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CALCISPONGIA FROM THE MIDDLE AND UPPER JURASSIC OF THE SHOTORI MOUNTAINS, NORTHEAST IRAN. PART I. *MAMMILLOPORA* BRONN, *TREMOSPONGIA* D'ORBIGNY, *STELLISPONGIA* GOLDFUSS, *ENAULOFUNGIA* FROMENTEL, AND *DEHUKIA* N. GEN.

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Abstract. Middle to Upper Jurassic shelf lagoon, platform, and slope deposits, called the Esfandiar Limestone Formation and Qal-eh Dokhtar Formation, respectively, are widespread in the Shotori Mountains of east-central Iran. Although small *in-situ* patch reefs are known only from the shelf lagoon, reef organisms (corals, sponges) are common as allochthonous components in slope deposits of the Qal-eh Dokhtar Formation and in proximal basinal silty marls of the Korond Formation. Here, some massive calcisponges, including the new genus *Dehukia*, are described comprising the taxa *Mammillopora iranica* n. sp., *Mammillopora polyosculata* n. sp., *Tremospongia pulvinaria* (Goldfuss), *Tremospongia pellisfera* n. sp., *Dehukia maxima* n. sp., *Dehukia raisossadati*, *Dehukia media* n. sp., *Stellispongia stellata* (Goldfuss), and *Enaulofungia globosa* n. sp.

Riassunto. Nelle montagne Shotori, in Iran centro-orientale, sono diffusi sedimenti di laguna interna, piattaforma carbonatica e pendio esterno, riferibili al Calcare di Esfandiar e alla Formazione di Qal-eh Dokhtar, di età Giurassico medio e superiore. Sebbene piccoli patch-reef *in-situ* siano conosciuti dalla laguna interna, gli organismi della scogliera (coralli e spugne) sono comuni quali componenti alloctoni nei depositi di pendio della Formazione Qal-eh Dokhtar, e nelle marne siltose prossimali nel bacino della Formazione Korond. Da questi depositi sono descritte alcune calcisponge massicce, comprendenti il nuovo genere *Dehukia*, e i taxa *Mammillopora iranica* n. sp., *Mammillopora polyosculata* n. sp., *Tremospongia pulvinaria* (Goldfuss), *Tremospongia pellisfera* n. sp., *Dehukia maxima* n. sp., *Dehukia raisossadati*, *Dehukia media* n. sp., *Stellispongia stellata* (Goldfuss), e *Enaulofungia globosa* n. sp.

Introduction

Sponges (including archaeocyathids, stromatoporoids, chaetetids and spongiomorphids) are one of the most abundant groups of invertebrates in Palaeozoic and Mesozoic deposits, occurring in reef biotopes and in shallow water environments. Different groups of them occur with varying abundance in different time intervals: the Cambrian is the peak-time of archaeocyathids, stromatoporoids dominate in the Ordovician-Devonian, chaetetids in the Carboniferous, and "pharetronids" ("inozoans" and "sphinctozoans") in the Permian to Cretaceous.

"Pharetronids" (Zittel, 1878), characterized by a rigid skeleton composed mainly of aragonite and rarely of calcite, are the most abundant sponge group in Permian and Mesozoic deposits. Based on their chambered or non-chambered construction they were subdivided into two polyphyletic groups (Steinmann 1882): "Sphinctozoa" (Steinmann, 1882) or "Thalamida" (de Laubenfels, 1955) with a chambered construction, and "Inozoa" (Steinmann, 1882) with non-chambered representatives. While the sphinctozoans seem to be more abundant in the late Palaeozoic and Triassic time interval, the inozoans are much more dominant in Jurassic-Cretaceous shallow-water carbonates.

The majority of Permian-Triassic sphinctozoans lack spicules, but some of them exhibit monaxonid spicules (replaced by calcite, pyrite, limonite, etc.) and are attributed to Demospongia (Senowbari-Daryan 1990). Spicules are also absent in the majority of Permian-Triassic inozoans (Rigby & Senowbari-Daryan 1996), but tuning fork-shaped spicules are known from several species of the Jurassic-Cretaceous representatives of

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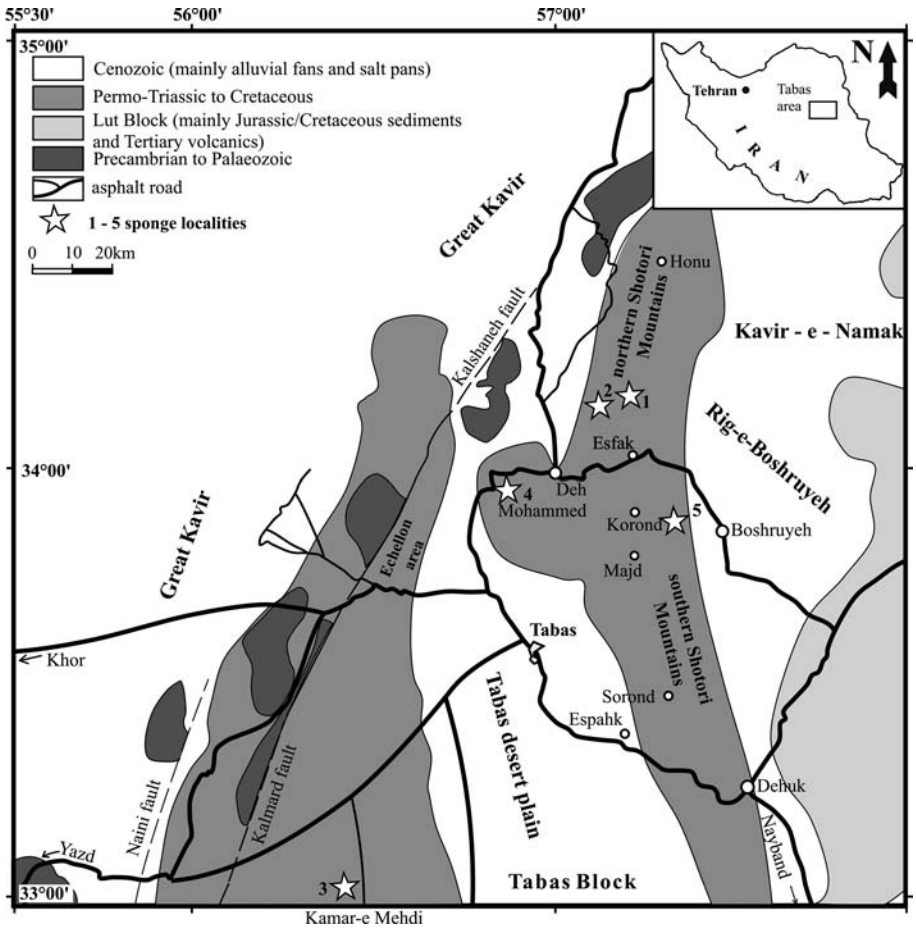

Fig. 1 - Geological sketch map of the Tabas area with position of the five localities where the sponges described in this paper have been collected. 1: NW of Esfak; 2: East of Heydar Ali; 3: Kamar-e Mehdi; 4: Kuh-e Bagh-e Vang.; 5: west of Boshrouyeh. For co-ordinates see text.

both groups, indicating the calcisponge nature of these groups.

Jurassic-Cretaceous pharetronids were described systematically by numerous European workers, as far back as in the eighteenth century. The most important studies include those by Lamouroux (1821), Goldfuss (1826-1833), Münster (1841), d'Orbigny (1852), Fromentel (1860, 1861), Laube (1865), Roemer (1866), Quenstedt (1958, 1878), Zittel (1878), Steinmann (1882), Dunikowsky (1883), and Hinde (1883). Compared with the high number of sponge publications in the nineteenth century only few systematic studies on Jurassic-Cretaceous pharetronids were carried out in the twentieth century. Important contributions are by Welter (1911), Opplinger (1907, 1929), Wagner (1964), Hurcewicz (1975), Müller (1984), Hilmer & Senowbari-Daryan (1986), and Reitner (1992).

During the last two decades a rich sponge fauna has been collected from different Upper Jurassic localities in the Shotori Mountains, east-central Iran, by the authors. The majority of the collected specimens are non-chambered calcisponges with some representatives of the chaetetids. Chambered sponges ("Sphinctozoa") have not been found in Jurassic rocks of Iran, except for the hexactinellid sponge *Casearia*. The sponge fauna, described in this paper, has been collected from a number of localities, which are briefly described below.

Localities and geological setting

The investigated material comes from five localities. The most prolific sponge locality (1) is situated several kilometres NW of Esfak, in the northern part of the Shotori Mountains (Fig. 1). There, limestones of the Qal-eh Dokhtar Formation (Fig. 2), interpreted as slope deposits of a carbonate platform (Esfandiar Limestone Formation) interfinger eastward with basinal silty marls of the Korond Formation (Fürsich et al. 2003). The Qal-eh Dokhtar Formation consists partly of allochthonous grainstones and rudstones, material that was shed from the carbonate platform. Some debris tongues extend beyond the slope and came to rest in soft silty marl of the basin (Korond Formation). Ammonites indicate a late Oxfordian age of this part of the Korond Formation (Schairer et al. 2003). The debris flows consist of biogenic hardparts of organisms [(bivalves, gastropods, corals, sponges, brachiopods, echinoids (spines), and crinoids (ossicles)]. As the material escaped diagenetic lithification, the material is externally very well preserved, although internally commonly recrystallized. The organisms must have formed small reefs, which are no longer preserved. Indeed no reef limestones have been observed by us within the platform sediments of the Esfandiar Limestone Formation, and wherever we could observe the platform mar-

gin it consisted of high-energy carbonates such as oograinstones. It appears therefore that these reefs were confined to the uppermost slope and that the reef material became incorporated in debris flows which started below the platform margin.

