, 1990.

The investigated material is deposited in collections at the Institute of Paleontology, University of Erlangen-Nürnberg, Germany ("material Senowbari-Daryan: Perm Iran, Bagh-e Vang").

Locality

The Permian deposits in Iran, defined as the Jamal Formation, outcrop in several localities in the Shotori Mts in eastern and also in central Iran. The type locality of the Jamal Formation is in Kuh-e Jamal (33°21′N, 57°19′ E) in the southern neighbouring area of Kuh-e Shotori (Stöcklin et al. 1965). Here the Jamal Formation has a total thickness of 473 m.

A section of the Permian Jamal Formation crops out on the western flank of the Kuh-e Bagh-e Vang (33°58′60″ N, 56°47′66″ E, Fig. 1), and is located about 65 km NW of Tabas (Fig. 1), approximately 5 km south of the town of Shirgesht (geol. map Shirgesht 1:100,000 by Ruttner et al. 1968). Here the section reaches a thickness of 293 m (Ruttner et al. 1968) to 300 m (Leven & Vaziri Moghaddam 2004). The Permian deposits of the Jamal Formation are underlain by the sandy and shaly Carboniferous Sardar Formation, and are overlain by the Lower Triassic Sorkhe Shale Formation (Fig. 2). The boundary of Carboniferous to Permian is placed at a hiatus, where sedimentation was interrupted (Fig. 3).

Generally the Jamal Formation is composed of dolomites, thin to medium bedded, massive, and different coloured limestones and marls with some olistoliths (up to 3 m in diameter) in the lower part. Partoazar (1995) defined the 60 m basal part of the Jamal Formation as an independent formation named the Bagh-e Vang Formation as Asselian–Sakmarian in age. This term was used as the Bagh-e Vang Member by Leven & Vaziri Maghaddam (2004), who differentiated 10 units within the Jamal Formation (Fig. 2). According to foraminiferal stratigraphy of Kahler (1974) and Leven & Vaziri Moghaddam (2004), the Bagh-e Vang Member (the basal part 60 m) of the Jamal Formation in Kuh-e Bagh-e Vang is Bolorian (Kungurian), the middle part (150 m) is Kubergandian–Murgabian (Roadian–Wordian), and the upper part (90 m) is Midian–Dorashamian (Capitanian–Changhisingian) in age. The described sponges are from the lower part of the section, which is of Bolorian (Kungurian) age (Fig. 3).

Ruttner et al. (1968) and Leven & Vaziri Moghaddam (2004) mentioned the occurrence of different micro- and macrofossil groups, including fusulinids, corals, cephalopods, gastropods, crinoids, and brachiopods, but reported nothing about the occurrence of sponges. The sponges, described here, were collected mostly in boulders derived from the lower and middle parts of the Jamal Formation.

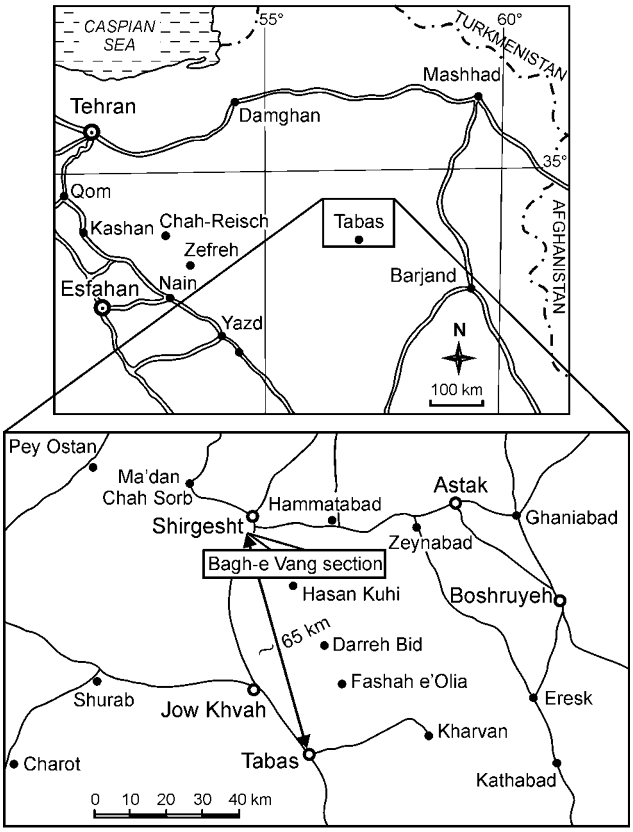

Fig. 1. Geographical position of Kuh-e Bagh-e Vang south of the town of Shirgesht (after Leven & Vaziri Moghaddam 2004).

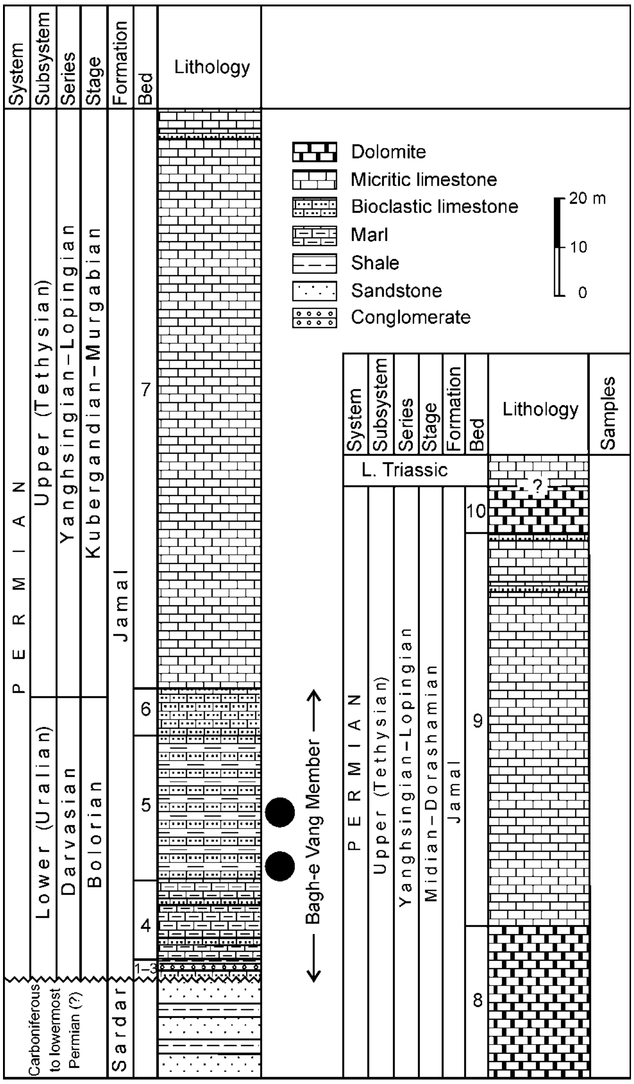

Fig. 2. Section of Kuh-e Bagh-e Vang. The dots indicate the sponge-bearing carbonate beds in the section (modified after Leven & Vaziri Moghaddam 2004).

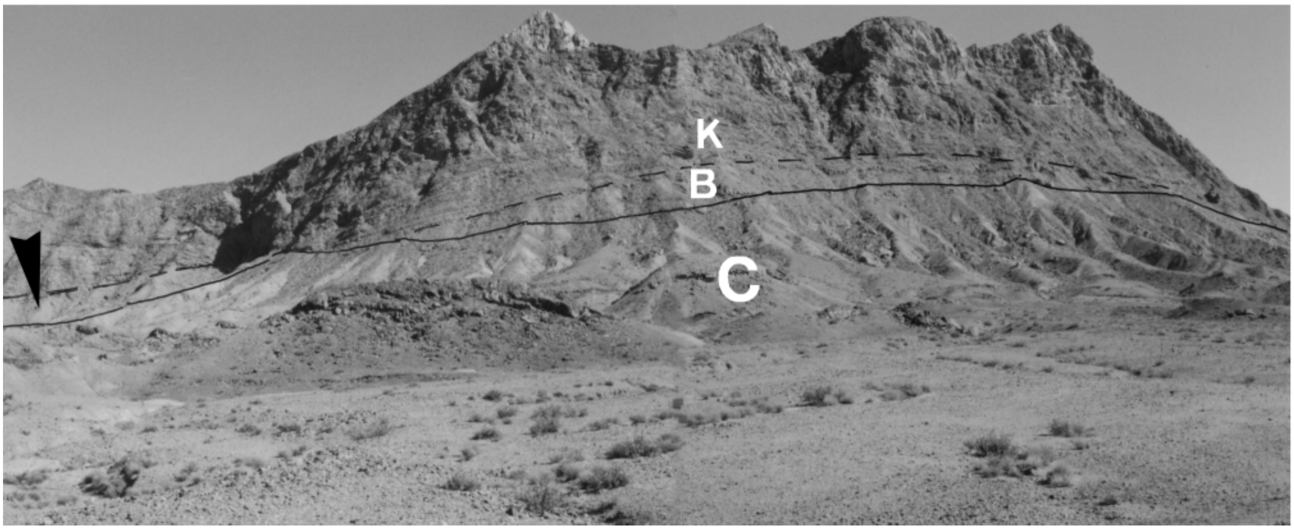

Fig. 3. View to the west flank of the Kuh-e Bagh-e Vang. The sponge-bearing reefal carbonate beds crop out in the middle part, where most sponge specimens were collected (arrow). **C** — Carboniferous, **B** — Bolorian, **K** — Kubergandian.

Systematic Paleontology

Phyllum: **Porifera** Grant, 1836
Class: **Demospongea** Sollas, 1875
Superclass: **Ceractinomorpha** Lévi, 1973
Order: **Permosphincta** Termier & Termier, 1974
Suborder: **Porata** Seilacher, 1962
Family: **Sebargasiidae** Laubenfels, 1955
Subfamily: **Sebargasiinae** Senowbari-Daryan, 1990
Genus: *Amblysiphonella* Steinmann, 1882

Diagnosis: See Senowbari-Daryan & Rigby (1988: p. 179).

Type species: *Amblysiphonella barroisi* Steinmann, 1882.

Amblysiphonella rigbyi nov. sp.
(Fig. 4.1–5)

Derivatio nominis: This species is dedicated to Prof. Dr. J.K. Rigby (Provo, Utah) for his contributions to sponge paleontology and especially for coordinating preparation of the revised volumes on Porifera of "Treatise on Invertebrate Paleontology, Part E, Vols. 2 and 3".

Holotype: The holotype is designated as the specimen in Fig. 4.4/H.

Paratypes: All specimens illustrated in Fig. 4.1–3,5.

Locus typicus: Kuh-e Bagh-e Vang, south of the town of Shirgesht, Shotori Mts, Iran.

Stratum typicum: Lower Permian (Bolorian, Kungurian) of the Jamal Formation.

Diagnosis: Small specimen of *Amblysiphonella* with weakly defined outer but clear internal segmentation. The thick outer-, inter- and endowalls are coarsely perforated. The barrel-like ring-chambers are relatively high and lack vesiculae or other internal structures within the chamber interiors.

Differential diagnosis: See after the species description.

Material: Numerous specimens in thin sections 1/3/1, 1/3/2 (holotype), 1/7, and 3/1.

Description: The catenulate stems of this species of *Amblysiphonella* have a length of up to 50 mm, usually with a diameter of 4–6 mm, maximum of 8 mm. Usually numerous specimens occur together. Outer segmentation of the sponge, corresponding to the internal segmentation, is weakly annulate or, in some specimens, almost not recognizable. An axial retrosiphonate spongocoel with a diameter of about 2 mm (1–3 mm) passes through the complete length of the sponge. The barrel-shaped (in longitudinal sections more quadrangular) ring-chambers have heights of up to 3.5 mm (2–3.5 mm). Chamber walls are about 0.3 mm thick, but they are usually recrystallized and thickened, measuring up to 0.9 mm thick. The exo- (outer), inter- (wall between two chambers) and endowalls (wall of spongocoel) are pierced by coarse pores of 0.2–0.3 mm in diameter (Fig. 4.3,4). Vesiculae or other types of filling structures are lacking within the chamber interiors. However, some vesiculae-like structure occurs within the spongocoel of the holotype connecting both sides of the endowalls.

Remarks: *Amblysiphonella* is a long-lasting sponge genus known from the Cambrian–Ordovician (to date *Amblysiphonella* has not been reported from the Silurian or Devonian) and from the Carboniferous to the Triassic (Senowbari-Daryan & García-Bellido 2002). Approximately 60 species are known from Paleozoic and Triassic deposits. All species known up to 1990 are listed with diagnostic features by Senowbari-Daryan (1990: p. 62) and those known up to 2000 by Senowbari-Daryan & García-Bellido (2002).

The genus *Amblysiphonella,* as *A. iranica* Senowbari-Daryan & Hamedani, 2002, was reported recently for the first time from Permian deposits of Iran. It came from the Lower Permian of Kuh-e La Kaftari, SE of Bahgerabad (NE of Esfahan). In comparison the stem diameter of *A. iranica,* at

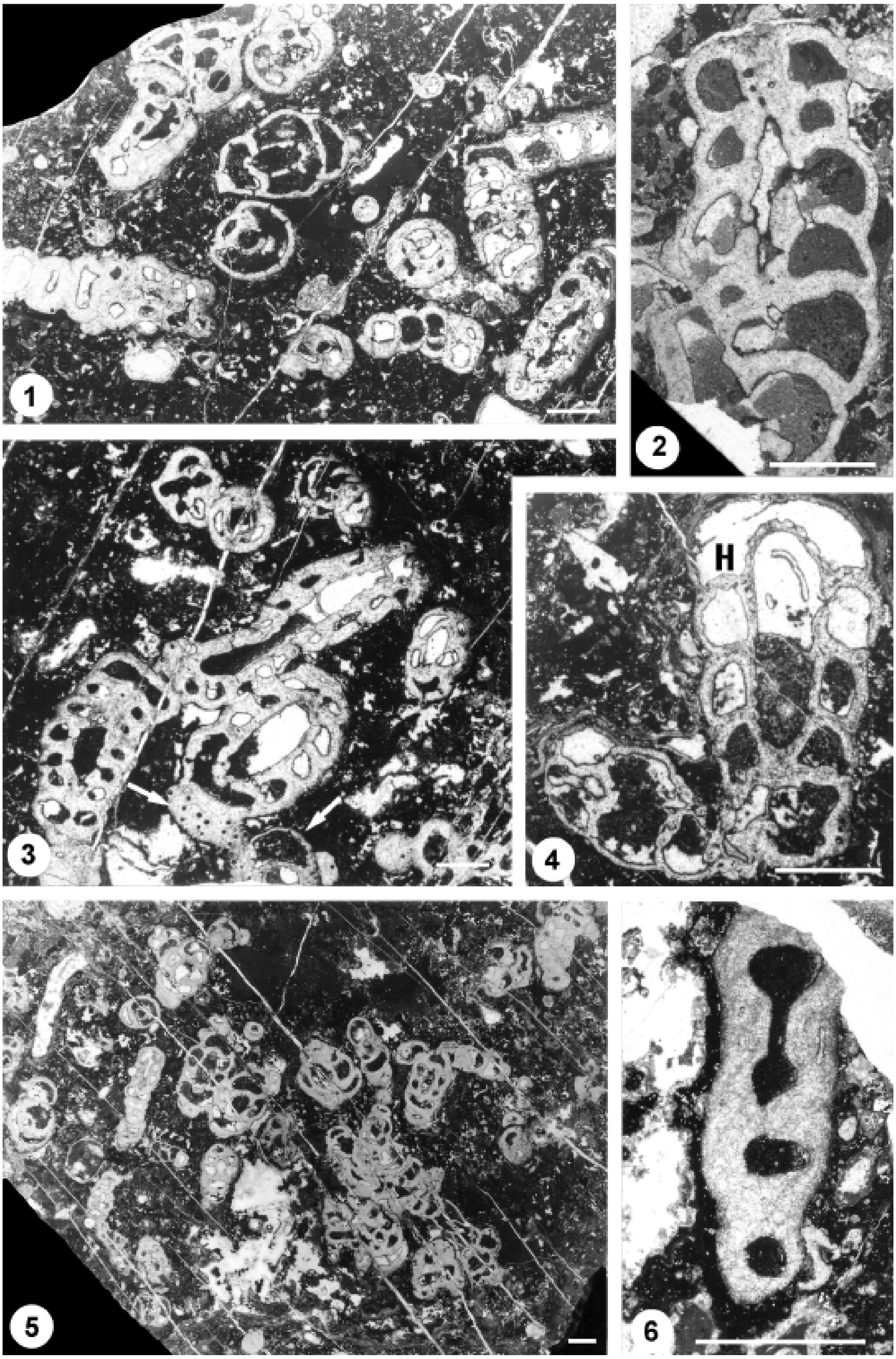

Fig. 4. *Amblysiphonella rigbyi* nov. sp. and *Sollasia cylindrica* nov. sp. from the Permian reefal limestones of Jamal Formation of Kuh-e Bagh-e Vang, Shotori Mountains. **1–5** — *Amblysiphonella rigbyi* nov. sp. 1 — Different sections through numerous specimens, which grow together. 1/3/2. 2 — Marginal axial section through a specimen exhibits the axial canal and perforation of the endowall. 7/1. 3 — Different sections through several specimens. Arrows indicate the coarse perforation of the chamber wall in a specimen. 1/3/2. 4 — Section through two specimens. H — Holotype. The perforation of endowall is clearly shown. 1/3/1. 5 — Sections through numerous specimens that grew together. 3/1. **6** — *Sollasia cylindrica* nov. sp. Longitudinal section through a cylindrical stem exhibiting thick chamber walls and the large opening between two chambers 7/2a. Scale bars = 4 mm.

15–27 mm, is much bigger than that of *A. rigbyi* (maximum of 8 mm). Other diagnostic features of the two Iranian species are also different, making a detailed comparison of these species unnecessary.

According to the sponge diameter and other diagnostic features (see Senowbari-Daryan 1990: p. 62) other species of *Amblysiphonella* are larger than *A. rigbyi*, except the following ones that may be compared with the new species from Iran:

— *A. yoshinoi,* described from the Permian of Japan by Akagi (1958), differs from *A. rigbyi* in having a large diameter (12.5 mm), thickness of the wall (0.1 mm exowall, endowall: 0.02 mm), and by much smaller pores in the exowall (0.06–0.1 mm) and endowall (0.02 mm).

— *A. planorbis* from the Permian of Japan, described by Hayasaka (1918), with a diameter of 11 mm is larger than the new species. Also, the diameter of the pores (less than 0.2 mm) in *A. planorbis* is much smaller than pores in *A. rigbyi.*

— *A. benschae* Zhuravleva (in Boiko et al. 1991), described from the Upper Carboniferous and Lower Permian of the Pamir Mts, is differentiated from *A. rigbyi* by large dimensions, well defined outer segmentation and by fine and dichotomously branched pores of the segment walls. This is also true of *A. eleganta* Belyaeva (in Boiko et al. 1991).

The sponge diameter (4 mm) of *A. tenuiramosa,* described by Boiko (in Boiko et al. 1991) from the Upper Permian of Primorie, corresponds to that in *A. rigbyi,* but it differs in the shape and the height of the chambers.

The dimensions of *A. rigbyi* are close to the Carboniferous species *A. carbonara* (Steinmann), but the later has smaller pores of endowalls (see García-Bellido et al. 2004). In addition, *A. carbonara* is limited to the Carboniferous and does not occur in Permian deposits. No other species of *Amblysiphonella* are comparable with the new species from the Permian of Kuh-e Bagh-e Vang.

Occurrence: Presently only known from the Permian of Kuh-e Bagh-e Vang, Shotori Mts, Iran.

?Family: **Phragmocoeliidae** Ott, 1974
Genus: *Baghevangia* nov. gen.

Derivatio nominis: Named after Kuh-e Bagh-e Vang (Mount Bagh-e Vang), where the sponge was found.

Diagnosis: Perforate, moniliform, weakly segmented, unbranched and small sponge of 2 mm in diameter with a wide axial spongocoel of prosiphonate(?) type. Filling skeleton of reticular to septate type resemble some archaeocyathid constructions. Microstructure of skeleton and spicules are not known.

Type species: *Baghevangia minima* nov. sp.

Discussion: The thalamid sponge family Phragmocoeliidae Ott (1974) is characterized by septate filling structures within the chambers. Two other genera with such filling skeletons are known: *Phragmocoelia* Ott (1974) from the Upper Triassic (Carnian) of the Alps, and *Radiothalamos* Pickett & Rigby (1983) from the Devonian of New South Wales (Australia). The filling skeleton of *Baghevangia* is arranged more radially in cross sections but in longitudinal section it appears more reticular, separating this genus from both of the mentioned genera. Therefore, the attribution of the new genus to the family Phragmocoliidae is uncertain.

Baghevangia minima nov. sp.
(Fig. 5.1–10, Fig. 6)

Derivatio nominis: Named for the small dimensions of the sponge.

Holotype: Specimen cut in longitudinal section is illustrated in Fig. 5.1/H (thin section 8/4/1).

Paratypes: All specimens figured in Fig. 5.1/P,2–10.

Locus typicus: Kuh-e Bagh-e Vang, south of the town of Shirgesht, Shotori Mts, Iran.

Stratum typicum: Lower Permian (Bolorian, Kungurian) of the Jamal Formation.

Diagnosis: See diagnosis of the genus.

Material: Numerous specimens in thin sections 3/2/1, 3/2/2, 4/1, 8/3, 8/4/1 (holotype), 12/2, 13/7, and 13/9.

Description: Numerous specimens are cut in transverse sections but only a few in longitudinal sections. The moniliform and unbranched stems of this species have spherical chambers and reach a height of up to 10 mm, with maximum diameters of 2.5 mm. Outer segmentation is more or less well developed but corresponding internal segmentation is weakly developed. An axial spongocoel, up to 1.1 mm in diameter (almost 50 % of the sponge diameter), extends through the whole sponge. Some paratypes (Fig. 5.2–3) suggest a possible prosiphonate type spongocoel, but this could not be definitely shown. The exowall of the sponge is characterized by a dermal layer that is pierced by numerous small pores 0.1 mm in diameter. The endowall (spongocoel wall) is usually thicker than the exowall. A reticular? to septate (radially arranged) fibrous skeleton fills the space between both walls. The spaces between the fibre are mostly circular and resemble some archaeocyathid constructions. Because of strong recrystallization, the primary mineralogy, microstructure of the fibrous skeleton and spicules are not known.

The holotype (Fig. 5.1/H) is a specimen with at least 4 segments cut in axial oblique section and exhibits almost all characteristics of the sponge.

Occurrence: Known up to now only from the Permian of Kuh-e Bagh-e Vang, Shotori Mts, Iran.

Family: **Colospongiidae** Senowbari-Daryan, 1990
Synonymy: **Colospongiidae** Boiko & Belyaeva (in Boiko et al. 1991)
Parauvanellidae Wu, 1991
Imbricatocoeliidae Wu, 1991
Subfamily: **Corymbospongiinae** Senowbari-Daryan, 1990
Genus: *Shotorispongia* nov. gen.

Derivatio nominis: Named after the Shotori Mountains where this sponge was collected.

Diagnosis: Upright cylindrical sponge with glomerate arrangement of the chambers and lacking a spongocoel, vesiculae and filling structures. Chamber walls perforated.

Type species: *Shotorispongia permica* nov. sp.

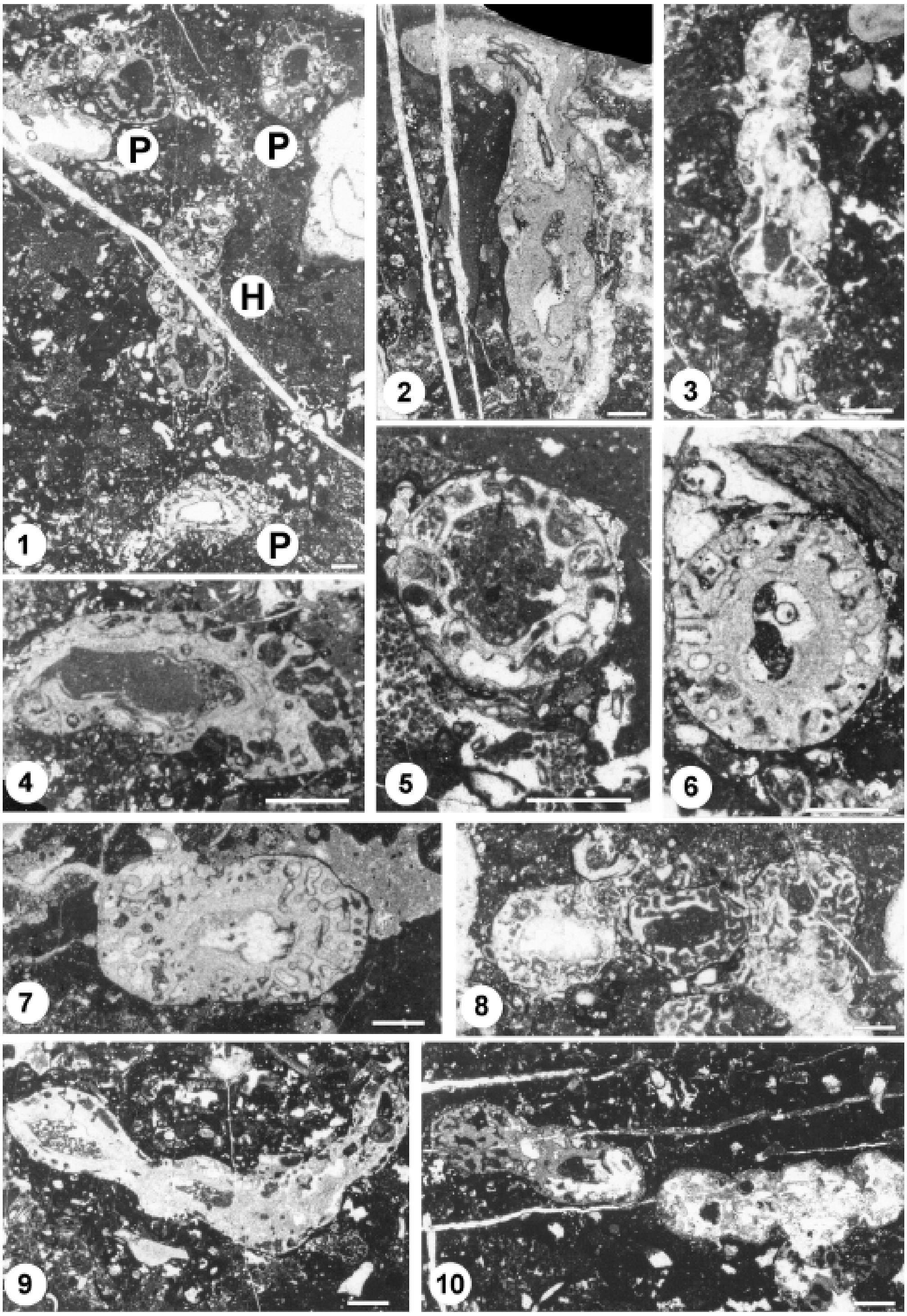

Fig. 5. 1–10 — *Baghevangia minima* nov. gen., nov. sp. from the Permian reefal limestones of Jamal Formation of Kuh-e Bagh-e Vang, Shotori Mountains. 1 — Several transverse and longitudinal sections. The holotype (H) is cut in oblique axial section, and exhibits four segments (compare Fig. 6). 8/4/1. 2 — The axial section of a specimen shows the spongocoel and weak segmentation of the sponge. At the upper end some unknown tubular organisms appear within the spongocoel. 8/3. 3 — The longitudinal section exhibits the possible prosiphonate type of spongocoel. 8/4/1. 4 — The oblique section shows the radially arranged filling skeleton and the thickened endowall of the spongocoel. 13/9. 5 — The cross section exhibits the wide spongocoel and the radially arranged filling skeleton between the exo- and endowalls. 4/1. 6 — Similar to fig. 5, but the thickened endowall makes the spongocoel appear to be double. 8/4/1. 7 — Oblique cross section exhibiting the axial canal and the filling skeleton around the spongocoel. 12/2. 8 — The section through three chambers shows the wide axial canal and the loose fibrous structure between the exo- and endowall. 13/7. 9 — The longitudinal section through a recrystallized specimen shows outer annulation of the sponge corresponding to internal segmentation. 3/2/1. 10 — Longitudinal section shows the outer annulation and weakly developed internal segmentaion. 3/2/2. Scale bars = 1 mm.

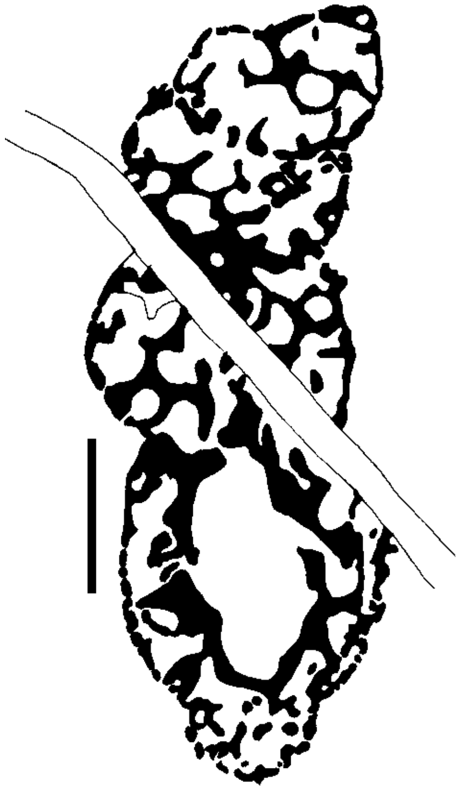

Fig. 6. *Baghevangia minima* nov. gen., nov. sp., holotype (compare with Fig. 5.1/H). The drawing from the thin section shows the four chambers and the wall with radially reticular fibrous skeleton. Thin section 8/4/1, scale 2 mm.

Discussion: Two subfamilies were attributed to the Family Colospongiidae by Senowbari-Daryan (1990: pp. 63–64): the Colospongiinae, with moniliform chamber arrangement, and the Corymbospongiinae, with glomerate or stratiform chamber arrangement. Because of its glomerate chamber arrangement *Shotorispongia* should be assigned to the Corymbospongiinae, which also includes the genera: *Corymbospongia* Rigby & Potter (1986), *Parauvanella* Senowbari-Daryan & Di Stefano (1988), *Neoguadalupia* Zhang (1987), *Platythalamiella* Senowbari-Daryan & Rigby (1988), and possibly *Imbricatocoelia* Rigby, Fan & Zhang (1989a). Later, Rigby et al. (1998b) added the genus *Exaulipora* to this subfamily. Both *Corymbospongia* and *Exaulipora* differ from *Shotorispongia* by having "adnate or glomerated, occasionally moniliform, chambers subspherical to egg-shaped" (Rigby & Potter 1986: p. 28) and by having exaules, which are lacking in *Shotorispongia*. *Neoguadalupia* and *Imbricatocoelia* differ from *Shotorispongia* by their sheet-like shapes and by the arrangement of their chambers above and beside one another in one layer. *Platythalamiella* has the same chamber arrangement as *Shotorispongia* but differs from it in having a sheet-like shape. Sections perpendicular to the plates of *Platythalamiella* might be confused with longitudinal sections of *Shotorispongia* (Fig. 7). The chamber arrangement of *Shotorispongia* is similar to *Cystothalamia* Girty, but *Cystothalamia* differs from *Shotorispongia* by having an axial spongocoel.

Shotorispongia permica nov. sp.
(Fig. 7, Fig. 8.1)

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

Holotype: Fig. 8.1/H (thin section 20).

Paratype: Fig. 8.1/P.

Locus typicus: Kuh-e Bagh-e Vang, south of the town of Shirgesht, Shotori Mts, Iran.

Stratum typicum: Lower Permian (Bolorian, Kungurian) of the Jamal Formation.

Diagnosis: Upright cylindrical sponge with glomerate arrangement of the crescentic chambers. Several chambers (at least 4) occur in each growth level. Chamber wall (as compared to *S. biserialis*) coarsely perforated. Lacks vesiculae and filling structures.

Material: Two specimens illustrated in Fig. 8.1.

Description: Two specimens of this species are available, and they grow together, or one colonized the other. Both are upright specimens composed of crescentic glomerate chambers. The sponges are up at least 30 mm tall and have diameters of approximately 10 mm. The holotype (Fig. 8.1/H) is 21 mm tall and has a diameter of 10 mm. It is overgrown by a brachiopod.