At a second locality (2), situated a few kilometres further west, east of Heydar Ali (co-ordinates: N 34°02′17″, E 57°10′13″), the sponges are again components of debris flows, but in contrast to locality (1) the debris flows occur in blackish wacke- to packstones of the Qal-eh Dokhtar Formation, i.e. somewhere on the lower slope. Pyritized ammonites yielded a late Oxfordian age for the blackish carbonates (pers. obs. F. T. F.).

The third locality (3) is the Kamar-e Mehdi area (N 33° 01′10″, E 56°26′36″), approximately 100 km SW of Tabas, where small patch reefs occur within the Callovian-Oxfordian Kamar-e Mehdi Formation. The Kamar-e Mehdi Formation represents sediments of an extensive shelf lagoon (Wilmsen et al. 2010: fig. 6), which existed in the western part of the northern and central Tabas Block during the Late Jurassic. The patch reefs, which are less than a metre in height, occur at several levels within the succession and are mainly composed of the small oyster *Nanogyra nana,* rarely of corals. Calcareous sponges form only a minor constituent of the reefs, together with the bivalves *Radulopecten*, *Trichites*, and *Actinostreon*.

Locality (4) is south of Kuh-e Bagh-e Vang (N 33°56′54″, E 56°47′05″). Calcareous sponges occur in small microbial patch reefs at the top of the Baghamshah Formation and at the base of the Esfandiar Limestone Formation (Echellon facies; Wilmsen et al. 2010: fig. 7). They are associated with *Crescentiella* and *Neuropora*.

Locality (5) is situated 15 km northwest of Boshrouyeh (N 34°02′05″, E 57°10′6″). The single sponge retrieved from this locality within the Qal-eh Dokhtar Formation was *Dehukia raisossadati* n. sp. As the specimen was given to the authors, no further locality information is available.

Material and methods

The Middle to Upper Jurassic sponge collection from Iran contains several hundred specimens, including Calcispongea ("inozoans"), Hexactinellida, and Lithistida. All sponges have been collected as isolated specimens, free of matrix. Because of poor preservation of internal structures, the determination and description of taxa is based on the external morphology. From some well preserved specimens thin-sections were made to obtain information about the internal structure and possibly the existence of spicules within the rigid skeleton. Spiculae were not observed in the majority of specimens. To illustrate the different growth forms, particularly of spherical and hemispherical specimens, several photographs from different sides of the sponge are given. Cylindrical specimens are mostly documented by two photographs, including side and top views. The illustrated material has been deposited in the Bayerische Staatssammlung für Geologie und Paläontologie Munich (Inventory: BSPG 2010XVII 1/1-1/45).

Systematic palaeontology

The systematic classification of sponges is based in the first instance on the composition, shape, and arrangement of the spicular skeleton. Spicules are lacking in most representatives of "pharetronids" (including "inozoans" and "sphinctozoans") or may have been lost during diagenesis. The lack of spicules in "pharetronids" is the main reason, why the sponge nature of this group has been doubted by some early authors (e.g. Dunikowsky 1883; Rauff 1893). They interpreted the rigid skeleton of pharetronids as a secondary skeleton, which was not produced by the sponges. The calcisponge nature of pharetronids has been accepted since Zittel (1878), but – due to the lack of spicules in the majority

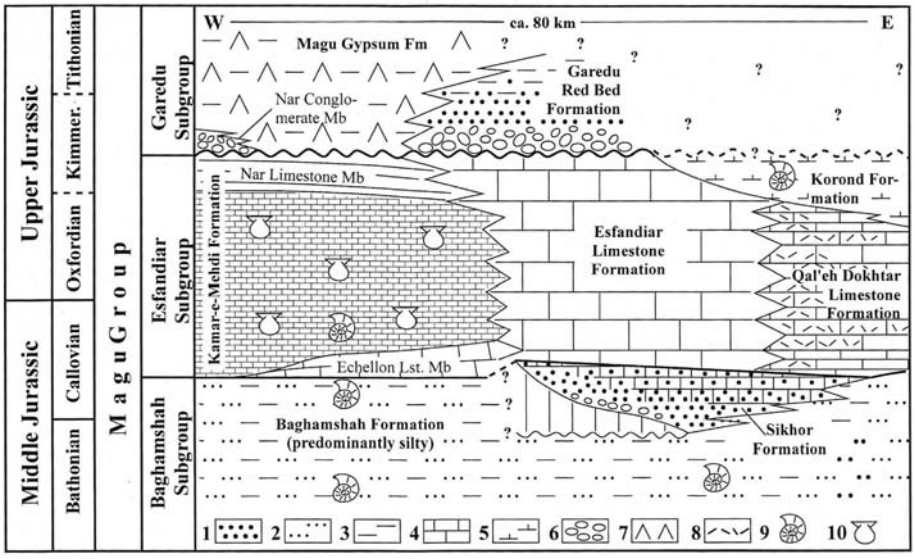

Fig. 2 - Stratigraphic framework of the Upper Jurassic rocks of the northern Tabas Block. Modified from Wilmsen et al. (2003). 1: sandstone; 2: siltstone; 3 clay; 4: limestone; 5: marl; 6: conglomerate; 7: gypsum; 8: bioclasts; 9: ammonites; 10: bivalves.

of representatives – their systematic classification is still under discussion.

An additionally problem for the determination is the fact that the majority of former classification schemes and the description of pharetronids is based on morphological criteria and often only on a single specimen. This way, the high morphological variability of species has not been taken into account.

Description of sponges in this paper is based on the classification of Finks & Rigby (2004). Due to the strongly recrystallization of almost all specimens, morphological criteria were used.

Class **Calcarea** Bowerbank, 1864

Subclass **Calcinea** Bidder, 1898

Order **Stellispongiida** Finks & Rigby, 2004

Family Stellispongiidae de Laubenfels, 1955

Genus *Mammillopora* Bronn, 1825

Type species: *Lymnorea mamillosa* Lamouroux (1821: 77) (erroneously *mamillata* in Bronn 1825: 42).

Synonymy: See Finks & Rigby (2004: 747).

Original diagnosis: "Gehäuse länglich-rund, unregelmäßig an Form. Unterer Theil napfförmig, tief in die Quere runzelig. Oberer Theil gebildet von 1-4 zitzenförmigen, mit leichten Eindrucken versehenen, nicht porösen Körpern, welche am oberen Ende fast immer mit einer rundlichen einfachen, oder strahlenförmig geschlitzten Oeffnung versehen sind" (Bronn 1825: 14).

Diagnosis: "Hemispherical to flabellate with conical base covered by concentrically wrinkled, imperforate layer. Upper surface composed of subequal, knoblike protuberances, each bearing a central osculum that may merge with radial, slit-like, exhalant canals to form a stellate outline; rest of upper surface covered with pores that open into intertrabecular space" (Finks & Rigby 2004: 747).

Further species: *Lymnorea sphaerica* Michelin (1846: 216) (this species has been attributed to *Synopella* by Zittel (1878); see Hinde 1883: 191). *Synopella* has been synonymized with *Tremospongia* by Finks & Rigby (2004: 748). *Lymnorea gigantea* Michelin (1847: 247, pl. 58, fig. 7). The upper surface of this mushroom-shaped sponge is more or less even and does not carry knoblike protuberances. It cannot be attributed to the genus *Mammillopora*.

The sponge described as *Cnemidium tuberosum* by Goldfuss (1826: 16, pl. 30, fig. 4) is a synonym of *Mammillopora* (*Lymnorea*) *mamillosa* Lamouroux.

Discussion. Bronn (1825) established the genus *Mammillopora* (p. 42, *Mammillopore* p. 14) with the description of the species *M. protogaea* Bronn (1825: 42). Apparently he considered his species (*M. protogaea;* erroneously called *potogaea* by Quenstedt 1878: 378) as identical to *Lymnorea mamillosa* (erroneously written as *mamillata* by Bronn 1825: 42), the type species of the genus *Lymnorea* described by Lamouroux (1821) from Bathonian oolites of Caen (Normandy). Because of priority *M. mamillosa* (Lamouroux) is the valid type species of the genus. Lamouroux (1821: pl. 79, figs. 2-4) illustrated three figures of this sponge. Fig. 4 of Lamouroux exhibits the wrinkled dermal layer of the basal part of a sponge, and it seems to be the base of the specimen illustrated in his fig. 2. Figs. 2 and 3 are different sponges. Fig. 3 is a specimen consisting of two individuals or "branched" sponges which have laterally grew together. The top of each "branch" carries a star-shaped exhalant canal or osculum, but the osculum at the top of the sponge, illustrated in his fig. 2, is clearly circular. Based on the star-shaped or circular osculum these two specimens are most probably two different species. The generic diagnosis of *Mammillopora* applies to the specimen illustrated in Lamouroux's fig. 2. Therefore, we consider the specimen, illustrated by Lamouroux (1821: pl. 79, fig. 2 in natural size) as lectotype of the genus *Mammillopora*.

Hinde (1893) illustrated a specimen from the Middle Jurassic of Cheltenham, England as *Mammillopora mamillosa* (Lamouroux), which has been re-illustrated by Finks & Rigby (2004: 746: fig. 495/1a-c). Fig. 1a shows the upper surface of a "large" specimen (about 60 mm in diameter) with numerous "ostia". The fibrous skeletal elements of Hinde's specimen are much coarser than the skeletal elements in Lamouroux's specimen illustrated on his pl. 79, fig. 2. The fibrous skeletal elements of Hinde's specimen are similar to almost identical to the specimens from Iran, described here as *Mammillopora iranica* n. sp. Possibly, Hinde's specimen is conspecific with it.

M. iranica n. sp. differs from *M. mamillosa* by the large diameters of nipple-like protuberances and by the distinctly coarse skeletal elements.

Mammillopora iranica n. sp.

Pl. 1, figs A-H; Pl. 2, figs A-E; Pl. 6, figs D-E; Pl. 11, Fig. A

? 1883 *Lymnorea mamillosa* Lamx.- Hinde: 184, pl. 35, fig. 1a-c.

? 1893 *Lymnorea mamillosa* Lamx.- Hinde: 235-236, pl. 18, fig. 2a-c.