Longitudinal sections of both specimens exhibit in each stage or growth level, three or four chambers arranged beside one another. The chamber heights range between 1.2 mm and 2.5 mm, with maximum widths of 5.5 mm. Chamber walls are relatively thin (0.2–0.6 mm) and pierced by unevenly destributed pores that are 0.1–0.2 mm in diameter. Chambers in the axial region are cut marginally and appear small. Long axes of chambers in the peripheral part are oriented oblique or almost parallel to the axis of the

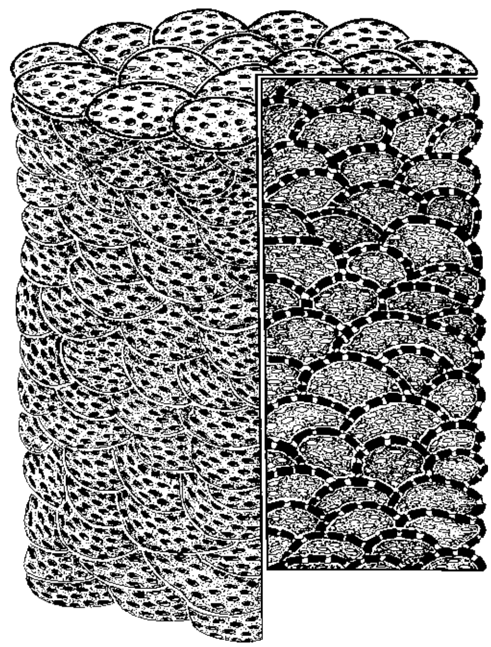

Fig. 7. Reconstruction of *Shotorispongia permica* nov. sp. The vertical section shows the crescentic chambers arranged one beside and above the others. Schematic, not to scale.

sponge. Spongocoel, vesiculae and filling structures are lacking. Fig. 7 shows a reconstruction of *S. permica.*

Occurrence: Known to date only from the Permian of Kuh-e Bagh-e Vang, Shotori Mts, Iran.

Shotorispongia biserialis nov. sp.
(Fig. 8.2)

Derivatio nominis: Named because only two chambers occur in each growth stage or level.

Holotype: Fig. 8.2 (thin section 15).

Locus typicus: Kuh-e Bagh-e Vang, south of the town of Shirgesht, Shotori Mts, Iran.

Stratum typicum: Lower Permian (Bolorian, Kungurian) of the Jamal Formation.

Diagnosis: Upright cylindrical sponge with glomerate arrangement of hemispherical chambers. In each growth level fewer chambers (in longitudinal section two, in whole sponge maybe four) than in the preceeding species. Chamber walls relatively thick and finely perforated (as compared to *S. permica*). Spongocoel, vesiculae and filling structures lacking.

Material: One specimen.

Description: Because only one specimen is known, descriptions of the holotype and species are identical. The sponge has a height of approximately 30 mm, with a diameter of about 10 mm. It is composed of numerous hemispherical chambers that are biserially arranged in each growth level or stage, as seen in longitudinal section, but may occur with four chambers, as seen in cross section. Heights of chambers range between 2.5 mm and 4 mm with width of 4.5–9.0 mm. Chamber walls are 0.4–1.0 mm thick and pierced by evenly distributed single pores that are 0.1–0.2 mm in diameter. Vesiculae and other filling structures are lacking.

Remarks: *Shotorispongia biserialis* differs from the type species, *S. permica,* in the shape and size of the chambers, the even distribution of perforations of the chamber walls, and especially, in the fewer number of chambers in each growth stage.

Occurrence: Known to date only from the Permian of Kuh-e Bagh-e Vang, Shotori Mts, Iran.

Suborder: **Aporata** Seilacher, 1962
Family: **Thaumastocoeliidae** Ott, 1967
Subfamily: **Thaumastocoeliinae** Senowbari-Daryan, 1990
Genus: **Thaumastocoelia** Steinmann, 1882

Thaumastocoelia? cf. *T. irregularis* Weidlich & Senowbari-Daryan, 1996
(Fig. 8.5)

Material: Four specimens in thin section 16.

Description: This irregularly bent sponge is composed of low chambers one above the others in moniliform arrangement. Outer segmentation is poorly developed. The sponge reaches a height of more than 20 mm, with a diameter of up to 5 mm that corresponds to the diameter of the chambers. Height of irregular chambers ranges between 0.7 mm and 2 mm. Thickness of chamber walls varies in the same chamber and in the whole sponge between 0.1 and 1 mm. Chamber walls are pierced by ostia with diameters of 0.2–0.4 mm. The chamber roofs are pierced by a large opening, but in one specimen several openings were observed in one roof (Fig. 8.5: arrow). The rigid skeleton is totally recrystallized and, therefore, the typically spherulitic microstructure of the family Thaumastocoeliidae cannot be confirmed.

Remarks: The irregular shape of the sponge, its poorly defined outer segmentation, chamber shape and arrangement, and the variable thickness of chamber walls of this species correspond to the species described as *Thamastocoelia*? *irregularis* by Weidlich & Senowbari-Daryan (1996) from the Upper Permian Ba'id Formation of Oman. However, the chamber interwalls are pierced by several openings in that species and such openings were observed in only one specimen from Kuh-e Bagh-e Vang. Therefore, the exact affiliation of the Iranian sponge is uncertain.

Genus: *Sollasia* Steinmann, 1882

Diagnosis: See Senowbari-Daryan & Rigby (1988: p. 197).

Type species: *Sollasia ostiolata ostiolata* Steinmann, 1882.

Other species: *S. abista* Rigby, Fan & Zhang, 1989a, *S. arta* Belyaeva, 1991 (in Boiko et al. 1991), *S.*? *amaurosa* Senowbari-Daryan & Rigby, 1988, *S.*? *baloghi* Kovács, 1978, *S. ostiolata permica* Parona, 1933, *S. ramosa* Rigby & Mundy, 2000, *S. spheroida* Rigby, Fan & Zhang, 1989a.

Sollasia ostiolata Steinmann, 1882
(Fig. 8.6, Fig. 9.1–2,7, Fig. 14.7)

1882 *Sollasia ostiolata* nov. sp. — Steinmann, p. 151–152, Pl. 7, Fig. 3
1990 *Sollasia ostiolata* Steinmann — Senowbari-Daryan, p. 128–129, Pl. 43, Fig. 7, Pl. 45, Figs. 4, 8, Pl. 56, Fig. 9, Text-fig. 47 (synonymy)
1991 *Sollasia ostiolata* Steinmann — Belyaeva (in Boiko et al.), p. 63, Pl. 7, Figs. 2–4, Pl. 8, Figs. 1–5, Pl. 9, Figs. 1–3
1994 *Sollasia ostiolata* Steinmann — Rigby et al., p. 92, Pl. 11, Fig. 1, Pl. 12, Fig. 1 (non Pl. 8, Fig. 1!)
1995 *Sollasia ostiolata* Steinmann — Rigby et al., p. 243–244, Figs. 8.6–8.13, 9.5, 9.6, 10.1, 10.2, 10.7
1998b *Sollasia ostiolata* Steinmann — Rigby et al., p. 54–55, Pl. 1, Fig. 1, Pl. 4, Figs. 11–14, Pl. 5, Figs. 1–2, Pl. 7, Fig. 1, Text-fig. 13 (synonymy)

Fig. 8. *Shotorispongia permica* nov. gen., nov. sp., *Shotorispongia biserialis* nov. sp., *Lemonea cylindrica* (Girty), *Sollasia ostiolata* Steinmann, *Thaumastocoelia*? cf. *irregularis* Weidlich et Senowbari-Daryan, and *Peronidella recta grossa* Wu from the Permian reefal limestones of the Jamal Formation of Kuh-e Bagh-e Vang, Shotori Mountains. **1** — *Shotorispongia permica* nov. gen., nov. sp. Longitudinal section through the holotype (H) and a paratype (P) that grew on the holotype. Each growth stage has three to five crescent-like chambers with glomerate arrangement. Chamber walls are pierced by relatively large and unevenly distributed pores. 20. **2** — *Shotorispongia biserialis* nov. sp. Longitudinal section through several glomerately arranged chambers with fine and evenly distributed pores in the chamber walls. 19. **3** — *Lemonea cylindrica* (Girty). The longitudinal section shows the tube-like chambers arranged radially around the axial spongocoel. 15.

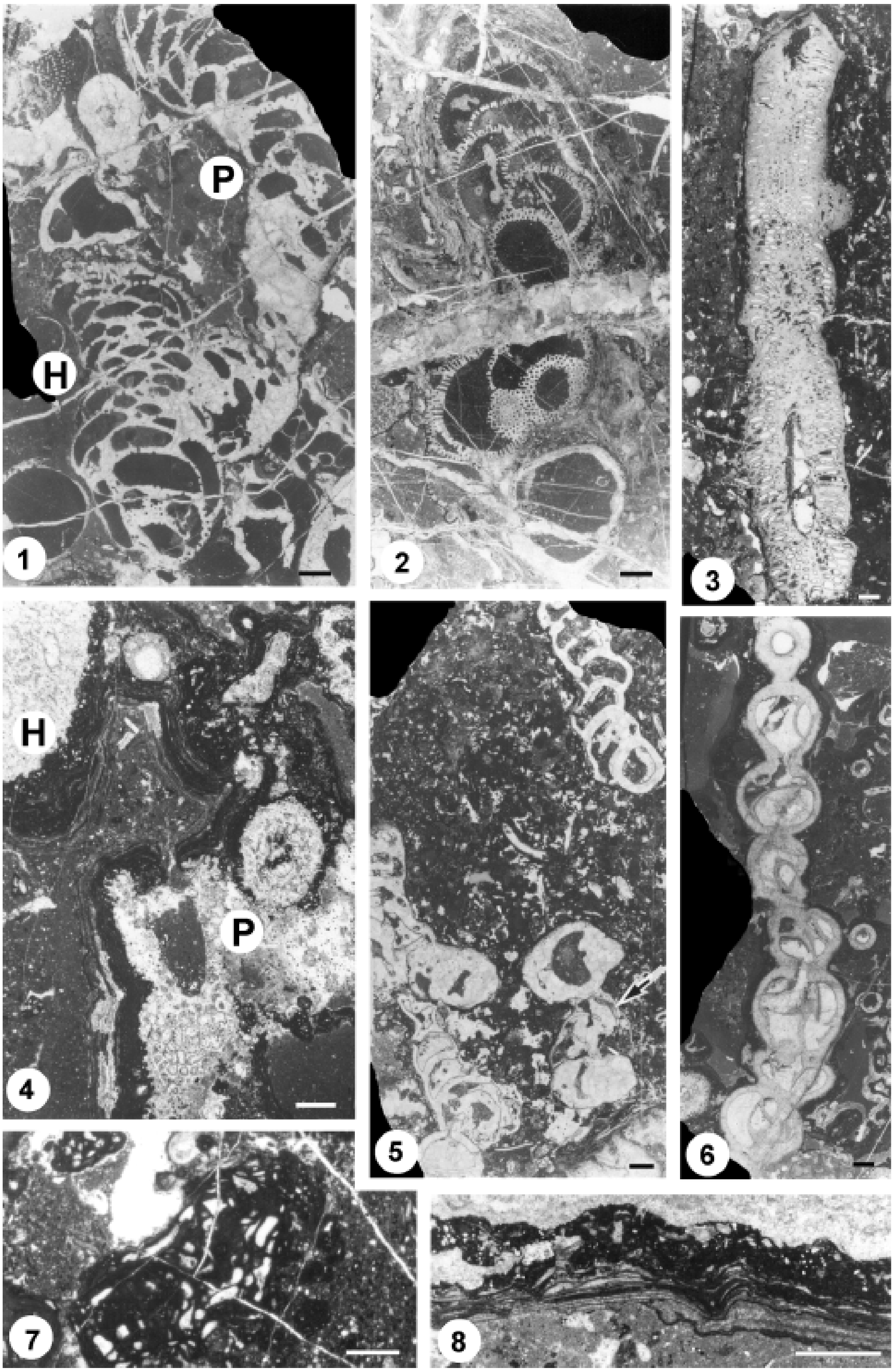

Fig. 8. *(Caption continued)* **4** — The sponges *Peronidella recta grossa* (P) and *Heptatubispongia symmetrica* (H) are encrusted and bound by *Archaeolithoporella* sp. The remaining cavities are filled by silty sediment with small component particles. 6/2. **5** — *Thaumastocoelia*? *irregularis*. Longitudinal sections through several specimens show the low chambers with thick walls and large openings in exo- and interwalls. The arrow points to a specimen with chamber roofs perforated by several openings. 16, ×2.3. **6** — *Sollasia ostiolata* Steinmann. Longitudinal section through several spherical chambers. Chamber interiors contain vesiculae and are filled with sparry calcite cement or partially with sediment. 21. **7** — Abundant lumpy aggregates within the investigated limestones show combinations of tube-like and dark micritic crusts without structure. 1/6. **8** — Incrustation of organisms (upper part of photograph) by *Archaeolithoporella* sp. The primary cavity (lower part of photograph) is filled with silty sediment and small fragments. 10/3. Scale bars: for Figs. 1, 2, 3, 5, 6 = 2 mm; for Figs. 4, 7, 8 = 1 mm.

2003 *Sollasia ostiolata* Steinmann — Noé, Pl. 12, Fig. 3, Pl. 33, Fig. 7
2004 *Sollasia ostiolata* Steinmann — García-Bellido, Senowbari-Daryan & Rigby, p. 1054, Fig. 15/1–8 (synonymy)

Material: Several specimens in thin sections 1/1, 10/4a.

Description: The moniliform stems of this sponge reach heights of more than 40 mm. The chambers have diameters of approximately 5 mm (rarely more) and heights of up to 8 mm. A spongocoel is not defined by endowalls. Chamber interwalls are pierced by a large opening (cryptosiphonate, Fig. 8.6), and exowalls by small openings (ostia, Fig. 9.1) with diameters of approximately 0.5 mm. Exowalls of the chambers reach thicknesses of 0.5 mm. Interwalls (the wall between two chambers) are double-layered, reaching thicknesses of up to 1 mm. The fibrous skeleton is composed of spherulites that are 0.05–0.08 mm in diameter (Fig. 9.7). Vesiculae occur within chamber interiors.

Occurrence: *Sollasia ostiolata* Steinmann is a common cosmopolitan sponge known from numerous Carboniferous and Permian localities on the world (see Senowbari-Daryan & García-Bellido 2002). The sponge is reported here for the first time from Iran.

Sollasia cylindrica nov. sp.
(Fig. 4.6, Fig. 9.2/S,3/S,4–6,8, Fig. 13.1/S,3)

Derivatio nominis: Named for the cylindrical shape and weak outer annulation of the sponge.

Holotype: Longitudinal section illustrated in Fig. 9.4/H (thin section 4/3).

Paratypes: All specimens figured in Fig. 4.6, Figs. 9.2/S,3/S,4/P,5–6,8, Fig. 13.1/S,3.

Locus typicus: Kuh-e Bagh-e Vang, south of the town of Shirgesht, Shotori Mts, Iran.

Stratum typicum: Lower Permian (Bolorian, Kungurian) of the Jamal Formation.

Diagnosis: A small species of the genus *Sollasia* with almost cylindrical or weakly annulated outer morphology, but with clear internal segmentation. Individual segments are usually higher than the diameter of the sponge. Exowalls contain rimmed ostia. Interwalls (wall between the segments) with a large opening (cryptosiphonate). Skeletal mineralogy was aragonite, microstructure spherulitic.

Material: Several specimens in thin sections 4/3 (holotype), 6/2, 10/3, 11/4.

Description: The cylindrical stems of this species are slender, reaching maximum diameters of 3 mm (2–3 mm). The most characteristic features of this species are the weak annulations in the outer wall but with clear internal segmentation. Individual segments are usually higher (up to 4 mm) than the diameter of the stems. Roofs or interwalls of segments are pierced by a central opening up to 0.3 mm in diameter. Outer walls have a thickness of 0.2–0.3 mm, with interwalls up to 0.5 mm thick. The exowall is pierced by ostia reaching diameters of approximately 0.2 mm.

The holotype (Fig. 9.4/H) is a specimen cut in longitudinal section, having a height of 25 mm and a diameter of 3 mm. It is a cylindrical stem almost without outer annulation and has lipped ostia in at least three chambers.

Remarks: *Sollasia cylindrica* nov. sp. differs from the type species *S. ostiolata* and other species of the genus (see above) by its cylindrical morphology, weak segmentation, and small diameter of sponge compared with *S. ostiolata*, 2–15 mm according to Senowbari-Daryan & Rigby (1988), while *S. cylindrica* is only 2–3 mm, and by its barrel- to pear-shaped segments.

Occurrence: Known to date from the Permian of Kuh-e Bagh-e Vang, Shotori Mts, Iran.

Subfamily: **Enoplocoeliinae** Senowbari-Daryan, 1990
Genus: *Girtyocoelia* Cossman, 1909
(pro *Heterocoelia* Girty, 1908a)
Genus: *Girtyocoelia beedei* (Girty) 1908a
(Fig. 14.6/G, Fig. 15.6)

1908a *Heterocoelia beedei* new species — Girty, p. 284, Pl. 14, Figs. 1–8
1990 *Girtyocoelia beedei* (Girty) — Senowbari-Daryan, p. 130, Pl. 45, Figs. 1–3, 5–7, Text-fig. 48 (synonymy)
1998b *Girtyocoelia beedei* (Girty) — Rigby et al., p. 56–57, Pl. 3, Fig. 3, Pl. 4, Figs. 6–10, Text-fig. 14
2000 *Girtyocoelia beedei* (Girty) — Rigby & Mapes, p. 38–39, Pl. 2, Figs. 9–11
2003 *Girtyocoelia beedei* (Girty) — Noé, Pl. 12, Fig. 4

Material: Three specimens in thin sections 1/4, and 2/3.

Description: *G. beedei* is a rare sponge species in the investigated Iranian material. Only three specimens were found, and all of them are small. One specimen, illustrated in Fig. 14.6, is composed of four chambers, and is 23 mm tall, with a diameter of only 4 mm. Maximum height of chambers is 4 mm with an exowall of 0.5 mm thickness. Endowalls have thicknesses of 0.15 mm, and are much thinner than the exowalls. The interwalls are double. Ostia in the exowall are lipped. Microstructure of the skeleton is spherulitic.

Occurrence: Like *Sollasia ostiolata* Steinmann, *Girtyocoelia beedei* (Girty) is an abundant cosmopolitan sponge species, occurring in several Carboniferous and Permian localities in the world (see Senowbari-Daryan & García-Bellido 2002). This sponge is reported here for the first time from Iran.

Family: **Guadalupiidae** Girty, 1908b
Genus: *Lemonea* Senowbari-Daryan, 1990

Diagnosis: “Porate, zylindrische oder konische Schwämme mit einem oder mehreren durch den Schwamm in seiner Länge durchziehenden Spongocoel(s), um welche die röhrenförmigen Segmente radial angeordnet sind. Astrorhizen-Systeme fehlen. Vesiculae können auftreten, sind jedoch nicht häufig. Solitär oder koloniebildend” (“Porate, cylindrical or conical sponges with one or several spongocoel(s) passing through the sponge. Tube-like chambers are arranged around the spongocoels(s). Astrorhizal systems lack. Vesiculae may occur, but not abundant. Solitary colonial.”) (Senowbari-Daryan 1990: p. 151).

Type species: *Guadalupia cylindrica* Girty, 1908b.

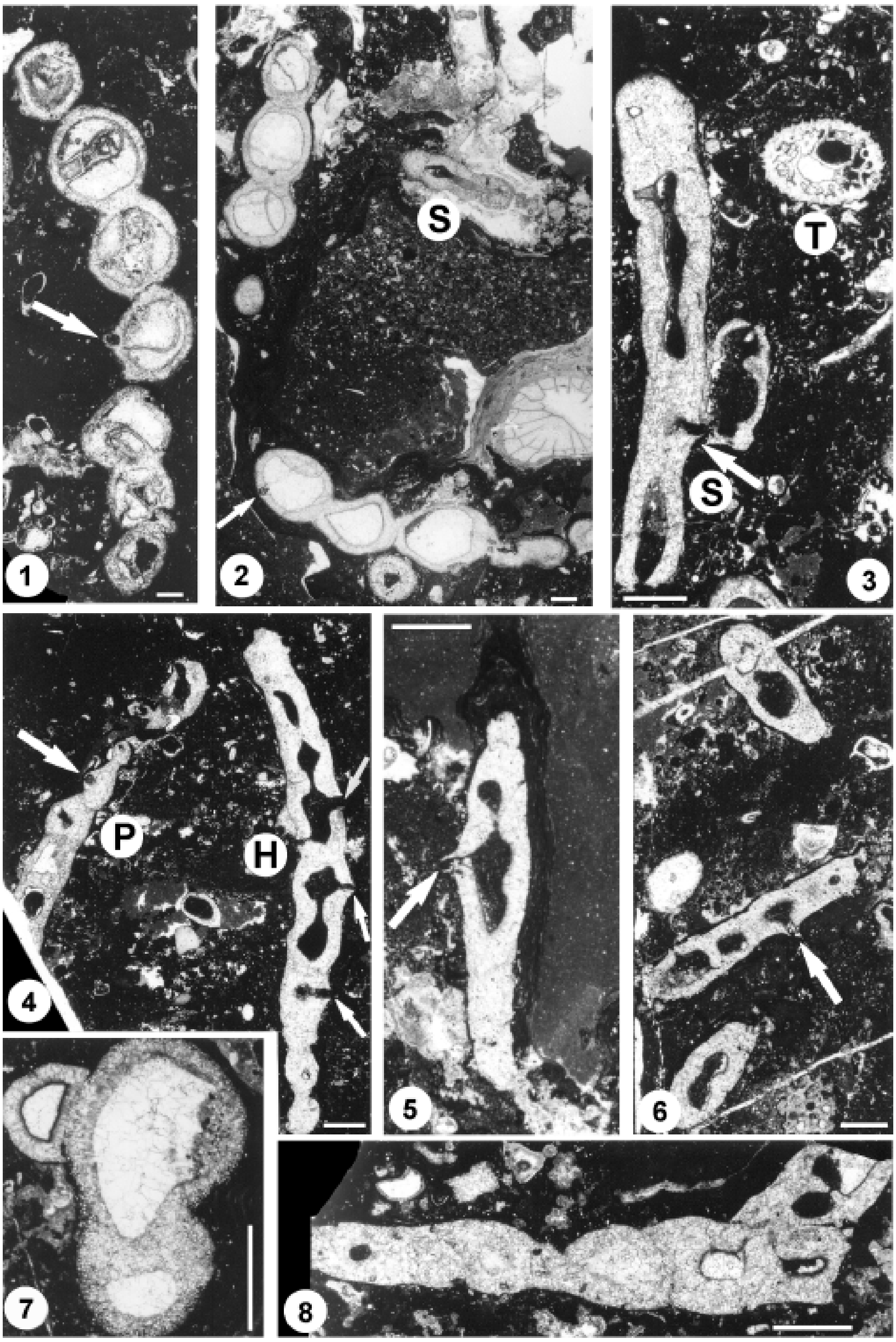

Fig. 9. *Sollasia ostiolata* Steinmann, *Sollasia cylindrica* nov. sp. and *Bicoelia spinosa* nov. sp. from the Permian reefal limestones of the Jamal Formation of Kuh-e Bagh-e Vang, Shotori Mountains. **1–2, 7** — *Sollasia ostiolata* Steinmann. 1 — Longitudinal section through a stem with spherical chambers. Chamber interiors contain some vesicular structures. Arrow points to rimmed ostium. 1/1. 2 — Section through two (or one curved?) specimens that exhibit the same characteristics as specimen shown in fig. 1. Arrow points to an ostium. *Sollasia cylindrica* nov. sp. (S). 1/1. 7 — The section through two chambers shows the spherulites of the rigid skeleton. 10/4a. **3–6, 8** — *Sollasia cylindrica* nov. sp. 3 — Longitudinal section through a specimen of *Sollasia cylindrica* nov. sp. (S) and cross section through a specimen of *Bicoelia spinosa* nov. sp. (T). *Bicoelia* clearly exhibits the two spongocoels (one filled with sediment, the other with cement) with separate walls and the exowall with a spine-like structure at the outer surface. Arrow points to a rimmed ostium. 12/4. 4 — Longitudinal sections through two specimens of *Sollasia cylindrica,* holotype (H). Both specimens show the weakly annulated outer morphology and the clear internal segmentation. Arrows point to the rimmed ostia. 4/3. 5 — Longitudinal to oblique section. Arrow points to a rimmed ostium. 6/2. 6 — Oblique and cross sections through three specimens of *S. cylindrica* nov. sp. Arrow points to a rimmed ostum. 6/2. 8 — Longitudinal section. 4/3. Scale bars = 2 mm.

Lemonea cylindrica (Girty, 1908b)
(Fig. 8.3)

1908b *Guadalupia cylindrica* n. sp. — Girty, p. 81, Pl. 6, Fig. 6
1990 *Lemonea cylindrica* (Girty) — Senowbari-Daryan, p. 151, Pl. 54, Figs. 7–8, Pl. 57, Figs. 2, 4–6 (synonymy)
1998b *Lemonea cylindrica* (Girty) — Rigby, Senowbari-Daryan & Liu, p. 62, Pl. 3, Fig. 1, Pl. 7, Figs. 1–4, 7, Pl. 13, Figs. 3, 6. (synonymy)
2003 *Lemonea cylindrica* (Girty) — Noé, Pl. 11, Fig. 1, Pl. 12, Fig. 2, Pl. 31, Fig. 6, Pl. 35, Fig. 5

Material: Two specimens in thin section 15.

Description: Two specimens of this sponge are available. The larger specimen is cut in longitudinal section, the small specimen in oblique section, having a diameter of only 5 mm.

The larger specimen has a height of 53 mm and a diameter of at least 10 mm (Fig. 8.3). The cylindrical sponge has tube-like monoglomerate chambers arranged in one layer, radially and horizontally, around a spongocoel 2 mm in diameter that passes through the full length of the sponge. Outlines of chambers in cross sections are polygonal to rounded polygonal, with diameters of 0.5 mm. Chamber walls are 0.2 mm thick. They appear relatively thick and are pierced by small unbranched pores. In longitudinal section the tube-like chambers are oriented almost perpendicular to the axis of sponge. Chamber interiors lack filling structures and vesiculae.

Remarks: The specimens from Iran are smaller than the general dimensions of *L. cylindrica* known from other Permian localities of the world, but all other characteristics correspond to the previously known specimens of *L. cylindrica*.

Occurrence: *Lemonea,* in general, and *L. cylindrica* in particular, is an abundant sponge in Permian reefs, especially in the Guadalupe Mountains in Texas and New Mexico (Girty 1908b; Senowbari-Daryan 1990; Rigby et al. 1998b; Fagerstrom & Weidlich 1999a,b; Weidlich & Fagerstrom 1999; Noé 2003). The species is also known from other Permian reef localities of the world (Senowbari-Daryan 1990; Senowbari-Daryan & García-Bellido 2002). *L. cylindrica* is reported here for the first time from Iran.

Class: **Calcarea**? Bowerbank, 1864
Superorder: **Aspiculata** Rigby & Senowbari-Daryan, 1996
Order: **Inozoida** Rigby et Senowbari-Daryan, 1996
Family: **Peronidellidae** Wu, 1991

Diagnosis: Sponges "in which excurrent system consists of only a spongocoel or a multispongocoel in the axial region of sponges. The water system is *Peronidella*-type or *Sestrostomella*-type" (Wu 1991: p. 56).

Type genus: *Peronidella* Hinde, 1893.

Subfamily: **Peronidellinae** Wu, 1991

Diagnosis: "Sponges with axial spongocoel but lacking inhalant and exhalant canals" (Rigby & Senowbari-Daryan 1996: p. 58).

Genus: *Peronidella* Hinde, 1893
(pro *Peronella* Zittel, 1878)

Diagnosis: See Zittel (1878: pp. 30, 120), Rigby & Senowbari-Daryan (1996: p. 58).

Type species: *Spongites pistilliformis* Lamouroux, 1821.

Peronidella recta grossa Wu, 1991
(Fig. 10.1–6,7S,8,9–10, Fig. 8.4)

1991 *Peronidella recta grossa* subsp. nov. — Wu, p. 63-64, Pl. 7, Figs. 7–8
1994 *Peronidella* sp. — Senowbari-Daryan & Ingavat-Helmcke, p. 24, Pl. 3, Fig. 3, Pl. 6, Fig. 5 (non Pl. 5, Fig. 7/B, Pl. 9, Figs. 3–4)
2004 Inozoid sponge — Flügel, Pl. 42/IS

Material: Numerous specimens in thin sections 2/3, 2/5, 7/2b, 10/4a, 10, 10/4/6, 10/7, 12/1, 13/6, 13/8.

Description: This *Peronidella* is the smallest species among all species known for the genus from the Permian (see Table 1). It is a single stemmed (not branched) cylindrical species, having an outer diameter that ranges from 2.5 mm to a maximum of 4.2 mm. An axial to peripherally located spongocoel, with a circular cross section, passes through the whole sponge. Diameter of spongocoel ranges between 0.5 mm and 1.75 mm. The diameter of spongocoel seems to be independent of the sponge diameter. The widest spongocoel of 1.75 mm is in a specimen with an outer diameter of 3.25 mm, so the spongocoel makes almost 53 % of the sponge. However, the largest specimen is 4.25 mm in diameter, but has a spongocoel only 1.4 mm in diameter (almost 33 %). The sponge wall, usually with the same size or less as the diameter of spongocoel, is composed of reticular fibrous structure. Inhalant and exhalant canals, a cortex (outer dermal layer) and endowall (spongocoel wall) are totally lacking. Primary skeletal mineralogy was most probably aragonite, microstructure and spicules are not known.

Remarks: All species of the genus *Peronidella* known from the Permian are listed in Table 1. The sponge diameter and other dimensions of the *Peronidella* from Iran fit with *Peronidella recta grossa* described by Wu (1991). However, this species was originally described and illustrated poorly by Wu. He figured only two cross sections in Pl. 7, Figs. 7–9. For that reason we have described and figured several specimens in this paper to show the characteristics of the species.

The general characteristics of *P. recta grossa* are similar to *Peronidella labiaformis* Wu (1991), which was also described insufficiently and illustrated by this author. However, according to Wu's description *P. recta grossa* differs from *P. labiaformis* by smaller dimensions of the sponge, a cylindrical shape (conical in *P. labiaformis*) and a spongocoel that is circular in cross section ("lip-like" in *P. labiaformis).*

Flügel (2004, Pl. 42) illustrated a thin section photograph of a sample from the Upper Permian sponge from western Hubei (south China) containing several specimens of *P. recta grossa.* Apparently this species is an abundant sponge in the Upper Permian of China.

Table 1: Dimensions of *Peronidella* species known from the Permian of the world. **SD** — diameter of sponge, **DS** — diameter of spongocoel, **TW** — thickness of the sponge wall around the spongocoel, **TF** — thickness of the fibre skeleton, **SFS** — space between the fibre skeleton, **M** — Middle, **U** — Upper. All dimensions in mm. **1** — H.W. Flügel (1973), **2** — Rigby et al. (1989b), **3** — Rigby & Senowbari-Daryan (1996), **4** — Wu 1991, **5** — Hinde 1893, **6** — Senowbari-Daryan (1991), **7** — Rigby et al. 1994. ***** — dimensions according to Wu (1991), ****** — pro *Peronidella parva* Rigby, Fan et Zhang, non *Peronidella parva* Nutzubidze, 1964 (see Senowbari-Daryan 1991).

Species	SD	DS	TW	TF	SFS	Age	References
P. baloghi	40–55	12×18	– –	– –	– –	U. Permian	1
P. beipeiensis	6.8 (16–21)	5.0–9.0	2.0–7.0	0.20–0.40	0.25–0.45	M.-U. Perm.	2
P. digitata	6–11	1.0–1.5	2–5	0.15–0.20	0.14–0.30	U. Permian	3
P. gravida	8.5	2.0–5.0	1.0–2.0	0.05–0.08	0.15–0.40	M. Permian	4
P. labiaformis	4–10	0.75–2.4	0.65–2.3	0.5–0.10	– –	M. Permian	4
P. magna	14–40	7.0–22	3–10	0.14–0.24	0.12–0.22	U. Permian	3
P. minima	4–5	0.6–1.0	1–1.5	0.08–0.12	0.08–0.15	U. Permian	7
P. multiosculata	5	1–2 (0.2–0.6)	1.5	0.5–0.7	0.06–0.14	U. Permian	3
P. minicoeliaca	13–21	3.75	4.8–5.7	0.13–0.20	0.15	M. Permian	4
P. recta grossa	3.6–4.7	1.0–1.8	1.0–1.5	0.1–0.15	0.20	M. Permian	4
P. recta recta	4.7–6.9	0.9–2.3	1.5–2.3	0.05–0.12	0.25	M. Permian	5*
P. regulara	12–38	2.0–10	4.5–90	0.10–0.20	0.12–0.18	M.-U. Perm.	2
*P. rigbyi***	4–6	1.2–2.0	1.5–2.5	0.18–0.25	0.20–0.25	U. Permian	6

Occurrence: *Peronidella recta grossa* in known from the Permian of China (Wu 1991; Flügel 2004), Thailand (Senowbari-Daryan & Ingavat-Helmcke 1994), and now from the Permian of Kuh-e Bagh-e Vang (Shotori Mts, Iran).

Genus: *Bicoelia* Rigby, Senowbari-Daryan & Liu, 1998

Synonymy: *Hikorocodium* (pars) Endo, 1951.