? 2004 *Mammilopora mamillosa*.- Finks & Rigby: 746, fig. 1a-c (re-illustration of Hinde's specimen).

Derivatio nominis: Named after the occurrence of the species in Iran.

Holotype: Specimen BSPG 2010XVII 1/2 (Pl. 1, figs D-H) (all photographs are views of the same specimen from different sides) from debris flow within the basal Korond Formation, NW of Esfak (Shotori Mts).

Paratypes: Specimens BSPG 2010XVII 1/1 (Pl. 1, figs A-C); BSPG 2010XVII 1/3-4(Pl. 2, figs A-E); BSPG 2010XVII 1/5 (Pl. 6, figs D-E), and BSPG 2010XVII 1/6 (Pl. 11, fig. A).

Locus typicus: NW of Esfak (see Fig. 1).

Stratum typicum: Basal Korond Formation (Fig. 2).

Diagnosis: Hemispherical to irregular sponge with concentrically wrinkled imperforate layer of the basal part. Upper and side surfaces covered with several nipple-like protuberances. Each nipple recognizable at the top, but laterally they are grown together. Each nipple with an osculum at the top. Coarse fibre skeleton with honeycomb appearance.

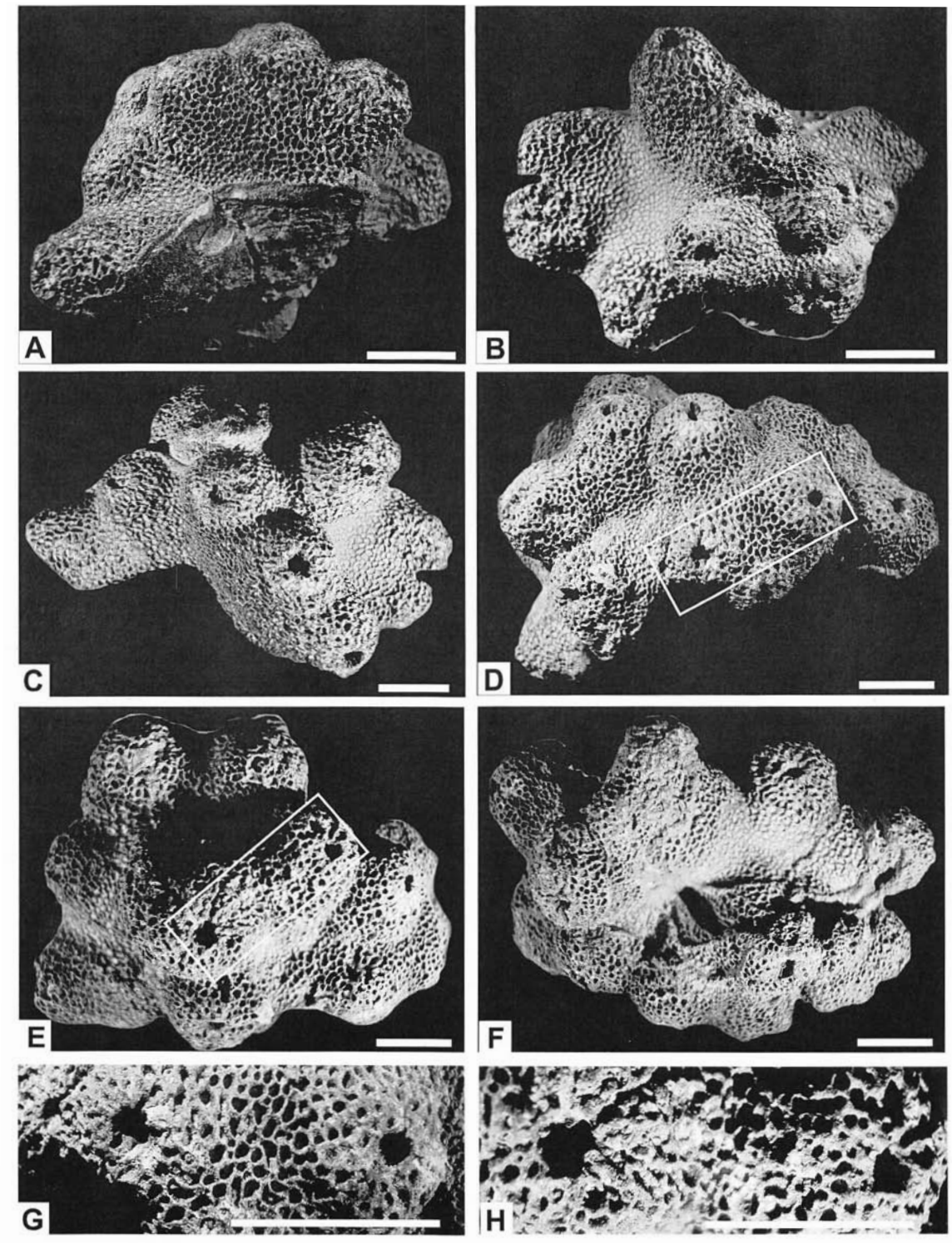

PLATE 1

Mammillopora iranica n. sp. Scale: 10 mm.

A) Specimen (BSPG 2010 XVII 1/1) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area showing the conical and wrinkled basal part an imperforate layer (epitheca). In the upper part individual nipples are seen from the side, which are grown together at the base. The surface of the nipples and the space between them is covered by the meshwork of the fibre skeleton with circular to polygonal openings. B) Upper surface of the specimen illustrated in Fig. A with several individual nipples. Each nipple possesses an osculum on its top. C) Side view of specimen illustrated in Fig. A. D) Holotype (BSPG 2010 XVII 1/2) from the basal Korond Formation NW of Esfak, Shotori Mts. showing several nipples, each with a circular osculum at the top. The surface of the sponge is covered with circular to polygonal and coarse interfibre openings producing a honeycomb appearance. For magnification of the area marked with a white rectangle see Fig. G. E) Side view of the specimen illustrated in Fig. D. For magnification of the area marked with a white quadrangle see Fig. H. F) Upper surface view of the holotype. G) Magnification of Fig. D showing the tops of two nipples, each with an osculum. The honeycomb surface of the sponge is clearly recognizable. H) Magnification of Fig. E showing two nipples and similar characteristics of the sponges as in Fig. G.

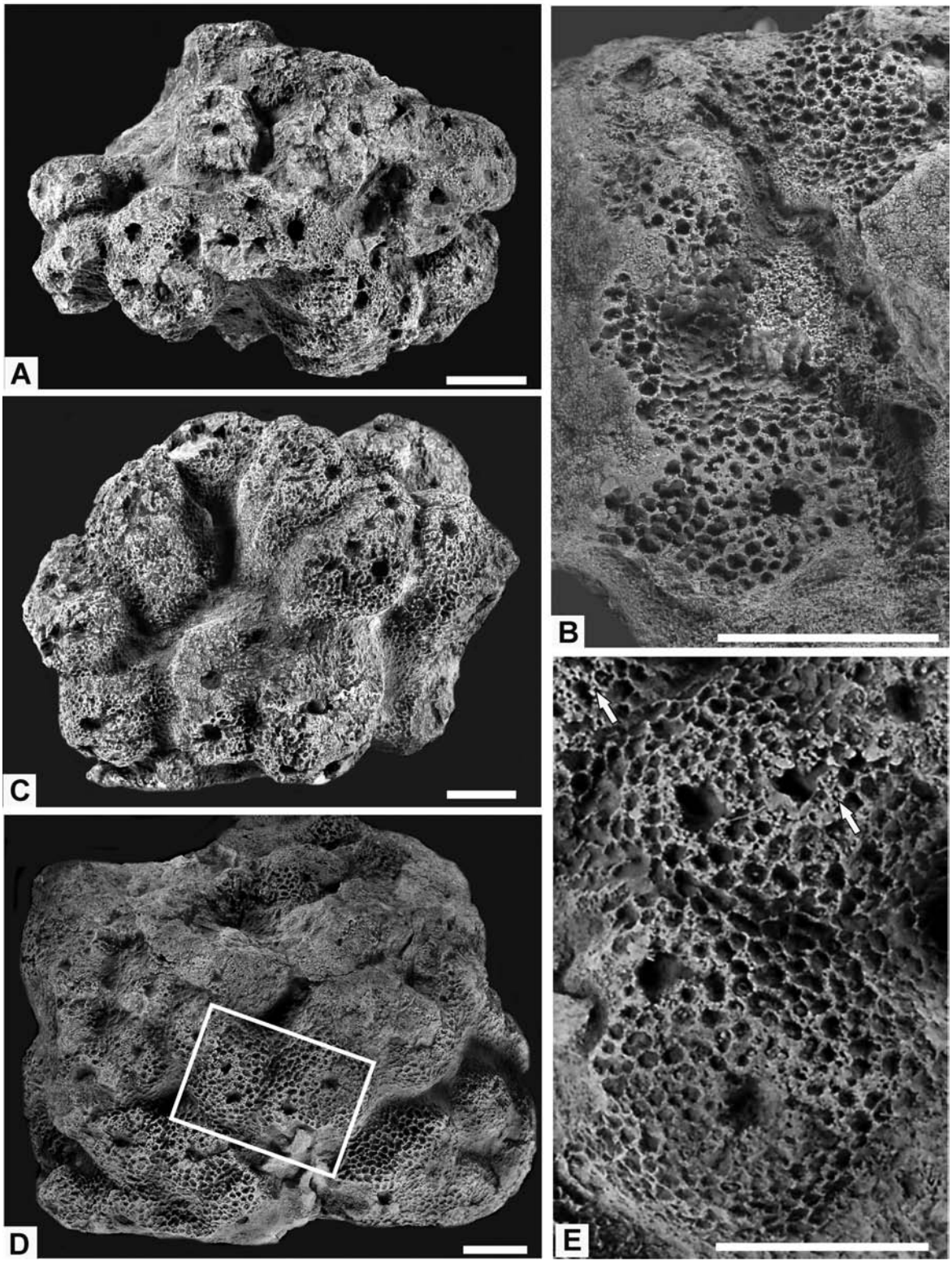

PLATE 2

Mammillopora iranica n. sp. Scale: 10 mm.
A) View of specimen (BSPG 2010 XVII 1/3) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area showing numerous nipples. Some nipples are growing together. Each nipple bears an osculum at its top. B) Magnification of specimen illustrated in Fig. A, showing some nipples with an osculum at the top and skeletal elements producing a honeycomb appearance. C) View of specimen (BSPG 2010 XVII 1/4) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area showing numerous nipples separated from each other at the top. Each nipple shows an osculum with some radiating grooves on its top. D) Another view of the specimen illustrated in Fig. B, showing some nipples and skeletal elements producing a honeycomb-like appearance. Area marked with white rectangle is magnified in Fig. E. E) Magnification of rectangular area in Fig. D, showing some nipples, each with an osculum at top and skeletal elements with a honeycomb appearance. Arrows indicate some small and irregularly arranged pores within the skeletal elements.