Diagnosis: "Single or branched cylindrical sponge, with two distinct, relatively broad, spongocoels that extend vertically through entire sponge. Each spongocoel with distinct wall and these walls side by side, lacking fibrous structure between them. Skeleton around spongocoel walls and differentiated outer wall composed of irregularly arranged to reticulate fibrous structure which appears finer textured toward exterior of sponge. Walls of spongocoel pierced by numerous pores that branch laterally into pores between skeletal fibers. Because of skeletal elements within spongocoels, some sections may falsely appear as though sponge has three or four spongocoels" (Rigby et al. 1998b: p. 73).

Type species: *Bisiphonella tubulara* Senowbari-Daryan & Ingavat Helmcke, 1994.

Other species: *Bicoelia guadalupensis* Rigby, Senowbari-Daryan & Liu, 1998.

Remarks: *Bicoelia* Rigby, Senowbari-Daryan & Liu (1998), *Bisiphonella* Wu (1991) and *Imperatoria* De Gregorio (1930) are characterized by two axial canals. For differentiation of these genera see Rigby et al. (1998b: pp. 72–73).

Bicoelia spinosa nov. sp.
(Fig. 9.3/T, Fig. 10.7/T, Fig. 11.6–12, Fig. 13.7)

1984 *Peronidella* sp. B. — Flügel et al., p. 402, Pl. 38, Fig. 7
1994 *Bisiphonella tubulara* nov. sp. (pars). — Senowbari-Daryan & Ingevat-Helmcke, Pl. 6, Figs. 1–2/A
1988 Inozoa or *Guadalupia*? sp. — Senowbari-Daryan & Di Stefano, Pl. 5, Fig. 6., Pl. 6, Fig. 2

Derivatio nominis: Named for the spine-like elements on the outer surface of the skeleton.

Holotype: Specimen cut in longitudinal section and illustrated in Fig. 11.12/H (thin section 8/1b).

Paratypes: All specimens illustrated in Fig. 9.3/T, Fig. 10.7/T, Fig. 11.6–11, Fig. 13.7.

Locus typicus: Kuh-e Bagh-e Vang, south of the town of Shirgesht, Shotori Mts, Iran.

Stratum typicum: Lower Permian (Bolorian, Kungurian) of Jamal Formation.

Diagnosis: Small species with two axial spongocoels separated by a thin wall. Exowall and endowall well developed. Exowall usually thicker than the endowall. Loose fibrous structure between the exo- and endowall. Sponge surface with small depressions appearing as spine-like elements in thin section.

Differential diagnosis: See remarks after the description.

Material: Numerous specimens in thin sections 1/4, 1/5b, 7/1, 8/1b, 10/4a, 12/1, 12/4, 13/5, and 13/7.

Description: This small, straight or curved species has heights of up to 20 mm and diameters between 2 mm and 5 mm. The most distinctive characteristics of the sponge are the two more or less axial canals, the small depressions at the outer surface, which appear spine-like in thin section (Fig. 9.3T, Fig. 11.9, Fig. 13.7), and the loose fibre structure between the exo- and endowalls. Some specimens (Fig. 11.8) have three axial canals. The exowall is usually thicker (see Table 2) than the endowall. The two axial canals are usually separated by a wall having the same thickness as the fibre structure. However, in some sections the wall between the two canals is not evident.

A loose fibre structure fills between the endo- and exowall. The spaces between the fibres, which appear circular or angular, are larger than the thickness of the fibres (Fig. 11.7, Fig. 13.7). The outer surface of the sponge in some specimens is annulated (Fig. 10.7/T, Fig. 11.10).

The holotype (Fig. 11.12/H) is a curved specimen cut in longitudinal section and having a height of 20 mm and a diameter of 3.5 mm. More or less axially placed canals have a combined diameter of 1.8 mm (one 0.8 mm, the other

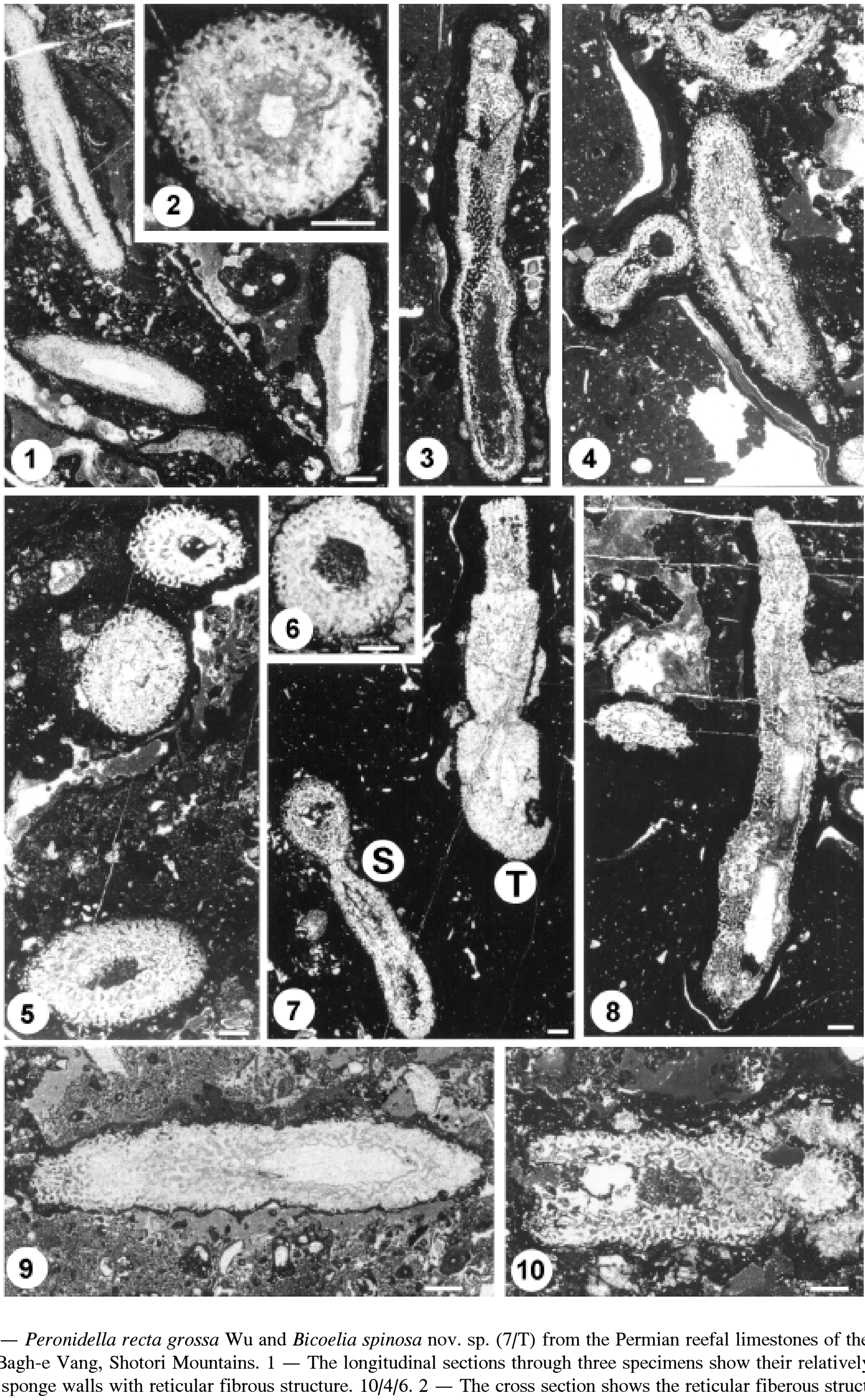

Fig. 10. 1–10 — *Peronidella recta grossa* Wu and *Bicoelia spinosa* nov. sp. (7/T) from the Permian reefal limestones of the Jamal Formation of Kuh-e Bagh-e Vang, Shotori Mountains. 1 — The longitudinal sections through three specimens show their relatively wide spongocoels and their sponge walls with reticular fibrous structure. 10/4/6. 2 — The cross section shows the reticular fiberous structure of the wall without distinction of exo- and endowalls. 13/8. 3 — Longitudinal section exhibits the wide spongocoel and loose fibrous structure of the sponge wall. 12/1. 4 — Longitudinal, transverse and oblique sections of three (or four) specimens 7/2b. 5 — The cross sections through three specimens show the same character as in Fig. 2. 10/4a. 6 — The cross section shows the same character as in Fig. 2. 13/8. 7 — *Peronidella recta grossa* (S) and *Bicoelia spinosa* nov. sp. (T), which shows some outer annulation, and the two spongocoels are recognizable in the lower part. 10/4a. 8 — Longitudinal and oblique sections through two specimens. 2/5. 9 — Longitudinal section showing details of the character seen in Fig. 1. 10/7. 10 — Longitudinal to oblique section. 10. Scale bars: for Fig. 1 = 2 mm; for Figs. 2–10 = 1 mm.

Table 2: Measurements of *Bicoelia spinosa* nov. sp. **DS** — diameter of sponges, **DBC** — diameter of both canals, **DIC** — diameter of individual canals, **TEW** — thickness of exowall, **TSP** — thickness of endowall, **H** — holotype. All data in mm.

Thin section	DS	DBC	DIC	TEW	TSP
1/5b	3.5	2.00	1.0/0.80	0.25	0.20
2/5	5.0	–	1.50	0.50	0.10
7/2b	2.0	1.20	0.60/0.55	0.50	0.10
”	2.8	1.50	0.75/0.60	0.40	0.15
8/1b (H)	3.5	1.75	0.80/0.75	0.50	0.15
”	5.0	–	1.5	0.50	0.10
10/4a	4.2	1.80	0.80/0.70	0.60	0.40
12/1	4.0	2.00	1.0/1.0	0.35	0.25
”	4.0	2.00	1.0/.08	0.35	0.25
”	2.5	1.75	0.80/0.70	0.50	0.10
12/4	5.0	–	1.0	0.60	0.25
”	2.5	1.25	0.70/0.50	0.30	0.10
13/5	2.3	1.50	0.75/0.60	0.50	0.10

0.9 mm, with a wall 0.1 mm thick between them). The wall between the canals has the same thickness as the fibrous structure around the canals.

Remarks: *Bicoelia spinosa* nov. sp. differs from the Upper Permian species *B. tubulara* Senowbari-Daryan & Ingavat-Helmcke (1994) of the Phrae province (northern Thailand) by having fibre structure between the exo- and endowall. Two specimens, however, described as *Bisiphonella tubulara* and illustrated in Pl. 6, Figs. 1–2/A by Senowbari-Daryan & Ingavat-Helmcke (1994) are assigned to *Bicoelia spinosa* in this paper.

The Iranian species differs from *B. guadalupensis* described by Rigby, Senowbari-Daryan & Liu (1998) from the Permian Upper Capitan Limestone of the Guadalupe Mountains, New Mexico and Texas, by the smaller diameter of the Iranian sponges (*B. spinosa*: 2.3–5.0 mm, *B. guadalupensis*: 5–10 mm) and by the spine-like appearing elements on the outer surface of the Iranian species.

The longitudinal sections of *B. spinosa* nov. sp. may appear like *Peronidella recta grossa*, if only one spongocoel is cut (compare Fig. 10.8T). In such sections *B. spinosa* differs from *P. recta grossa* by having a spongocoel wall, which is lacking in *P. recta recta,* and by the type of fibre structure around the spongocoel.

Occurrence: *B. spinosa* nov. sp. is known from the Permian of Slovenia (Flügel et al. 1984: described as *Peronidella* sp. B), from Thailand (Senowbari-Daryan & Ingavat-Helmcke 1984: Pl. 6, Figs. 1–2/A, described as *Bisiphonella tubulara*), from Sicily (Senowbari-Daryan & Di Stefano 1988, described as “Inozoa or *Guadalupia* sp.”) and, now, from the Lower Permian of Kuh-e Bagh-e Vang, Shotori Mts, Iran.

Subfamily: **Heptatubispongiinae** Rigby & Senowbari-Daryan, 1996

Genus: *Heptatubispongia* Rigby & Senowbari-Daryan, 1996

Diagnosis: “Cylindrical to branched sponge with relatively large axial canal or spongocoel, and 6 to 8 symmetrically arranged, collateral vertical canals located near periphery of sponge. Relatively coarse reticular fibrous skeletal structure fills between canals. Outer surface may be weakly annulated and growth lines clearly developed in some specimens. A few ostia occur in outer surface. Ostia may unite to form larger openings” (Rigby & Senowbari-Daryan 1996: p. 83).

We add to that diagnosis that the number of collateral canals may be less than 6 or more than 8, up to 10.

Type species: *Heptatubispongia symmetrica* Rigby & Senowbari-Daryan, 1996.

Remarks: See following description of the species.

Heptatubispongia symmetrica Rigby et Senowbari-Daryan, 1996
(Fig. 11.1–5, Fig. 13.1/H,2/H)

1961 *Hikorocodium elegantae* Endo — Endo, p. 135, Pl. 4, Fig. 7
1977 *Graminospongia girtyi* (Parona) — Termier & Termier, Pl. 8, Fig. 1
1980 *Hikorocodium elegantae* Endo — Flügel, Pl. 2, Fig. 7
1996 *Heptatubispongia symmetrica* nov. sp. — Rigby & Senowbari-Daryan, p. 83–84, Pl. 33, Figs. 9–16, Pl. 49, Fig. 9

Material: Numerous specimens in several thin sections.

Description: Cylindrical and usually single stemmed, rarely branched, specimens of this sponge reach diameters of up to 5 mm (Table 3). The most characteristic features of this sponge are a main, large, axial spongocoel and 6 to 8 (on occasion less than 6 or up to 10) small, and symmetrically arranged, collateral vertical canals that are located near the periphery of the stem. Both types of canals have their walls pierced by numerous pores. The main axial spongocoel reaches diameters up to 1 mm, and the collateral canals are smaller, reaching diameters of less than 1 mm. The spaces between the canals are filled with relatively fine reticulate fibrous skeleton. Outer surface of the sponge may not be smooth; grooves or spine-like structures (Fig. 11.4–5) can be recognized.

Remarks: Specimens described as *Hikorocodium elegantae* Endo by the same author (Endo 1961, Pl. 4, Fig. 7) and by Flügel (1980: Pl. 2, Fig. 7) should be assigned to *Heptatubispongia symmetrica* Rigby & Senowbari-Daryan.

Occurrence: *Heptatubispongia symmetrica* is known from the Permian of Japan (Endo 1961: described as *Hiko-*

Table 3: Measurements of *Heptatubispongia symmetrica* Rigby & Senowbari-Daryan in cross sections. **DS** — diameter of sponge, **DAS** — diameter of axial spongocoel, **DPC** — diameter of peripheral canals, **NPC** — number of peripheral canals. All measurements in mm.

Thin section	DS	DAS	DPC	NPC
1/6	5.0×4.8	0.90	0.50	8
3/2	5.2×4.8	0.80	0.30	7
7/1	3.5	0.90	0.40–0.50	7
7/2a	4.0	0.75	0.50	8
7/2b	4.50	0.90	0.30–0.40	8
10/1	3.0×4.8	0.75	0.40	6
10/2	4.5×3.7	0.75	0.40	8
“	4.5	0.85	0.40–0.50	9
“	4.0	1.0	0.50	6
10/3	3.5	0.75	0.5	5
10/4a	3.0	0.5	0.25–0.35	6

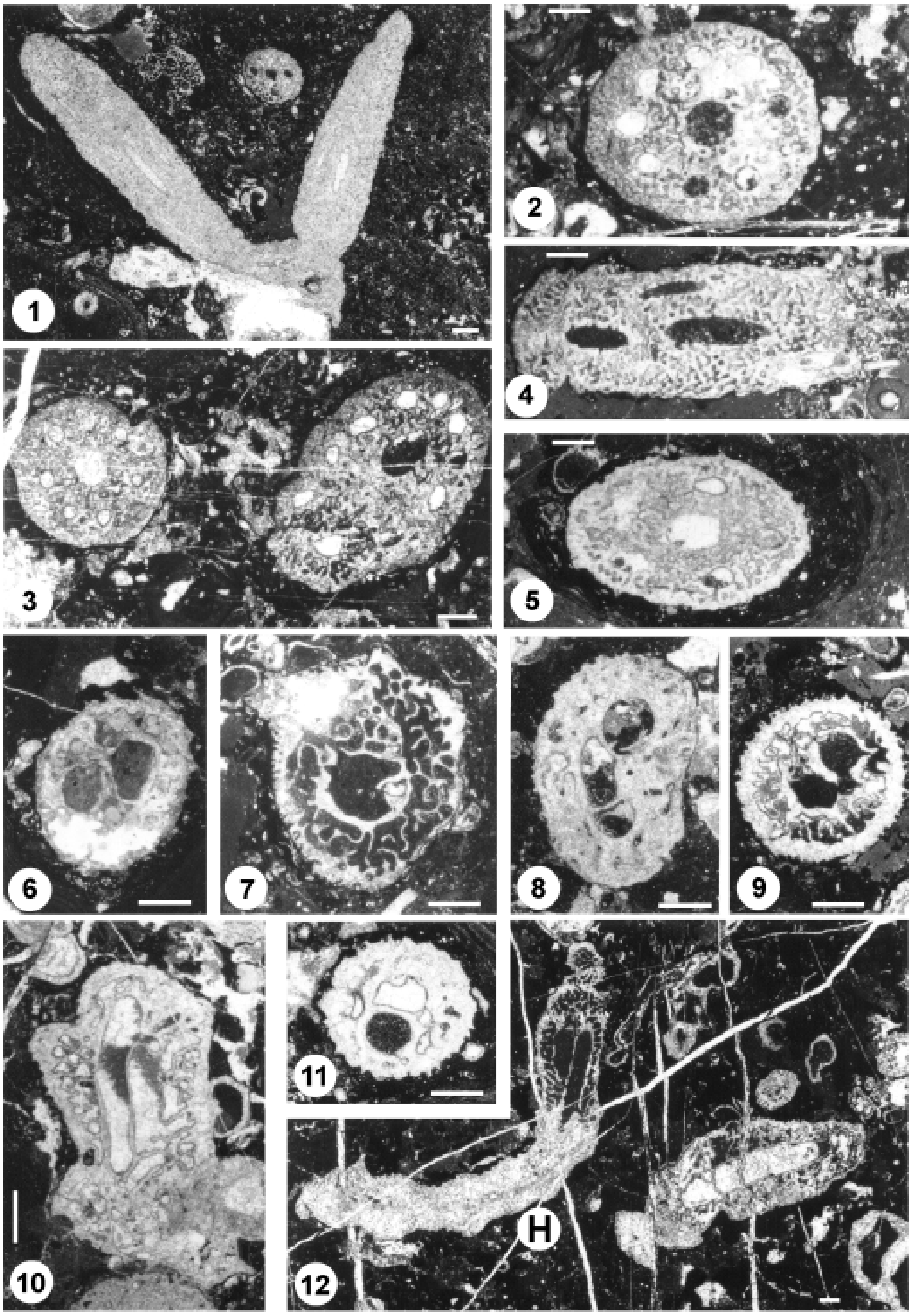

Fig. 11. *Heptatubispongia symmetrica* Rigby et Senowbari-Daryan and *Bicoelia spinosa* nov. sp. from the Permian reefal limestones of the Jamal Formation of Kuh-e Bagh-e Vang, Shotori Mountains. **1–5** — *Heptatubispongia symmetrica* Rigby et Senowbari-Daryan. 1 — Longitudinal to oblique section through a branched specimen. The axial spongocoel and some collateral peripheral canals are cut in both branches. A third specimen with less well developed peripheral canals (only 3 or 4) is also cut in cross section. 10/7. 2 — The cross section of a specimen exhibits the large axial spongocoel and 8 collateral peripheral canals. 1/6. 3 — Cross and oblique sections of two specimens exhibit the large axial spongocoel and 8 or 10 peripheral collateral canals. 10/2. 4 — The oblique section of a specimen exhibits the large axial spongocoel and some peripheral collateral canals. 11/2. 5 — The oblique section of a specimen exhibits the axial spongocoel and only 5 collateral peripheral canals. 10/3. **6–12** — *Bicoelia spinosa* nov. sp. 6 — The cross section shows the two axial spongocoels. 1/4. 7 — The cross section shows only one spongocoel and the loosely packed fibrous structure between the exo- and endowalls. 13/7. 8 — The cross section exhibits the (three?) axial spongocoels. 7/1. 9 — The cross section exhibits character comparable to those shown in Fig. 6. 12/1. 10 — The oblique section exhibits the axial canals and the loose packed fibrous structure between the exo- and endowalls. 7/1. 11 — Cross section similar to those shown in Figs. 6 or 9. 13/5. 12 — Section through holotype (H) and a paratype. The holotype shows two axial spongocoels in the upper part, with exo- and endowalls and reticular fibrous structure between the two walls. 8/1b. Scale bars = 1 mm.

rocodium elegantae), from the Carnic Alps, Austria (Flügel 1980: described as *Hikorocodium elegantae* Endo), and now from Kuh-e Bag-e Vang, Shotori Mts, Iran. *H. symmetrica* is also an abundant species within the Lower Permian reef boulder embedded in the Lercara Formation in the Sosi Valley, Sicily (unpublished material of B. Senowbari-Daryan, compare Senowbari-Daryan & Di Stefano 1988) and in the Upper Permian of Tunisia (Rigby & Senowbari-Daryan 1996).

Family: **Maeandrostiidae** Finks, 1971
Genus: *Maeandrostia* Girty, 1908a

Diagnosis: See Rigby & Mapes (2000: p. 43) and Finks & Rigby (in Finks et al. 2004: p. 644).

Type species: *Maeandrostia kansasensis* Girty, 1908a.

Other species: *Maeandrostia rostrata* Deng, 1982a, *Maeandrostia triassica* Senowbari-Daryan et al., 1993.

Remarks: The sponge species originally described as *Maeandrostia tortacloaca* by King (1933) was transferred to the genus *Fissispongea* by the same author (1938).

De Laubenfels (1955: p. 103) listed *Maeandrostia* under the sponges of "Uncertain Class". Finks (1960: p. 27) assigned *Maeandrostia* to the sphinctozoan sponges. However, *Maeandrostia* represents definitely an inozoid sponge, and was placed in the family Peronidellidae by Senowbari-Daryan et al. (1993) and Rigby & Mapes (2000). Finks (1971: p. 292) proposed the family Maeadrostiidae, and Finks & Rigby (in Finks et al. 2004: p. 644) attributed *Maeandrostia* and five other genera, including *Eurysiphonella* (Haas 1909) to this family. *Eurysiphonella,* known from the Rhaetian Zlambach Formation of Fischerwiese (Altaussee/Austria), is clearly a porate sphinctozoid sponge and was placed in synonym with *Amblysiphonella* Steinmann by Senowbari-Daryan (1990). Following the systematic classification of inozoid sponges by Finks & Rigby (in Finks et al. 2004), the genus *Maeandrostia* is placed here in the family Maeandrostiidae.

The genus *Fissispongia* King (1938) is very similar to *Maeandrostia* Girty, but differs from the latter genus especially in having two spongocoels (for more discussion see Rigby & Mapes 2000: p. 42).

Occurrence: The genus *Maeandrostia* is known from the Carboniferous of USA (Kansas: Girty 1908a; King 1933; Mehl-Janussen 1999; Texas: Rigby & Mapes 2000), from the Permian of China (Deng 1982a,b), Slovenia (Flügel et al. 1984 described as "*Peronidella* sp. B"), Sicily (Senowbari-Daryan & Di Stefano 1988), Oman (Weidlich 1992), and Iran (this paper); and from the Middle Triassic (Anisian) of the southern Alps/Italy (Senowbari-Daryan et al. 1993).

Maeandrostia kansasensis Girty, 1908a
(Fig. 12.1–6)

1908a *Maeandrostia kansasensis* new species — Girty, p. 285, Pl. 15, Figs. 1–7
1933 *Maeandrostia kansasensis* Girty — King, p. 82, Pl. 7, Figs. 9–10
1955 *Maeandrostia kansasensis* Girty — De Laubenfels, p. 103, Fig. 885A,B
1984 *Peronidella* sp. B — Flügel et al., p. 204, Pl. 38, Figs. 8–9 (non Fig. 7)
1988 *Maeandrostia* sp. — Senowbari-Daryan & Di Stefano, p. 6, Pl. 6, Fig. 4, Pl. 8, Figs. 2–4
1992 *Peronidella* sp. — Weidlich, p. 32–33, Pl. 7, Fig. 7
1999 *Maeandrostia kansasensis* Girty — Mehl-Janussen, Pl. 12, Figs. 7, 10
2000 *Maeandrostia kansasensis* Girty — Rigby & Mapes, p. 43, Pl. 4, Figs. 1–4
2004 *Maeandrostia kansasensis* Girty — Finks & Rigby (in Finks et al.), p. 644, Fig. 424/2b–c

Description: The single and unbranched specimens of this species are slender, having an outer diameter between 1.75 mm and 7.5 mm (Table 4). The largest specimen has a length of almost 8 cm. An axial spongocoel, whose diameter is dependent on the diameter of the sponge (Table 4), passes through the complete body of the sponge. An endowall and an exowall are well developed. The space between these walls is filled by a loose fibrous skeleton with irregular arrangement or reticulate structure connecting both walls. The fibrous skeleton and the endo- and exowall are pierced by openings. Ostia (usually 0.2–0.4 mm in diameter) in the outer wall may be lipped. The fibrous skeleton (primary aragonite) is composed of spherulites. Spicules are absent.

Remarks: Girty (1908a) gave a maximum sponge diameter of 13 mm for *Maeandrostia kansasensis*. Specimens from Kuh-e Bagh-e Wang seem to be smaller than Girty's specimens but all other characteristics are identical.

Occurrence: *M. kansasensis* is known from the Carboniferous of the USA (Kansas: Girty 1908a; King 1933; Mehl-Janussen 1999; Texas: Rigby & Mapes 2000).

M. kansasensis seems to be an abundant sponge in Permian reefs in the Tethyan realm. It was described as *Peronidella* from Middle Permian reef limestones of Slovenia (Flügel et al. 1984) and from the Upper Permian of Oman (Weidlich 1992). However, *Peronidella* differs from *Maeandrostia* by

Table 4: Measurements of skeletal elements of *Maeandrostia kansasensis* Girty. **D** — outer diameter of sponge, **DS** — inner diameter of spongocoel, **R** — percent ratio sponge diameter/spongocoel diameter, **WD** — thickness of inter- or exowall, **OD** — inner diameter of ostia, **FD** — thickness of fiber skeletal elements. All measurements in mm.

Thin section	D	DS — R	WD	OD	FD
12/4	3.25	1.00 — 30.7	0.20	0.5	0.20
12/1	2.75	0.60 — 21.8	0.35	0.25	0.30
„	2.25	0.75 — 33.3	0.20	–	0.20
10/4b	3.25	0.75 — 23.0	0.40	–	0.40
10/4a	2.50	0.50 — 20.0	0.35	0.4	0.35
2/5	4.25	1.50 — 35.2	0.25	–	0.25
1/5a	4.50	1.50 — 33.3	0.40	–	0.30
8/12a	7.00	2.25 — 32.1	0.25	–	0.35
„	4.50	1.10 — 24.4	0.25	–	0.25
„	4.75	1.50 — 31.5	0.25	–	0.35
„	5.75	2.25 — 39.1	0.40	–	0.35
„	6.25	2.25 — 36.0	0.25	–	0.35
„	4.75	1.50 — 31.5	0.30	–	0.30
„	3.75	0.80 — 21.3	0.30	–	0.35
10/5	1.75	0.50 — 28.5	0.15	–	0.20
1/5b	6.00	2.00 — 33.3	0.40	–	0.30
2/4	7.50	2.00 — 26.6	0.25	–	0.30
1/7	6.00	2.50 — 41.6	0.25	–	0.25

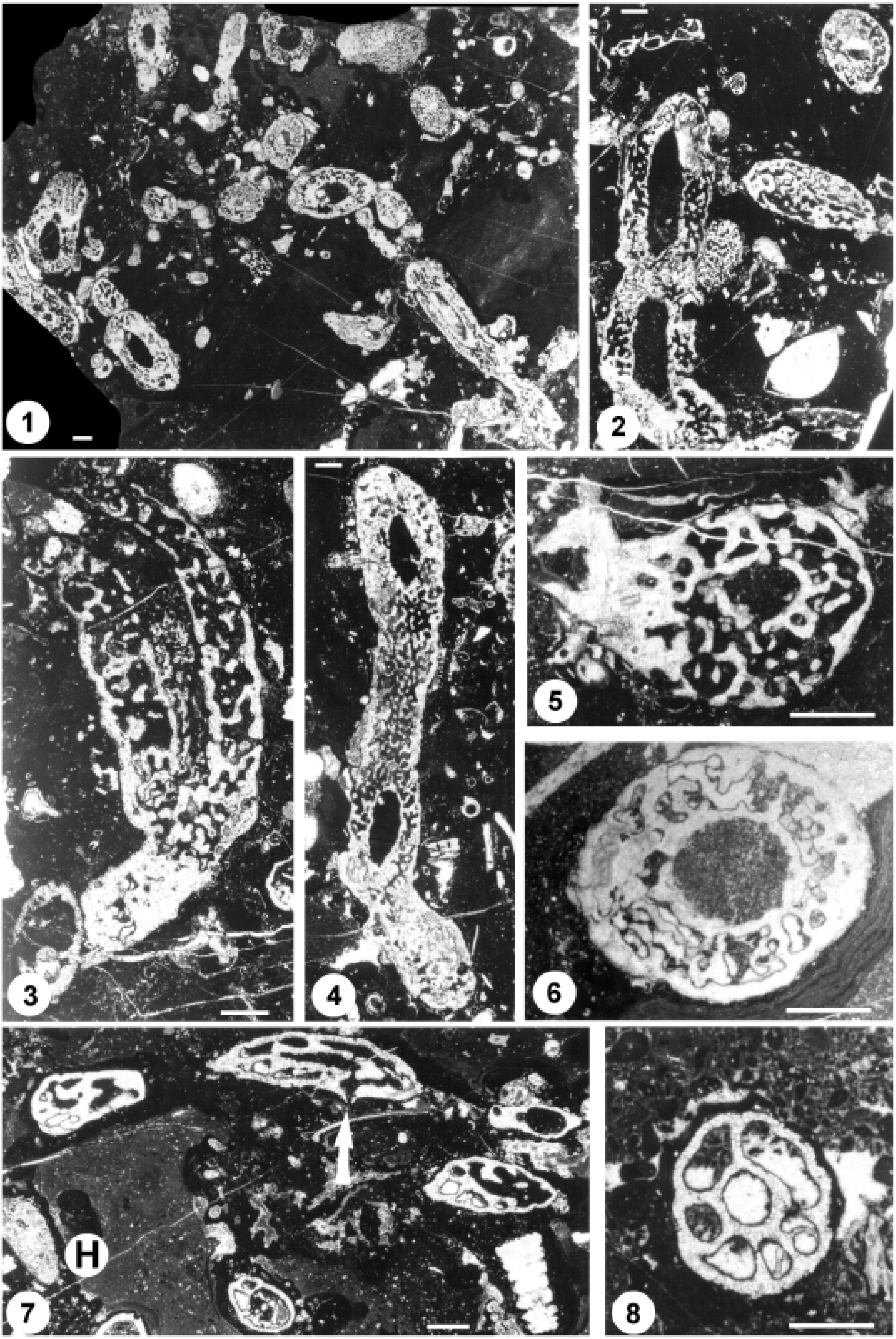

Fig. 12. *Maeandrostia kansasensis* Girty and *Maeandrostia radiata* nov. sp. from the Permian reefal limestones of the Jamal Formation of Kuh-e Bagh-e Vang, Shotori Mountains. **1–6** — *Maeandrostia kansasensis* Girty. 1 — Cross and oblique sections through several specimens 8/12b. 2 — The longitudinal and cross sections show the axial spongcoel and the coarse fibrous structure of the sponge wall. 8/12a. 3 — The longitudinal section shows the axial canal, with perforated exo- and endowalls and the loose fibrous structure between the walls. 2/4. 4 — The marginally axial section exhibits same characteristics as Fig. 2. 1/5b. 5 — The cross section exhibits the reticular fibrous structure between the weakly developed exo- and endowall. 1/4. 6 — Cross section. 9/1. **7–8** — *Maeandrostia radiata* nov. sp. 7 — Oblique sections through several specimens. Arrow indicates a rimmed ostium. (H) *Heptatubispongia symmetrica* Rigby & Senowbari-Daryan. 12/1. 8 — The cross section exhibits the radially arranged and coarse fibers between the exo- and endowalls. 10/5. Scale bars: for Figs. 1-7 = 2 mm; for Fig. 8 = 1 mm.

having a much finer fiber skeleton and, especially, by the lack of ostia. *Maeandrostia kansasensis* is an abundant sponge in Lower Permian reef boulders imbedded in the Lercara Formation in Sicily (Senowbari-Daryan & Di Stefano 1988) and in Permian reefal limestones in Kuh-e Bag-e Vang in the Shotori Range, Iran (this paper).

Maeandrostia radiata nov. sp.
(Fig. 12.7–8, Fig. 13.1/F,2/F, 4–6)

Derivatio nominis: Radiatus (lat. = radiating). Named for the radially arranged skeletal fibres between the exo- and endowall, as seen in transverse section.