Material: At least 10 specimens from the basal Korond Formation (Oxfordian), NW of Esfak, and from patch reefs in the Callovian-Oxfordian Kamar-e Mehdi Formation of the Kamar-e Mehdi area, ca. 100 km SW of Tabas (Fig. 1).

Description. The irregularly hemispherical specimens of this sponge reach dimensions of up to 60 mm. The base of the sponge is covered with a wrinkled dermal layer without any other structure and perforations (Pl. 1, fig. A). The sides and upper surface of the sponge are composed of numerous nipple-like protuberances. The nipples are usually adjoined laterally, but are always separated near the top (Pl. 1, figs A-F; Pl. 2, figs A, C; Pl.11, fig. A). The diameter of each nipple is almost constant, reaching a diameter of approximately 10 mm. The top of individual nipples is rounded and carries an osculum about 1.5-2.0 mm in diameter. Some osculi exhibit radially arranged grooves indicating the exhalant canals around the spongocoel (Pl. 1, figs G-H; Pl. 11, fig. A). The outer surface of the nipples and of the areas between the nipples is covered with a mesh of coarse fibrous skeletal elements and pores (Pl. 1, figs A, G; Pl. 2, figs B, E). The skeletal elements are 0.2-0.3 mm thick and the space between them is composed of circular to polygonal openings of various sizes with a honeycomb appearance (Pl. 1, figs A, D, G; Pl. 2, figs B, E).

Internal structure. A longitudinal section through two nipples of a small specimen provides information about the internal structure (Pl. 6, figs D-E). The oscula on the nipples extend as canals into the sponge (Pl. 6, fig. E). Several canals diverge laterally from the large canal and connect to the small pores within the fibre skeleton on the sponge surface. The two specimens illustrated on Pl. 2, figs A and C were also cut. They are internally recrystallized. The sponge edges margins are filled with fine sediment so that the internal structure is visible. It seems to be identical to that of the small specimen.

Because of the poor preservation spicules were not observed. However, Hinde (1883: 184, pl. 35, fig. 1b) found in his specimen "three- or four-rayed spicules, with rays about 0.24 mm in length". Similar or identical spicules may occur within the rigid skeleton of the Iranian species.

Comparison. *Mammillopora iranica* n. sp. differs from the type species *Lymnorea mamillosa* described by Lamouroux (1821) by the large nipples and by large skeletal elements. The Iranian species is very similar to specimens described by Hinde (1883) and Hinde (1893; this species has been re-illustrated by Finks & Rigby 2004: 746, fig. 495/1a-c), but it differs from Hinde's specimens by moderately large nipples and skeletal elements. Possibly Hinde's specimens should be attributed to *Mammillopora iranica* n. sp.

Mammillopora polyosculata n. sp.

Pl. 3, figs A-F; Pl. 4, figs A-F

Material: At least 25 specimens from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area.

Derivatio nominis: Named for the several exhalant canals present in each protuberance.

Holotype: Specimen BSPG 2010 XVII 1/7 (Pl. 3, figs A, C).

Paratypes: Specimens BSPG 2010 XVII 1/8 (Pl. 3, figs B, D), BSPG 2010 XVII 1/9 (Pl. 3, figs E-F), BSPG 2010 XVII 1/10 (Pl. 4, figs A-B), BSPG 2010 XVII 1/11 (Pl. 4, figs C, E), BSPG 2010 XVII 1/12 (Pl. 4, figs D, F).

Locus typicus: Kamar-e Mehdi area, about 100 km SW of Tabas.

Stratum typicum: Kamar-e Mehdi Formation (Callovian-Oxfordian).

Diagnosis: Bun-shaped, hemispherical to irregularly hemispherical sponge with protuberances on the upper surface. Each protuberance bears several osculi at its top. The spaces between the protuberances are filled with reticulate skeletal fibres.

Description. This sponge is one of the most abundant species in the collection and is documented here by several specimens to show the variability of sponge morphology and of the skeletal elements.

Morphology. Bun-shaped hemispherical to 3/4-spherical specimens of this sponge reach diameters and heights of more than 100 mm. The starting point and the base of most specimens exhibit concentric growth lines. The upper surface of the sponge is composed of numerous protuberances of about 6-8 mm in diameter. In well preserved specimens the individual protuberances reach heights of almost 10 mm, but they grow adnate at the base. Each protuberance is characterized by an osculum of about 2-3 mm in diameter on its summit. Each osculum is composed of several (usually 6-8, maximum 12) individual openings of 0.4-0.8 mm in diameter. Some osculi exhibit seven individual, radially arranged openings: one of them is located in the centre and the other six are arranged symmetrically around it. Some osculi exhibit a large, circular opening in the centre and several slit-like openings arranged radially around the central circular opening (Pl. 4, fig. F). The outer wall of individual protuberances and the space between them are composed of coarse skeletal elements and irregular interfibre openings of different size between them. In some specimens three or four protuberances and their osculi have grown together (Pl. 4C). We interpret such intimate connection as the beginning of the separation of individual protuberances.

Comparison. *Mammillopora polyosculata* n. sp. differs from *M. iranica* n. sp., described above, by the presence of osculi, composed of several openings at the top of each protuberance and by the reticulate (not honeycomb-like) fibre skeleton between the individual protuberances.

Goldfuss (1829: 84, pl. 30, fig. 4) described and illustrated a sponge as *Trogos tuberosum*. This sponge