Holotype: Specimen illustrated in Fig. 13.5 (thin section 2/5a).

Paratypes: All specimens figured in Fig. 12.7–8, Fig. 13.1F,2/F,4,6.

Locus typicus: Kuh-e Bagh-e Vang, south of the town of Shirgesht, Shotori Mts, Iran.

Stratum typicum: Lower Permian (Bolorian, Kungurian) of the Jamal Formation.

Diagnosis: Slender specimens of *Maeandrostia* with coarse fibrous skeleton and thick exo- and endowalls (spongocoel wall). Fibrous skeleton has radial arrangement between the exo- and endowall. Both walls are pierced by scattered openings. Ostia of outer wall are lipped.

Differential diagnosis: See remarks after description of species.

Material: Numerous specimens in thin sections 2/5a (holotype), 3/4, 10/5, 10/4a, and 12/1.

Description: The unbranched specimens of this slender sponge reach heights of more than 40 mm, with diameters of up to 4.5 mm, with most specimens about 3 mm in diameter. The stems are characterized by thick exo- and endowalls. Both walls are pierced by large scattered openings 0.5 mm in diameter. The clearly lipped ostia reach diameters of between 0.4 and 0.5 mm (Fig. 12.7: arrow, Figs. 13.6: arrow). The space between the exo- and endowalls has almost the same thickness as the walls and is filled with a loose and coarse fibrous skeleton. The fibrous skeleton has the same thickness as the exo- or endowall and appears radially arranged in cross sections (Fig. 12.8, Fig. 13.2/F).

A spongocoel 0.5–1.2 mm in diameter and circular in cross section passes through the whole sponge. The microstructure is composed of spherulites that are 0.04–0.05 mm in diameter and are recognizable in thin sections.

The holotype (Fig. 13.5) is a specimen cut in longitudinal section and has a length of at least 40 mm with a diameter of 3 mm. The spongocoel appears to be only 0.5 mm in diameter, but possibly is cut only tangentially.

Remarks: *Maeandrostia radiata* nov. sp. differs from the type species *M. kansasensis*, described by Girty (1908a) from the Carboniferous of Allen limestone (Chanute, Kansas), in having a smaller diameter, thiner sponge mass, thicker exo- and endowalls. In cross section fibres between the exo- and endowall in *M. radiata* appear radially arranged, but in *M. kansasensis* they are reticulate (compare Fig. 12.5–6,8).

Maeandrostia rostrata, described by Deng (1982a: p. 192, Pl. 1, Fig. 3a,b) from the Permian of Xizang (China), is poorly described and illustrated. However, the species from China differs from *M. radiata* by having a very narrow spongocoel, and long exauli of the ostia.

Maeandrostia triassica, described by Senowbari-Daryan et al. (1993) from the Middle Triassic (Anisian) reef boulders of Southern Alps (Dolomites, Italy), is differentiated from *M. radiata* nov. sp. by having fine skeletal elements, and especially by having long exauli of the ostia.

Occurrence: *Maeandrostia radiata* nov. sp. is known only from the Permian of Kuh-e Bagh-e Vang (Shotori Mts, eastern Iran). However, the species may also occur in Lower Permian reef boulders embedded in the Lercara Formation, Sosio Valley, Sicily.

Family: **Auriculospongiidae** Termier et Termier, (in Termier et al.) 1977
Subfamily: **Acoeliinae** Wu, 1991

Diagnosis: "Cylindrical to club-shaped inozoid sponges lacking spongocoel or major inhalant and exhalant canals in fibrous skeletal net" (Rigby & Senowbari-Daryan 1996: p. 38).

Genus: *Solutossaspongia* Senowbari-Daryan & Ingavat-Helmcke, 1994

Diagnosis: "Cylindrical and unbranched sponge, each with a distinct thick outer wall. The skeleton interior of each sponge is composed of loose reticular fibre. Sponge lacks a spongocoel" (Senowbari-Daryan & Ingavat-Helmcke 1994: p. 25).

Type species: *Solutossaspongia crassimuralis* Senowbari-Daryan & Ingavat-Helmcke, 1994.

Solutossaspongia tabasensis nov. sp.
(Fig. 13.8/S,9, Fig. 14.1-3, Fig. 15.7)

Derivatio nominis: From Tabas, the next large town nearest to the type locality.

Holotype: Fig. 14.3 (thin section 7/1).

Paratypes: All specimens illustrated in Fig. 13.8–9, Fig. 14.1–2.

Locus typicus: Kuh-e Bagh-e Vang, south of the town Shirgesht, Shotori Mts, eastern Iran.

Stratum typicum: Lower Permian (Bolorian, Kungurian) of the Jamal Formation.

Diagnosis: Cylindrical sponge with a distinct and porous outer wall. The interior of the sponge is filled by fine reticular fibrous structure. Lacks spongocoel and inhalant or exhalant canals. Spicules not known.

Differential diagnosis: See remarks after the species description.

Material: In thin sections 7/1 (holotype), 8/1/a and 8/1b.

Description: This cylindrical to club-shaped sponge has a maximum diameter of 5 mm. The height of the sponge is not known. It is characterized by a distinct porous exowall 0.5–1 mm thick. A spongocoel, inhalant and exhalant canals are lacking. The interior of the sponge is filled by a fine

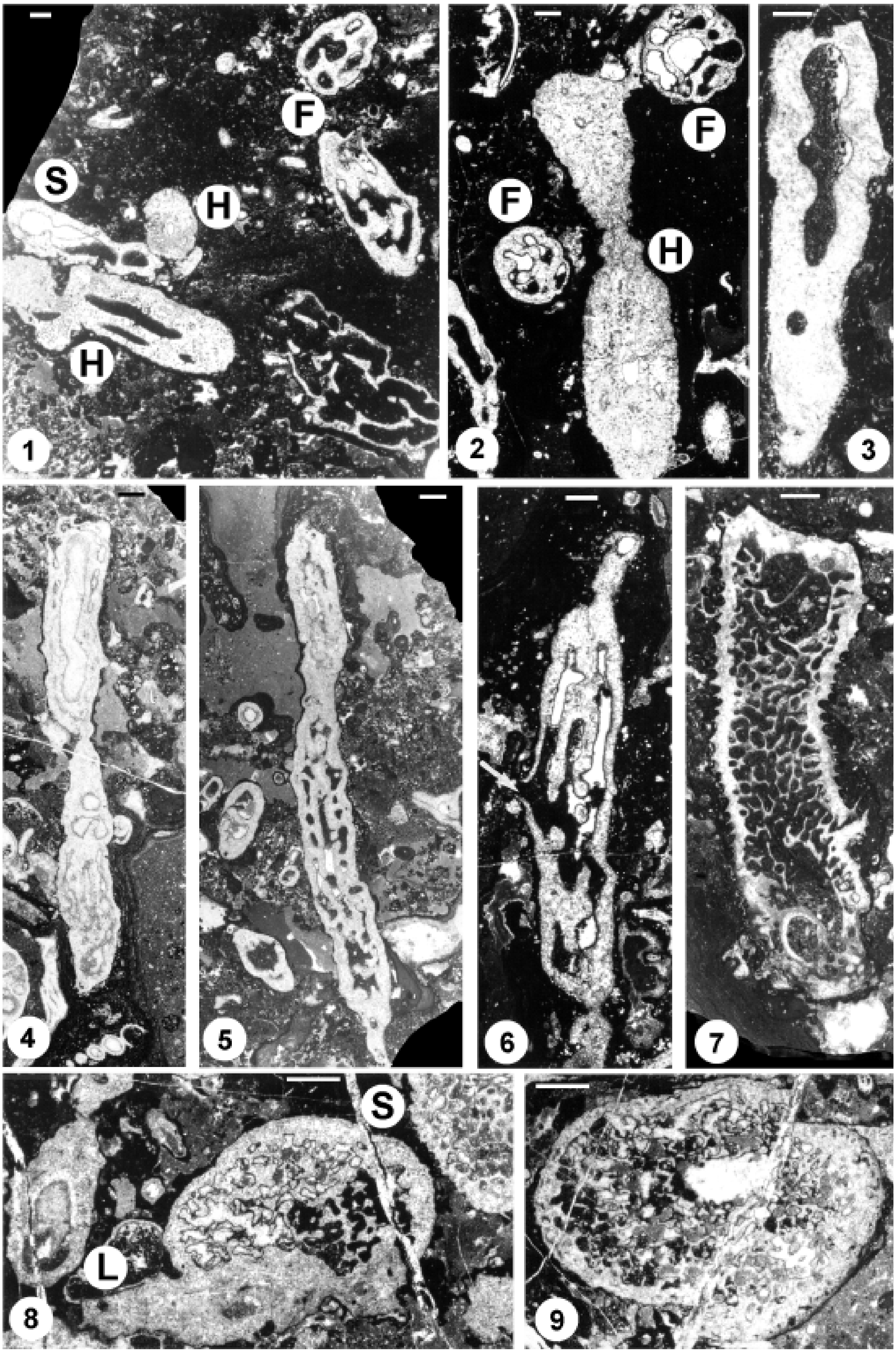

Fig. 13. *Maeandrostia radiata* nov. sp., *Sollasia cylindrica* nov. sp., *Heptatubispongia symmetrica* Rigby et Senowbari-Daryan, *Bicoelia spinosa* nov. sp., *Solutossaspongia tabasensis* nov. sp., and *Lercaritubus problematicus* Flügel, Senowbari-Daryan et Di Stefano from the Permian reefal limestones of Jamal Formation of Kuh-e Bagh-e Vang, Shotori Mountains. 1 — Oblique sections of two specimens of *Maeandrostia radiata* nov. sp. (F), with oblique section of *Heptatubispongia symmetrica* Rigby et Senowbari-Daryan (H) that shows the large axial canal and some collateral canals, and a section of *Sollasia cylindrica* nov. sp. (S). 3/4. 2 — *Heptatubispongia symmetrica* Rigby et Senowbari-Daryan (H) and *Maeandrostia radiata* nov. sp. (F) with radially arranged fibrous skeleton between the exo- and endowalls. 2/5. 3 — *Sollasia cylindrica* nov. sp. The longitudinal section

reticular fibrous structure (0.1–0.15 mm thick), which shows, in longitudinal section, a weak orientation parallel to the axis of the sponge (Fig. 14.3).

The holotype (Fig. 14.3) is a longitudinal to oblique longitudinal section 15 mm long and 5 mm in diameter, which exhibits all characteristics of the sponge. At one end (Fig. 14.3: upper-right corner) it shows a narrow extension, with an open end that could be broken at this point.

Remarks: *Solutossaspongia tabasensis* nov. sp. differs from the type species *S. crassimuralis*, described by Senowbari-Daryan & Ingavat-Helmcke (1994) from the Permian of Phrae province (northern Thailand), by having a fine internal fibrous structure and porous exowalls. Finks & Rigby (in Finks et al. 2004) re-illustrated from Senowbari-Daryan & Ingavat-Helmcke (1994: Pl. 4, Fig. 3), erroneously, a species of sphinctozoid sponge *Intrasporeocoelia hubeiensis* Fan & Zhang (1985) as *Solutossaspongia*.

Occurrence: *Solutossaspongia tabasensis* nov. sp. is presently known only from the Permian of Kuh-e Bagh-e Vang (Shotori Mts, Iran).

Sponge gen. et sp. indet 1
(Fig. 14.4,5)

Description: This cylindrical and branched sponge lacks a spongocoel, distinctly inhalant and exhalant canals, and reaches a maximum diameter of 10 mm. The sponge is composed of fine reticulate fibrous skeleton. Some specimens exhibit small inhalant canals in the periphery of the sponge (Fig. 14.4).

Remarks: The systematic position of inozoid sponges without a spongocoel, nor inhalant and exhalant canals, is disputed. A detailed discussion of this problem was given in Rigby & Senowbari-Daryan (1996: p. 21). For that reason we describe this species here as gen. et sp. indet.

Sponge gen. et sp. indet 2 (*Peronidella*?)
(Fig. 15.1,3–4)

Description: This V- or U-shaped sponge species has a diameter of 4–6 mm with a height of up to 8 mm. The most characteristic feature of the sponge is its very wide spongocoel and thin sponge wall, having a thickness of 0.8–1.2 mm, which is variable within the same sponge. The outer dermal surface of the wall is smooth but the inner surface is very diffuse. The wall is pierced by a labyrinthic branched pore system. The skeleton is recrystallized but relicts of spherulites were observed, indicating the original microstructure.

Remarks: According to the definition of the genus *Peronidella,* this sponge could be a species of that genus.

In addition to the above described sponges, abundant sponge fragments of calcareous tubes or chambers also occur in the investigated thin sections. They could be different inozoid or sphinctozoid sponge taxa but they cannot be determined in detail (e.g. Fig. 15.2,5).

Porifera?
Incertae Sedis
Genus: *Lercaritubus* Flügel, Senowbari-Daryan & Di Stefano, 1990

Diagnosis: "Sessile, tube-like multibranched organism with a calcareous skeleton, composed of thick wall segments put into one another. The aperture of the tubes widens distally and is characterized by a distinct collar. The outer surface of skeleton shows small polygonal depressions. The interior of the tubes is subdivided by perforated tabulae and shows an additional calcareous tissue. A few specimens show small pores within the outer wall of the tubes" (Flügel et al. 1990: p. 361).

Type species: *Lercaritubus problematicus* Flügel, Senowbari-Daryan & Di Stefano, 1990.

Lercaritubus problematicus Flügel, Senowbari-Daryan & Di Stefano, 1990
(Fig. 13.8/L, Fig. 15.8,9)

?1984 "Problematicum A" — Flügel, Kochansky-Deividé & Ramovs, p. 197, Pl. 30, Figs. 13, 14
*1990 *Lercaritubus problematicus* nov. sp. — Flügel, Senowbari-Daryan & Di Stefano, p. 361–362, Pl. 1, Figs. 1-16, Text-Figs. 2–3
1996 *Lercaritubus problematicus* Flügel, Senowbari-Daryan et Di Stefano — Senowbari-Daryan & Rigby, p. 23, Figs. 3.1–3.7, 4.1–4.8
1992 *Lercaritubus problematicus* Flügel et al. — Weidlich, p. 44–45, Pl. 16, Fig. 3

Description: This tube-like, multibranched organism has an outer diameter of up to 10 mm, with an inner diameter of approximately 5 mm. The most characteristic feature of the fossil are the segments inserted one into another and the depressions of the outer surface of the tubes (Fig. 15.8–9). Because of recrystallization, boundaries between segments are hardly recognizable in the Iranian material. The segments have a distinct collar around the aperture. As observed in specimens of the original material, and in Iranian specimens too, the tubes can be rejuvenated internally (Fig. 15.9). Tabulae-like elements occur within the tubes. A detailed description of the fossil was given by Flügel et al. (1990).

Occurrence: *Lercaritubus problematicus* was originally described from Lower Permian reef boulders embedded in the Lercara Formation of western Sicily (Flügel et al.

Fig. 13. *(Caption continued)* shows ill-defined annulation of the outer wall, and the wide opening between the chambers. 10/3. **4–6** — *Maeandrostia radiata* nov. sp. 4 — The brous skeleton between the exo- and endowalls. The two spongocoels are cut in lower and upper parts of the sponge. Note the spine-like elements on the outer surface. 1/5b. **8–9** — *Solutossaspongia tabasensis* nov. sp. 8 — Two specimens (S) cut in cross sections show the fine internal fibrous skeleton and the thick exowall. A specimen of *Larcaritubus problematicus* Flügel, Senowbari-Daryan et Di Stefano (L). 9 — The transverse to oblique section shows characteristics like those in specimens shown in fig. 8. Because the central area is filled with calcite it looks like a spongocoel. 7/1. Scale bars: for Figs. 1–4, 6–9 = 1 mm; for Fig. 5 = 2 mm.