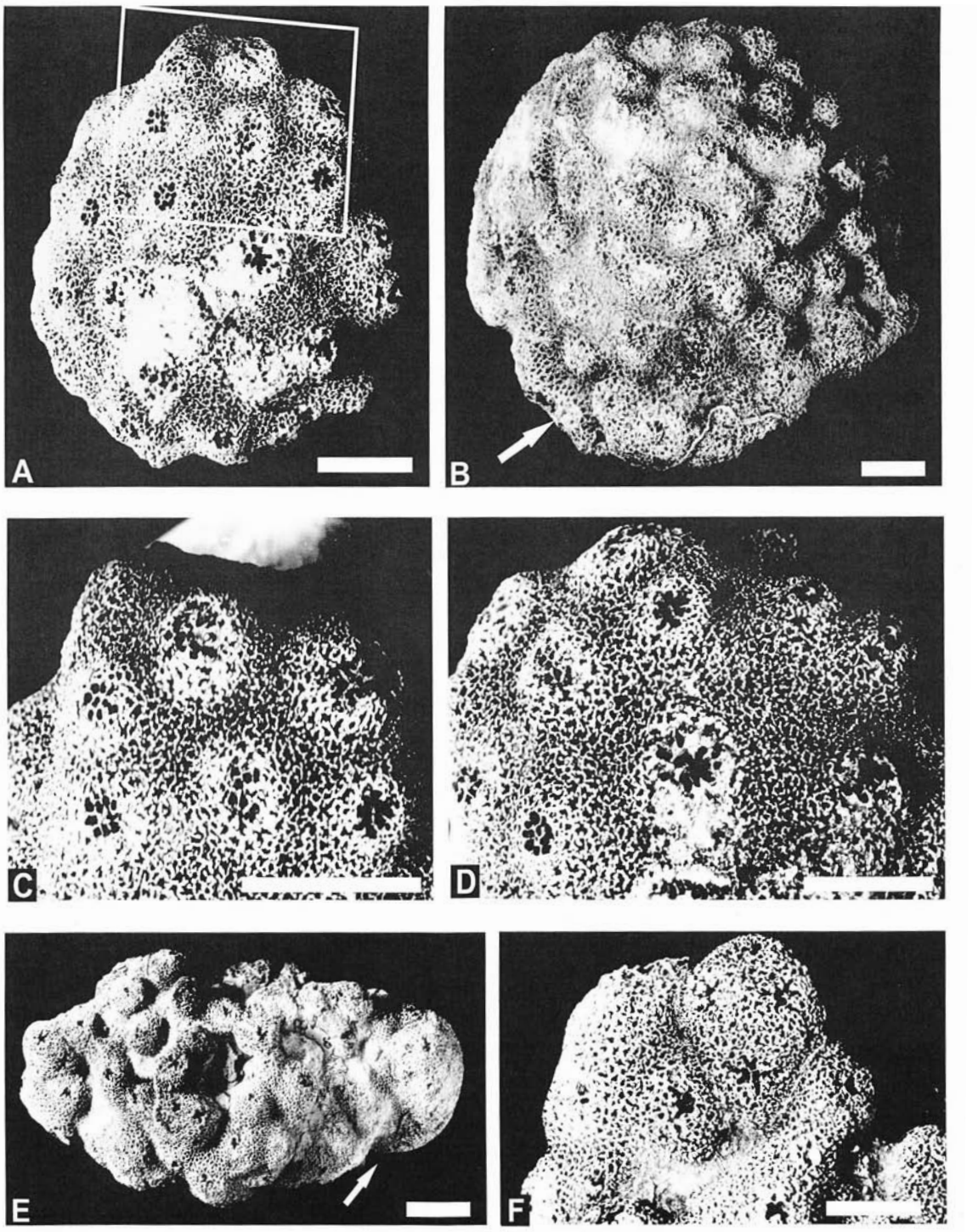

PLATE 3

Mammillopora polyosculata n. sp. from Upper Jurassic strata of the east-central Iran. Scale: 10 mm.
A) Holotype (BSPG 2010 XVII 1/7) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area. Top view of the hemispherical, bun-shaped specimen with numerous circular and nipple-like protuberances. The space between the individual protuberances is composed of equal-sized and loosely packed skeletal elements. For magnification of the area marked with the white quadrangle see Fig. C. B) Specimen (BSPG 2010 XVII 1/8) from the basal Korond Formation NW of Esfak, which is similar to the holotype and shows numerous nipple-like protuberances. (For magnification of the area marked with the white arrow see Fig. D). C) Magnification of the area marked with white quadrangle in Fig. A, showing several nipple-like protuberances. The top of each protuberance contains numerous (about 8-10) osculi arranged around a central point or opening. D) Magnification of the area indicated with the white arrow in Fig. B showing similar nipple-like protuberances with osculi as seen in Fig. C. E) View of specimen (BSPG 2010 XVII 1/9) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area with an oval outline and irregular base. The specimen shows nipple-like protuberances similar to those of the specimens illustrated in Fig. A and Fig. B. For magnification the area indicated with the white arrow see Fig. F. F) Magnification of arrowed side of the specimen illustrated in Fig. E, showing hardly separated protuberances. One protuberance has two (or three?) osculi. Possibly another sponge with star-like osculi was growing on *M. polyosculata*.

should be attributed to *Mammillopora*. This species shows also numerous protuberances, each with several (3) osculi. The species differs from *M. polyosculata* by radially arranged grooves, which are not connected with the osculi (Goldfuss 1829: pl. 30, fig. 4b). Also, the reticulate fibre skeleton of *M. polyosculata* differs from that of Goldfuss' species.

Genus *Tremospongia* d'Orbigny, 1849

Type species: *Manon pulvinarium* Goldfuss, 1826.

Geinitz (1871-1875: 27) stated that according to d'Orbigny (1849) the type species of *Tremospongia* is *Lymnorea sphaerica*, but he synonymed *L. sphaerica* with *M. pulvinarium* Goldfuss.

Synonyms: *Orosphecion* Pomel, 1872, *Aplosphecion* Pomel, 1872, *Synopella* Zittel, 1878 (compare Finks & Rigby 2004: 748).

Further species: *T. fromenteli* Etallon, 1859, *T. parandieri* Etallon, 1859, *T. grandis* Roemer, 1864-1866, *T. dialata* Roemer, 1864-1866, *T. pulvinaria* (Goldfuss, 1826), and *T. ternata* (Reuss, cited by Roemer 1864-1866: 40).

Diagnosis: "Spheroidal with conical base covered by concentrically wrinkled, imperforate, dermal layer; surface of spheroidal part bearing numerous small clusters of exhalant openings; remainder of upper surface reveals trabeculae and intertrabecular spaces; trabecular microstructure unknown" (Finks & Rigby 2004: 748).

Remarks. The morphology of the genera *Tremospongia* d'Orbigny, 1849, *Stellispongia* d'Orbigny, 1849, *Mammillopora* Bronn, 1825, and *Aplosphecion* Pomel, 1872 is quite similar. All four genera are massive, hemispherical or mushroom-shaped sponges with numerous exhalant canals composed of one or several osculi. The upper surface of *Tremospongia* is smooth and the exhalant canals are not placed on protuberances or nipple-like elevations as in *Mammillopora*. The distinctly star-shaped (astrorhiza-like) exhalant canals are usually placed on mamelon-shaped elevations in *Stellispongia*. In *Mammillopora* the exhalant canals, containing one or several osculi, are placed on the top of nipple-shaped protuberances. According to Finks & Rigby (2004: 748) *Aplosphecion* is similar to *Tremospongia*, but the exhalant canals are single.

Tremospongia pulvinaria (Goldfuss, 1826)

Pl. 4, figs G-H; Pl. 5, figs A-F; Pl. 13, figs A-G

1826 *Manon pulvinarium* Goldfuss, p. 2, pl. 29, fig. 7a, b (non pl. 1, fig. 6, which according to Goldfuss on page 13 is *Tragos pisiforme* Goldfuss)

1840-47 *Lymnorea sphaerica* Michelin, p. 216, pl. 52, fig. 16a, b

1860 *Tremospongia sphaerica* Fromentel, p. 37, pl. 2, fig. 13

1864-1866 *Tremospongia pulvinaria* (Goldfuss) – Roemer, p. 40, fig. 8

1871-1875 *Tremospongia pulvinaria* Goldfuss sp. – Geinitz, p. 27, description of Goldfuss, without illustration, but with synonymy list

1878 *Manon pulvinarium* Goldfuss – Quenstedt, p. 355, pl. 132, figs. 18-19

1911 *Synopella pulvinaria* Goldfuss – Welter, p. 70, pl. 1, fig. 9, pl. 3, fig. 1 (cum synonymy).

Material: At least 50 specimens (BSPX 2010 XVII 1/16-20) (thin-section, Pl. 13A-B), BSPG 2010 XVII 1/14, BSPG 2010 XVII 1/13 (thin-section; Pl. 13, figs C, E), and BSPG 2010 XVII 1/15 (thin-section; Pl. 13, figs D, F-G) from the Kamar-e Mehdi area.

Description.

Morphology. The bun-like hemispherical to mushroom-shaped specimens reach diameters of 60 mm and heights of up to 30 mm. The base of the sponge is characterized by a concentrically wrinkled and imperforate dermal layer (Pl. 5, figs D, F). The upper surface is convex and bears numerous clusters of exhalant canals about 1-2 mm in diameter. Each exhalant canal is composed of usually 4-6 openings, circular in cross-section and about 0.3 mm in diameter. The openings are separated from each other by a 0.2 mm thick fibre skeleton. The distance between two neighbouring clusters is usually about 10 mm. The space between the exhalant canals is filled with fibre skeleton containing two kinds of small pores or openings. The larger ones reach diameters of about 0.2-4 mm, the small openings have diameters of less than 0.2 mm. The majority of specimens are recrystallized. Neither the microstructure nor spicules could be observed.

Internal structure. Thin-sections of some well preserved specimens are illustrated in Pl. 13. In thin-sections perpendicular to the growth direction (perpendicular to the protuberances) the sponge exhibits internally concentric lines, reflecting growth stages (Pl. 13, figs A, E). The sponge skeleton between the concentric lines is composed of reticulate fibres with relatively large interfibre spaces. The osculi of protuberances or indistinct nipples appear as groups of tubes extending into the sponge skeleton (Pl. 13, figs B, C, F). Numerous transverse tabulae-like elements exist within the tubes (Pl. 13, figs C, F).

Spicules were not observed in thin-sections by transmitted light nor were they found in a SEM sample of the specimen illustrated in Pl. 13, fig. E.

Thin-sections of *T. pulvinaria* were investigated by Welter (1911). He described large tri- and tetractine spicules. Welter compared *T. pulvinaria* with *Sestrostomella essenensis* Dunikowsky (1883) and synonymized the latter species with *T. pulvinaria* (Goldfuss).

Occurrence. *Tremospongia pulvinaria* (Goldfuss) is the most abundant sponge species in collection. It is known from several European localities (see synonymy list). The species is reported here for the first time from Jurassic rocks of Iran.

Tremospongia pellisfera n. sp.

Pl. 6, figs A-C

Derivatio nominis: *Pellis* (lat.) = skin, *ferre* (lat.) = to bear. Named for the dermal layer between the clusters of exhalant canals on the upper surface of the sponge.