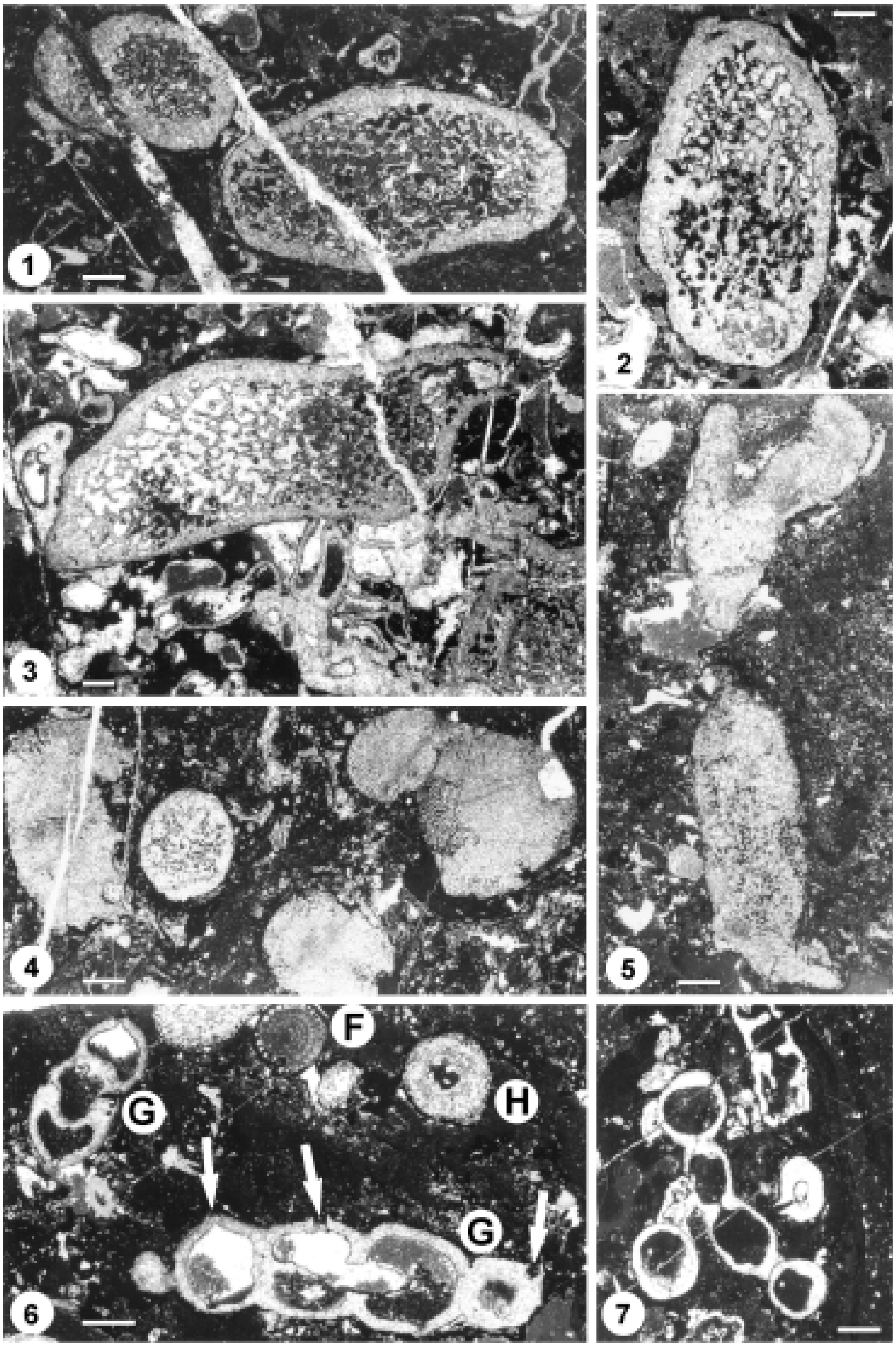

Fig. 14. *Solutossaspongia tabasensis* nov. sp., *Girtyocoelia beedei* (Girty), *Sollasia ostiolata* Steinmann, *Peronidella recta grossa* Wu and Sponge gen. et sp. indet 1 from the Permian reefal limestones of the Jamal Formation of Kuh-e Bagh-e Vang, Shotori Mountains. **1–3** — *Solutossaspongia tabasensis* nov. sp. 1 — Oblique sections through two specimens exhibiting the thick exowall and the relatively fine reticular internal fibrous skeleton. 8/1a. 2 — The oblique section exhibits the same character as those seen in Fig. 1. 1/8a. 3 — Holotype. The oblique to longitudinal? section shows almost the same characteristics as Fig. 1. This specimen exhibits at the right side of photograph an opening (osculum?). The sponge is colonized by an undetermined sphinctozoan sponge with glomerate arrangement of the chambers. 7/1. **4–5** — Sponge gen. et sp. indet 1. 4 — Several specimens cut in cross sections. 10/2. 5 — Longitudinal section of a (or two?) branched specimen. 13/4. **6** — *Girtyocoelia beedei* (Girty) (G). The section through one specimen shows four chambers, the axial spongocoel, and several rimmed ostia (arrows), cross section of *Peronidella recta grossa* Wu (H), and a specimen of a fusulinid foraminifer (F). 2/3. **7** — *Sollasia ostiolata* Steinmann. Longitudinal section through four chambers. 13/8. Scale bars: for Figs. 1–3 = 1 mm; for Figs. 4–7 = 2 mm.

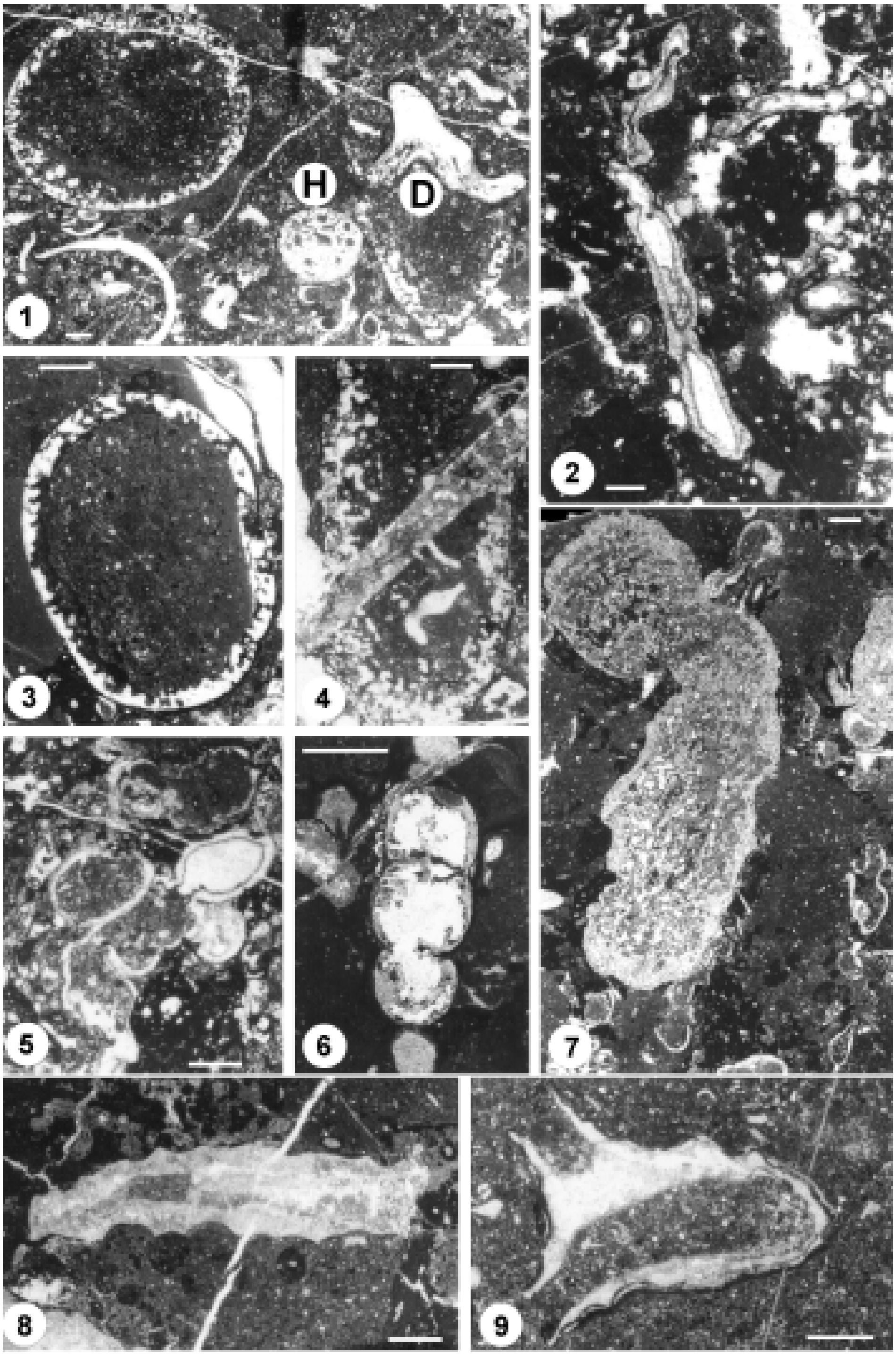

Fig. 15. *Girtyocoelia beedei* (Girty), *Solutossaspongia tabasensis* nov. sp., *Heptatubispongia symmetrica* Rigby et Senowbari-Daryan, Sponge gen. et sp. indet 2, and *Lercaritubus problematicus* Flügel, Senowbari-Daryan et Di Stefano from the Permian reefal limestones of the Jamal Formation of Kuh-e Bagh-e Vang, Shotori Mountains. **1**— Sponge gen. et sp. indet 2. Cross section of a large specimen and longitudinal section through a U-shaped small specimen. Both specimens exhibit the wide spongoceol and the thin wall of sponge. Bryozoan (D), *Heptatubispongia symmetrica* Rigby et Senowbari-Daryan (H). 9/1. **2** — Tube-like organisms (two specimens in photograph, possibly sponges?) occur relative abundantly in the investigated material. 5/1. **3–4** — Sponge gen. et sp. indet 2. 3 — The cross section exhibits the wide spongocoel and the thin wall of sponge. 15b. 4 — Longitudinal section through a U-shaped sponge shows the thin wall, with a smooth outer surface and an uneven inner surface. 9/1. 5 — Several chambers of an undetermined sphinctozoid sponge (*Parauvanella*?), with ostia. 8/3. 6 — *Girtyocoelia beedei* (Girty). Section through a recrystallized specimen with three chambers. 1/4. 7 — *Solutossaspongia tabasensis* nov. sp. Longitudinal section. 8/1a. **8–9** — *Lercaritubus problematicus* Flügel, Senowbari-Daryan et Di Stefano. 8 — The longitudinal section shows the axial canal and the wall of the tube. Outer annulations are indicated by grooves in the outer surface. 7/1. 9 — The longitudinal section through a V-shaped specimen shows internal rejuvenescence of the specimen. 9/1. Scale bars = 1 mm.

1990). It is known also from the Permian reef limestone of the Guadalupe Mountains, New Mexico, USA (Senowbari-Daryan & Rigby 1996) and from the Upper Permian of Oman (Weidlich 1992). The systematic position of *Lercaritubus* is still uncertain.

Comparision of the Permian sponges of Kuh-e Bagh-e Vang with sponge faunas of some other Permian localities

The sponge fauna of the Permian Jamal Formation of Kuh-e Bagh-e Vang is represented by at least 7 sphinctozoan genera (2 new) and 9 species (3 new) and 5 inozoan genera with 6 species (3 new).

Comparing the Permian sponge assemblage of the Jamal Formation of Kuh-e Bagh-e Vang with sponge faunas of some other Permian localities in western (Sicily), southern (Oman, Tunisia) and eastern Tethys (China, Thailand), as well as in the Guadalupe Mts (Texas/New Mexico, USA) the Iranian sponge association is most similar to the sponge associations of Lower Permian reef boulders from the Sosio Valley, Sicily (Senowbari-Daryan & Di Stefano 1988, unpublished inozoid sponges from the same locality) and association from Oman. The sphinctozoid sponge genera *Amblysiphonella, Girtyocoelia,* and *Sollasia*, and the inozoid genera *Peronidella, Maeandrostia*, and *Heptatubispongia,* and partly the problematic organism *Lercaritubus* seem to be more or less cosmopolitan organisms, known from all or from the majority of these localities (Table 5).

The new sphinctozoid sponge genera and species *Baghevangia minima* and *Shotorispongia permica* and *S. biserialis,* and the new species *Amblysiphonella tabasensis*, *Sollasia cylindrica*, *Maeandrostia radiata*, and *Solutosspongia tabasensis* seem to be endemic faunal elements and are not known as yet from other localities. The inozoid species *Bicoelia spinosa* nov. sp. occurs in Iran and in Thailand (Senowbari-Daryan & Ingavat-Helmcke 1994: described as *Bisiphonella tubulara*).

Table 5: Occurrence of sphinctozoid and inozoid sponges, as well as the problematic organism *Lercaritubus problematicus,* in Iran, compared with some other Permian localities on the world. The data are based on publications of Weidlich (1992) and Weidlich & Senowbari-Daryan (1996) from Oman; Senowbari-Daryan & Ingavat-Helmcke (1994) from Thailand; Senowbai-Daryan & Rigby (1988), Rigby & Senowbari-Daryan (1996) from Tunisia; Girty (1908b), King (1943), Senowbari-Daryan (1990), Rigby et al. (1998b) from Texas/New Mexico; Deng (1981, 1982a,b), Fan & Zhang (1985), Rigby et al. (1989a,b, 1994) from China. + — known; – — not known.

Genus/Species	Iran	Oman	Sicily	China/Thailand	Tunisia	USA
Amblysiphonella	+	+	+	+/–	+	+
A. tabasensis	+	–	–	–/–	–	–
Baghevangia	+	–	–	–/–	–	–
B. minima	+	–	–	–/–	–	–
Girtyocoelia	+	+	+	+/+	+	+
G. beedei	+	+	+	+/+	+	+
Lemonea	+	+	+	+/–	+	+
L. cylindrica	+	+	+	+/–	+	+
Shotorispongia	+	–	–	–/–	–	–
S. permica	+	–	–	–/–	–	–
S. biserialis	+	–	–	–/–	–	–
Sollasia	+	+	+	+/+	+	+
S. ostiolata	+	+	+	+/+	+	+
S. cylindrica	+	–	–	–/–	–	–
Thaumastocoelia?	?	?	–	–/–	–	–
T.? irregularis	?	+	–	–/–	–	–
Bicoelia	+	–	+	–/+	–	+
B. spinosa	+	–	+	–/+	–	–
Heptatubispongia	+	–	+	–/–	+	–
H. symmetrica	+	–	+	–/–	+	–
Maeandrostia	+	+	+	–/–	+	+
M. kansasensis	+	+	+	–/–	–	+
M. radiata	+	–	–	–/–	–	–
Peronidella	+	–	+	+/+	+	+
P. recta grossa	+	–	–	+/–	–	–
Solutossaspongia	+	–	–	–/+	–	–
S. tabasensis	+	–	–	–/–	–	–
Lercaritubus	+	+	+	–/–	–	+
L. problematicus	+	+	+	–/–	–	+

Organism association and facies of sponge-bearing Permian reefal limestones of the Jamal Formation in Kuh-e Bagh-e Vang

On the basis of occurrences and frequency of reef building organisms, reefal limestones of the Jamal Formation exposed in Kuh-e Bagh-e Vang should be classified as sponge-*Tubiphytes-Archaeolothoporella*-boundstones. The framework resulted from the in-situ upright growth of coralline sponges and incrustation of these organisms by couplets of dark and light irregular layers, without internal microstructure, of *Archaeolithoporella* and other moderate or rarely incrusting organisms like *Tubiphytes,* bryozoans, and *Pseudovermiporella* (Fig. 8.4,8). Other frame-building organisms, like corals, are extremely rare (Fig. 9.2) and do not play a significant role. Specimens of *Tubiphytes* occur as isolated and upright growing (frame-builder) as well as encrusting organisms. Algae, including codiacean, dasycladacean and phylloid types, occur between the frame-builders but are not abundant. Representatives of red algae are extremely rare. *Pseudovermiporella* is very abundant. The most abundant organisms between the coralline sponges are single or branched tubes, such as *Koivaella* Chuvashov, which are usually encrusted by dark micritic crusts without internal structure or by *Pseudovermiporella* forming aggregate-like components (Fig. 8.7). Such aggregates or lumps seem to be also abundant in other Permian reefs and were described, e.g. by Wahlman (1985) as "*Tubipytes* boundstone" or by Noé (2003) as a combination of *Koivaella/Tubiphytes* or *Tubiphytes*/Foraminifera. Small foraminifers of different taxonomic position and fusulinids are relatively rare (Fig. 14.6F). Other organisms like gastropods, brachiopods, echinoderms etc. also occur, but are minor elements in the boundstones.

Quantitatively, frame-builders, including *Archaeolithoporella,* make up less than 50 % of the rock and the rest is formed by bioclastic micritic sediment or cement. Spaces between the frame-builders without the encrustation by *Archaeolithoporella,* are usually filled by fine bioclastic or micritic sediment. In the case of the encrustation of frame-builders by *Archaeolithoporella* the spaces between these were originally large cavities that were filled later, usually by silty sediment or sparry calcite cement (Fig. 8.8). Some organisms are silicified but their preservation is relatively good.

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