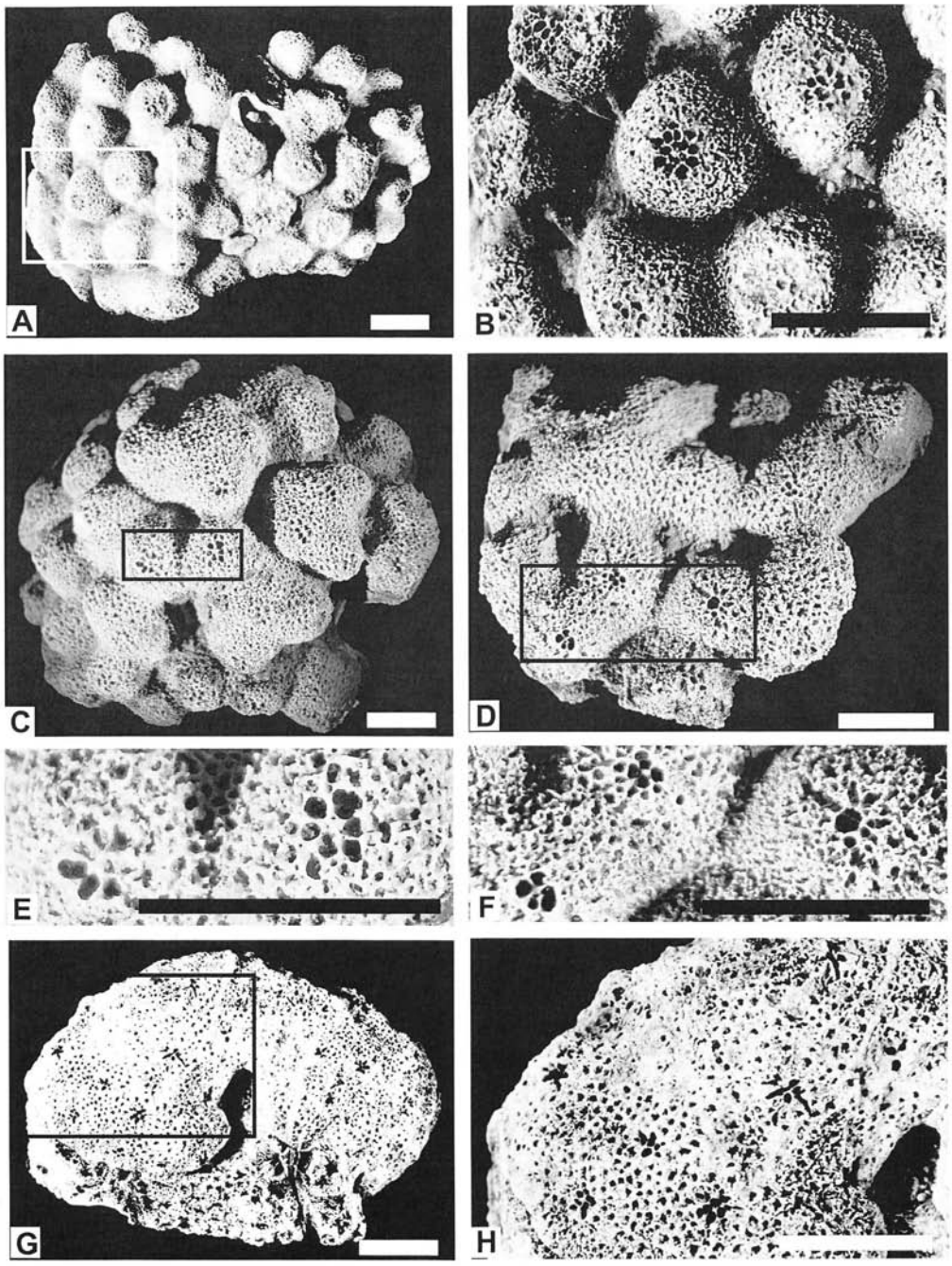

PLATE 4

Figs A-F - *Mammillopora polyosculata* n. sp. from Upper Jurassic strata of east-central Iran. Scale: 10 mm.
A) Top of specimen (BSPG 2010 XVII 1/10) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area exhibiting numerous nipple-like protuberances. For magnification of the area marked with a white quadrangle see Fig. B. B) Magnification of white rectangle area of Fig. A showing individual nipples, each with an osculum composed of numerous (up to 12) individual openings. C) View of specimen (BSPG 2010 XVII 1/11) from the basal Korond Formation NW of Esfak, with numerous nipple-like protuberances. Two or more protuberances are amalgamated. The top of each protuberance contains an osculum with several small openings. For magnification of the area marked with dark rectangle see Fig. E. D) Specimen (BSPG 2010 XVII 1/12) from the basal Korond Formation NW of Esfak, similar to that illustrated in Fig. C. For magnification of the area marked with a dark quadrangle see Fig. F. E) Magnification of quadrangle in Fig. C, showing two osculi with six or seven openings arranged radially around an axial point. Between the osculi the sponge surface is composed of irregularly arranged skeletal elements with small interfibre openings. F) Magnification of quadrangle in Fig. D showing three osculi composed of several openings. The osculum on the right side exhibits a large central pore surrounded by several radially arranged ovoid pores.
Figs G-H - *Tremospongia pulvinaria* (Goldfuss) from Upper Jurassic strata of east-central Iran. Scale: 10 mm.
G) Specimen (BSPG 2010 XVII 1/16) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area with numerous osculi composed of several asterisk-shaped osculi. Each osculum is composed of several openings located not in nipple- or mamelone-like protuberances. For magnification of the area marked with dark quadrangle see Fig. H. H) Magnification of quadrangle in Fig. G showing the individual asterisk-shaped osculi. The sponge surface between the osculi exhibits numerous small pores.

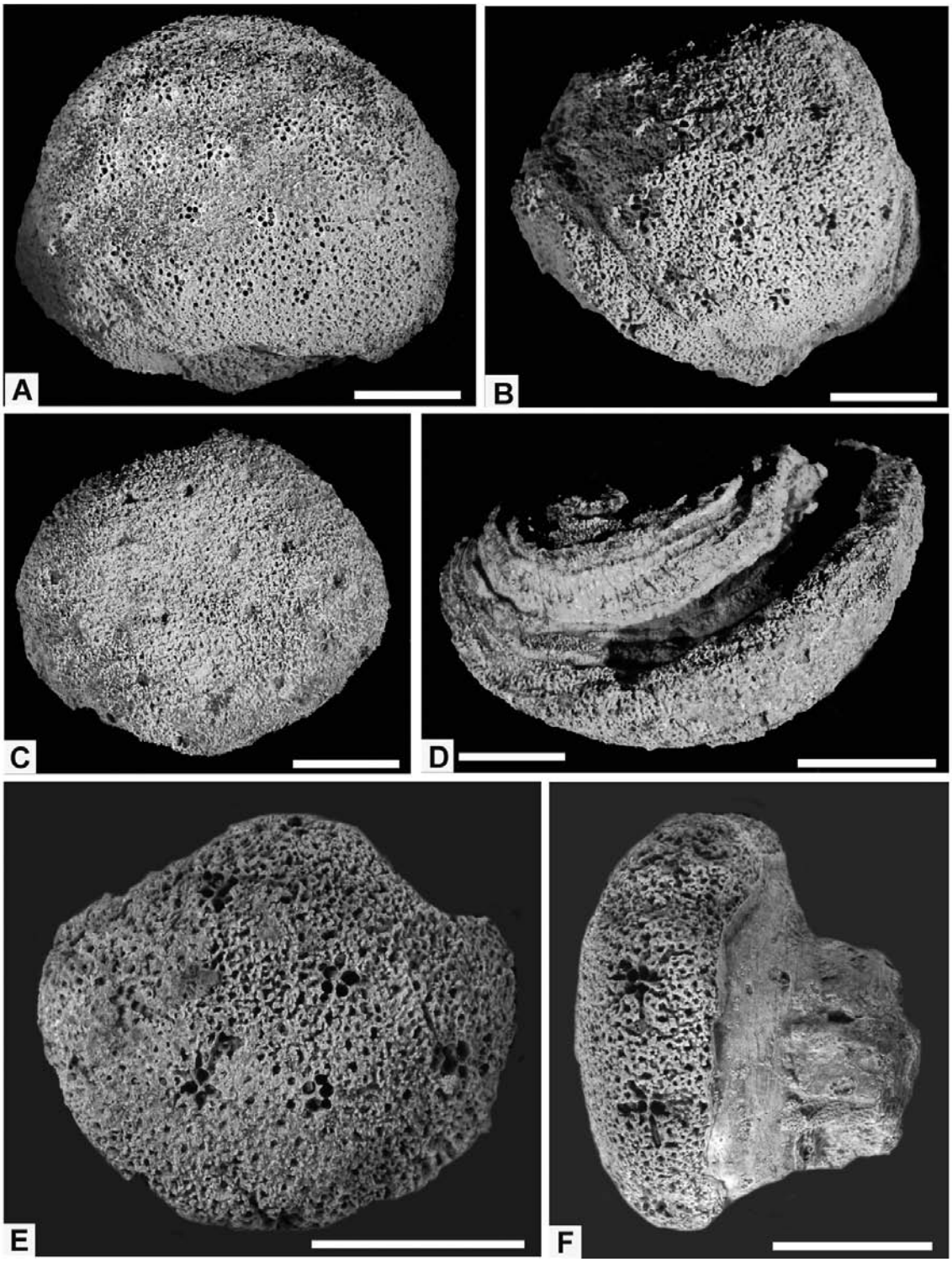

PLATE 5

Tremospongia pulvinaria (Goldfuss) from Upper Jurassic strata of the Shotori Mountains, east-central Iran. Scale: 10 mm.
A) Upper surface of the almost hemispherical specimen (BSPG 2010 XVII 1/17) from the base of the Korond Formation NW of Esfak, showing numerous exhalant canal bundles. Each canal bundle is composed of several (usually 5-6) canals and is not located on mamelone-like protuberances. Numerous small inhalant pores are located between the canal bundles. The sponge is grown on a shell. B) Upper surface of hemispherical specimen (BSPG 2010 XVII 1/19) from the basal Korond Formation NW of Esfak, which is encrusting - like Fig. A - a shell fragment. The exhalant canal bundles and the inhalant openings between them are clearly recognizable. C) Upper surface of mushroom-shaped specimen (BSPG 2010 XVII 1/20) from the basal Korond Formation NW of Esfak showing numerous exhalant canals. For a basal view of this sponge see Fig. D. D) The base (epitheca) of the mushroom-shaped specimen illustrated in Fig. C showing the concentric lines (wrinkled structure) of the dermal layer without any canal system. E) Upper surface of mushroom-shaped specimen (BSPG 2010 XVII 1/18) from the basal Korond Formation NW of Esfak showing similar characteristics as Fig. A. For side-view see Fig. F. F) Side view of the specimen illustrated in Fig. E showing the mushroom-shape with the imperforated and wrinkled dermal layer (epitheca) at the base and two exhalant canals.

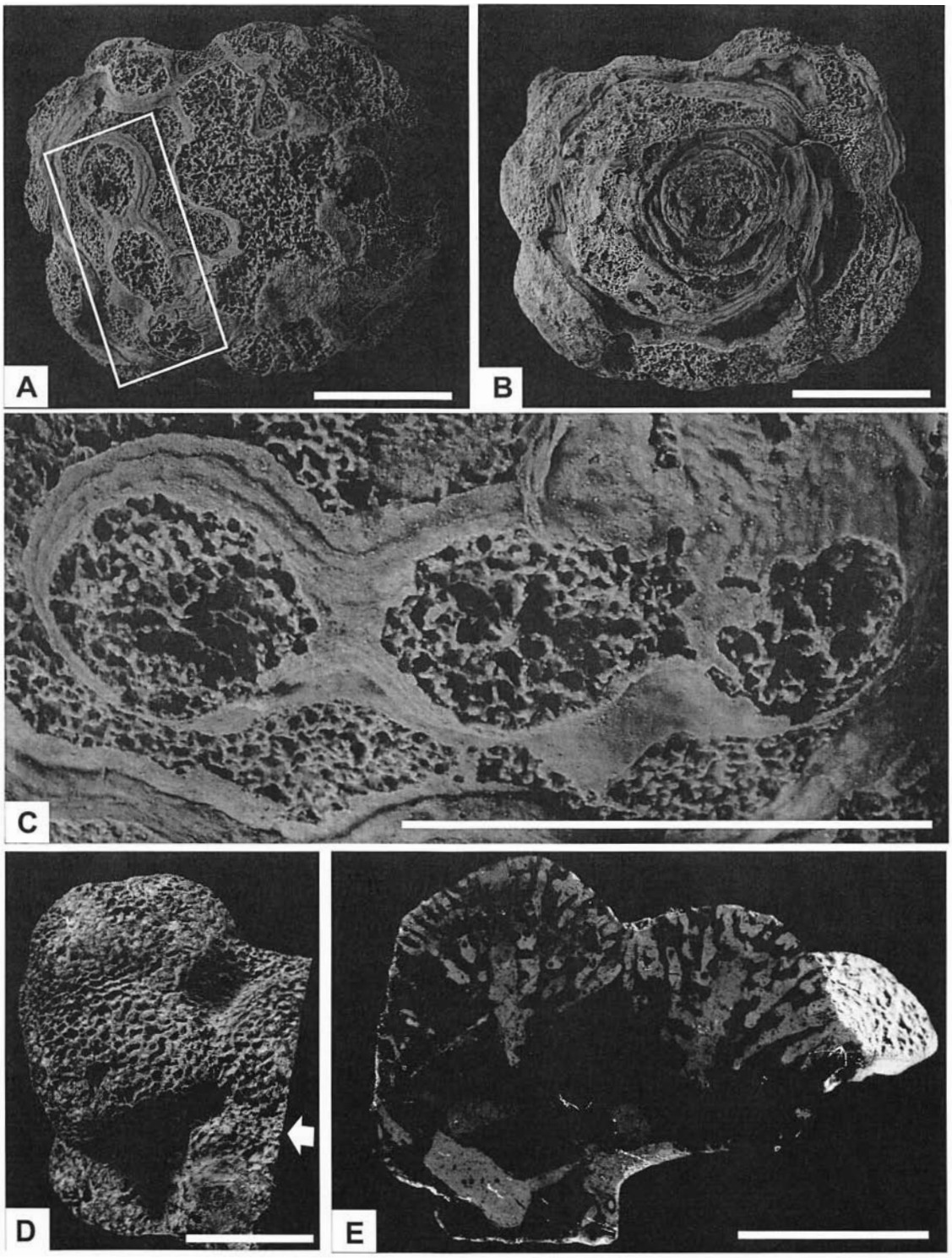

PLATE 6

Figs A-C - *Tremospongia pellisfera* n. sp. from the Upper Jurassic strata of the Shotori Mountains, east-central Iran. Scale: 10 mm.
A) Upper surface of the holotype (BSPG 2010 XVII 1/21) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area showing the star-like exhalant canals surrounded by the thin imperforated dermal layer. The space between the individual osculi is composed of skeletal and interskeletal elements. B) Epitheca of the specimen illustrated in Fig. A, showing the wrinkled and imperforated dermal layer, which has been partly destroyed. C) Magnification of rectangle in Fig. A, showing three star-shaped exhalant canals surrounded by the wrinkled and imperforated dermal layer.
Figs D-E - *Mammillopora iranica* n. sp. from the Upper Jurassic strata of the Shotori Mountains, east-central Iran. Scale: 10 mm.
D) View of the upper surface of the paratype (BSPG 2010 XVII 1/5) from the basal Korond Formation NW of Esfak showing four nipples, each with a circular osculum on their top. Arrow indicates the cut surface illustrated in Fig. E. E) Polished slab cutting through two nipples, each with a large canal ending at the top of the nipple. From the large canal several small canals diverge ending in the small pores between the fibre skeletal at the surface.

Holotype: Specimen BSPG 2010 XVII 1/21 (Pl. 6, figs A-C).

Locus typicus: Kamar-e Mehdi area, about 100 km SW of Tabas (Fig. 1).

Stratum typicum: Kamar-e Mehdi Formation (Callovian – Oxfordian).

Diagnosis: Hemisperical to mushroom-shaped sponge with concentrically wrinkled and imperforate dermal layer at the base. Upper surface with numerous weakly developed protuberances. Each protuberance bearing an exhalant canal bundle composed of several (usually 8) individual and pear-shaped osculi arranged radially around a pillar-shaped element in the centre. The flanks of the protuberances are covered with and imperforate dermal layer.

Material: A single specimen (BSPG 2010 XVII 1/21).

Description. The single specimen is mushroom-shaped, reaching a diameter of 30x25 mm and a height of almost 20 mm. The lower part of the sponge base is covered – as in the case of *Tremospongia pulvinaria* – by a concentrically wrinkled and imperforate dermal layer, which has been partly destroyed. The upper surface exhibits weakly developed protuberances, which are clearly recognizable at the margin of the upper surface. The top of each protuberance bears an exhalant canal composed of about eight pear-shaped or oval individual osculi arranged radially around a pillar-shaped element in the centre (Pl. 6, fig. C). Each exhalant canal has a diameter of 2.0-2.3 mm. Individual protuberances are surrounded by an imperforate dermal layer, like the one in the lower part of the sponge (Pl. 6, figs A, C). The space between the protuberances and under the dermal layer is composed of skeletal elements with a thickness of 0.2 mm. The spaces between the skeletal elements are circular to oval or irregular and have a diameter of about 0.4-0.5 mm.

Comparison. *Tremospongia pellisfera* n. sp. differs from *T. pulvinaria* by the imperforated dermal layer around the protuberances.

Dehukia n. gen.

Type species: *Dehukia maxima* n. sp.

Derivatio nominis: Named after the town of Dehukia, south of Tabas.

Diagnosis: Irregularly shaped sponge with irregularly folded walls. Between the folded walls there are deep grooves of different shapes. The top of the wall bears numerous osculi. The wall between the osculi is composed of a reticulate fibre skeleton and interfibre openings.

Additional species: *Dehukia raisossadati* n. sp., *Dehukia media* n. sp., and *Dehukia crassa* (= *Elasmocoelia crassa* Hinde, 1883; see discussion).

Discussion. Fromentel (1860: 34) established the genus *Elasmoierea* with the type species *E. sequana*. On his pl. 2, fig. 3 he illustrated a conical sponge characterized by folded walls and numerous osculi, arranged in rows on the top of the walls. Roemer (1864/66: 31) established the new genus *Elasmocoelia* - without giving any arguments – and attributed Fromentel's species *Elasmoierea sequana* to *Elasmocoelia*. On his pl. 1, fig. 11 he illustrated a specimen as *E. sequana*, which seems to be different from Fromentel's species. Roemer's specimen is clearly composed of eight cylindrical branches, which are fused at the base. Such cylindrical branches are not recognizable in Fromentel's specimen. Roemer's specimen has been re-illustrated by Finks & Rigby (2004: 740, fig. 492/3) as *Elesmoierea sequana* Fromentel. Roemer (1864/66) described a second species of the genus as *Elasmocoelia orbitulata*, which is ear- to leaf-shaped and bears numerous osculi on the margin of the ear.

Elasmoierea and *Elasmocoelia* were correctly synonymized by Finks & Rigby (2004: 741), with *Elasmoierea* having priority.

Hinde (1883: 176) described and illustrated a sponge as *Elasmocoelia crassa* Fromentel, 1861. The specimen of Hinde differs from species attributed to *Elasmoierea* or *Elasmocoelia* but is similar to sponges, which are described here as species of the genus *Dehukia* nov. gen. It is therefore attributed to the new genus (see above).

Dehukia maxima n. sp.

Pl. 7, figs A-D

Derivatio nominis: Named after the large dimensions of the sponge.

Holotype: Specimen BSPG 2010 XVII 1/21 (Pl. 7, figs A-D) from *Nanogyra* patch reef in the Kamar-e Mehdi Formation of the Kamar-e Mehdi area.

Locus typicus: Kamar-e Mehdi area (Fig. 1).

Stratum typicum: Kamar-e Mehdi Formation.

Diagnosis: Large bun-shaped to irregularly spherical sponge with irregularly folded wall. Between the folded wall there are deep grooves. With numerous osculi on the top of the walls continuing as tubes into the sponge skeleton. Outer surface composed of fibre skeleton of the reticulate type. Microstructure and spicules not known.

Material: A single specimen (BSPG 2010 XVII 1/21).

Description. *Dehukia maxima* n. sp. is the largest specimen in our collection of calcisponges. It is almost globular, with diameters of 160x130 mm. A small area on the outer surface lacking a wall might be the attachment surface.

The sponge is composed of an irregularly folded wall about 10 mm thick. The lateral surfaces of the wall are composed of coarse reticulate skeletal elements. Additional pores or canals are missing. The top of the wall bears numerous openings (osculi) 2-3 mm in diameter. The osculi show a linear arrangement and the distance between individual osculi is 5-13 mm. Polished surfaces reveal that the osculi extend as tubes into the sponge skeleton (Pl. 7, figs B, D: black arrows). Several marginal and small tubes (exhalant canals) end into the main tubes (Pl. 7, fig. D). The internal skeleton of the sponge is strongly recrystallized; only at the margin of the sponge where the pore space is filled with micritic sedi-

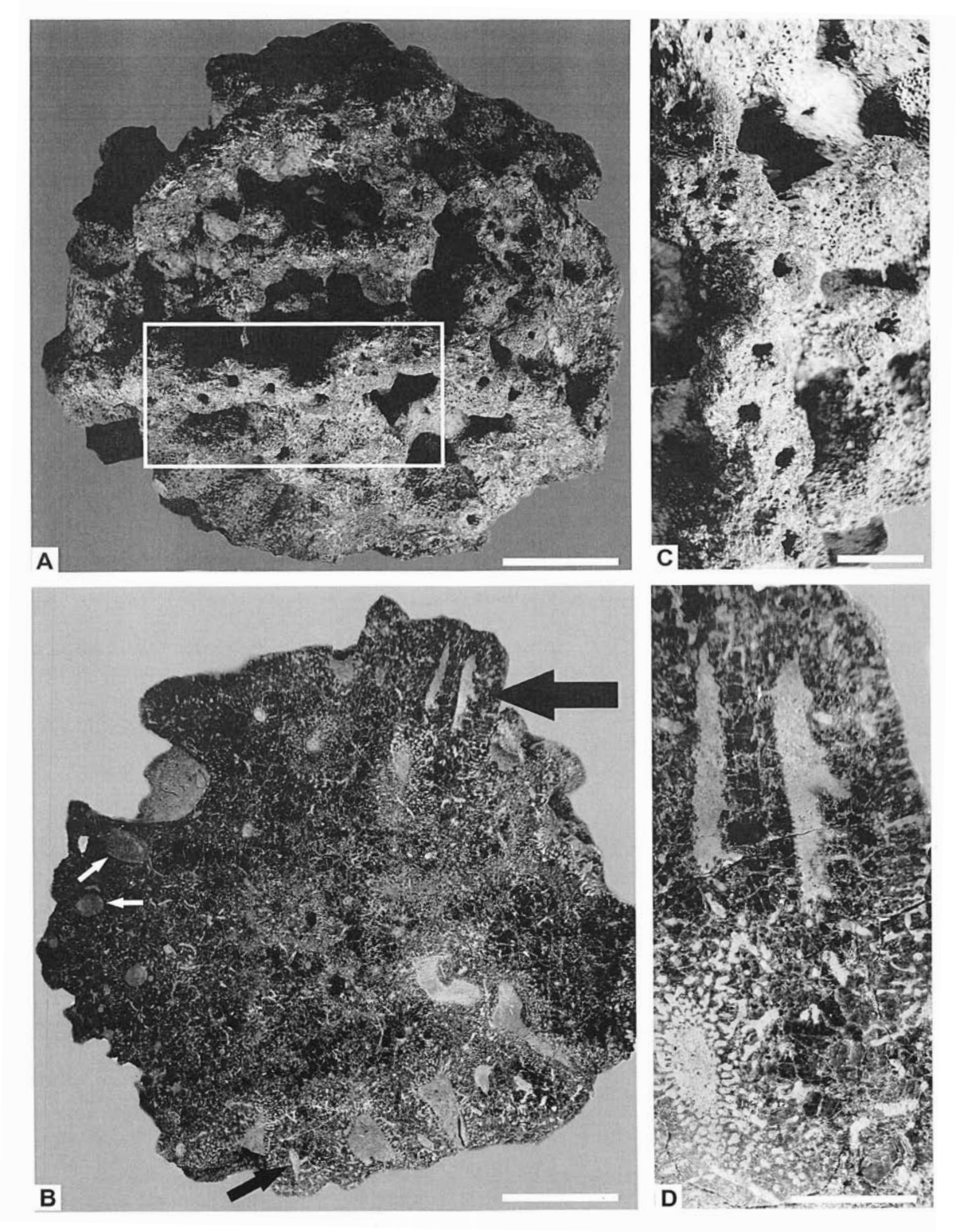

PLATE 7

Dehukia maxima n. gen., n. sp. (Holotype: BSPG 2010 XVII 1/21) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area. Scale: 30 mm (Figs A, B) and 10 mm (Figs C, D).

A) The surface of the irregularly growing sponge shows numerous exhalant osculi located on the thick, folded sponge wall. The grooves between the folded walls are without exhalant canals but are covered with small inhalant openings. For magnification of the area marked with rectangle see Fig. C. B) The polished lower side shows the strongly recrystallized skeleton. The sponge structure is seen only on the marginal parts. The osculi (see Figs A, C) at the sponge surface extend as tubes (exhalant canals) into the sponge interior (black arrows). The area, indicated with the large black arrow is magnified in Fig. D. The small black arrow shows another exhalant canal surrounded by small marginal canals ending into the main canal (compare Fig. D). The white arrows on the left side show borings. C) Magnification of area marked with a rectangle in Fig. A, showing the sponge wall with several osculi. Two osculi show partly radiating exhalant canals around them. D) Magnification of area at large black arrow in Fig. B, showing two exhalant canals with marginal canals leading to them.

ment the reticulate fibre skeleton is seen (Pl. 7, fig. D). Some areas, filled with micritic red sediment, probably represent borings (Pl. 7, fig. B: white arrows).

Dehukia raisossadati n. sp.

Pl. 8, figs A, C-D, F

Derivatio nominis: The species is dedicated to Dr. Nasser Raisossadat (University of Birgand), who collected the specimen.

Holotype: Specimen BSPG 2010 XVII 1/22 (Pl. 8, figs A, C, D) from the Qal-eh Dokhtar Formation.

Locus typicus: 15 km northwest of Boshrouyeh (co-ordinates 34°02′05″N, 57°10′6″E).

Stratum typicum: Qal-eh Dokhtar Formation (Callovian-Oxfordian).

Diagnosis: Irregularly bun-shaped, folded sponge. Large groove-like depressions are surrounded by the folded sponge wall. The top of the wall carries numerous smalls osculi. The outer wall of the sponge is composed of a reticulate fibre skeleton.

Material: A single specimen (BSPG 2010 XVII 1/22).

Description. The irregularly bun-shaped, folded sponge reaches a diameter of 60x35 mm with a height of 34 mm. It is composed of an irregularly folded wall of about 10 mm thickness. By the folding of the sponge wall large, irregular, deep depressions up to 20 mm in diameter are formed. The top of the wall carries numerous small osculi of about 1.2 mm (range: 0.5-1.8 mm) in diameter. The wall of the osculi is pierced by relatively large pores (0.3-0.4 mm in diameter), which are circular to oval in cross-section and are arranged in vertically lines. Up to four osculi were counted within a distance of 10 mm. Radiating grooves around the osculi were observed. The wall between individual osculi has almost the same width as the osculi. The wall of the depressions is composed of a reticulate fibre skeleton. The thickness of the skeletal fibres is about 0.2 mm, and the space between them is circular, oval or irregular having a diameter of about 0.2 mm. Spicules were not observed.

Comparison. According to the numerous osculi at the top of the sponge wall *Dehukia raisossadati* nov. sp. is similar to sponges attributed to *Elasmoierea* or *Elasmocoelia*. The general differences to these sponges have been discussed above. *D. raisossadati* differs from *D. maxima* by the small dimension of the sponge and of the sponge skeleton. The osculi on the top of the sponge wall are arranged in one row in *D. maxima*, whereas they do not form a line in *D. raisossadati.*

Dehukia media n. sp.

Pl. 8, figs B, E

Derivatio nominis: Named for the medium-sized skeletal elements when compared with *Dehukia maxima* n. sp. or *D. raisossadati* n. sp.

Holotype: Specimen BSPG 2010 XVII 1/23 (Pl. 8, figs B, E) from debris flow within the basal Korond Formation.

Locus typicus: NW Esfak, Shotori Mts. (Fig. 1)

Stratum typicum: Basal Korond Formation (Oxfordian).

Diagnosis: Irregularly folded sponge. Large, irregular, groove-like depressions are surrounded by the folded wall of sponge. The top of the thick wall carries numerous, relatively large osculi. The sponge is composed of skeletal fibres of the reticulate type.

Material: A single specimen (BSPG 2010 XVII 1/23).

Description. The irregularly shaped and folded specimen reaches a height of 50 mm and a diameter of 80 mm. As the preceding species it is composed of an irregularly folded sponge wall of 15-18 mm in thickness. The sponge wall surrounds irregularly shaped depressions more than 30 mm in diameter. The top of the sponge walls carries numerous osculi of about 2.2 mm (range: 2-3 mm) in diameter. Additionally, small openings of about 0.6 mm (at most 1 mm) in diameter occur sporadically between the large osculi. As in the preceding species the wall of the osculi is pierced by relatively large, circular to oval pores (0.4 mm in diameter). It was not possible to find out whether the pores of the osculi walls are arranged in vertical rows as in the preceding species. Three osculi were counted across a distance of 10 mm. The space between the osculi and small openings is filled by fibre skeleton having a thickness of 0.2-0.4 mm. The fibre skeleton of the wall of the depressions is very regular, containing small circular or oval openings about 0.5 mm in diameter. The skeleton is strongly recrystallized. Spicules were not observed.

Comparison. The skeletal elements of *Dehukia media* n. sp. are smaller than in *D. maxima* n. sp., but larger than in *D. raisossadati* n. sp. The biometric data of the three species of *Dehukia* are listed in Tab. 1.

Subfamily Stellispongiinae de Laubenfels, 1955

Genus *Stellispongia* d'Orbigny, 1849

Type species: *Tragos stellatum* Goldfuss, 1826.

Diagnosis: "Bun-shaped or tuberoid, with flattened base covered by concentrically wrinkled dermal layer; upper surface bearing mamelons, each with astrorhiza-like, exhalant groove system without central osculum or pore cluster; entire upper surface covered with small, circular, intertrabecular pores, some clearly larger than others" (Finks & Rigby 2004: 739).

Species	SH	SD	SW	DO	DOOW	TFS
D. maxima	120	160x130	10	2-3	?	0.4
D. raisossadati	34	60 x 35	10	0.5-1.8	0.3-0.4	0.2
D. media	50	80 x 60	15-18	2-3	0.4	0.2-0.4

Tab. 1 - Biometrical data of *Dehukia maxima* n. sp., *D. raisossadati* n. sp. and *D. media* n. sp. SH: sponge height, SD: sponge diameter, SW: thickness of the sponge wall, DO: diameter of osculi on the top of the sponge wall, DOOW: diameter of the openings in the osculi wall, TFS: thickness of fibre skeleton. All measurements in mm.

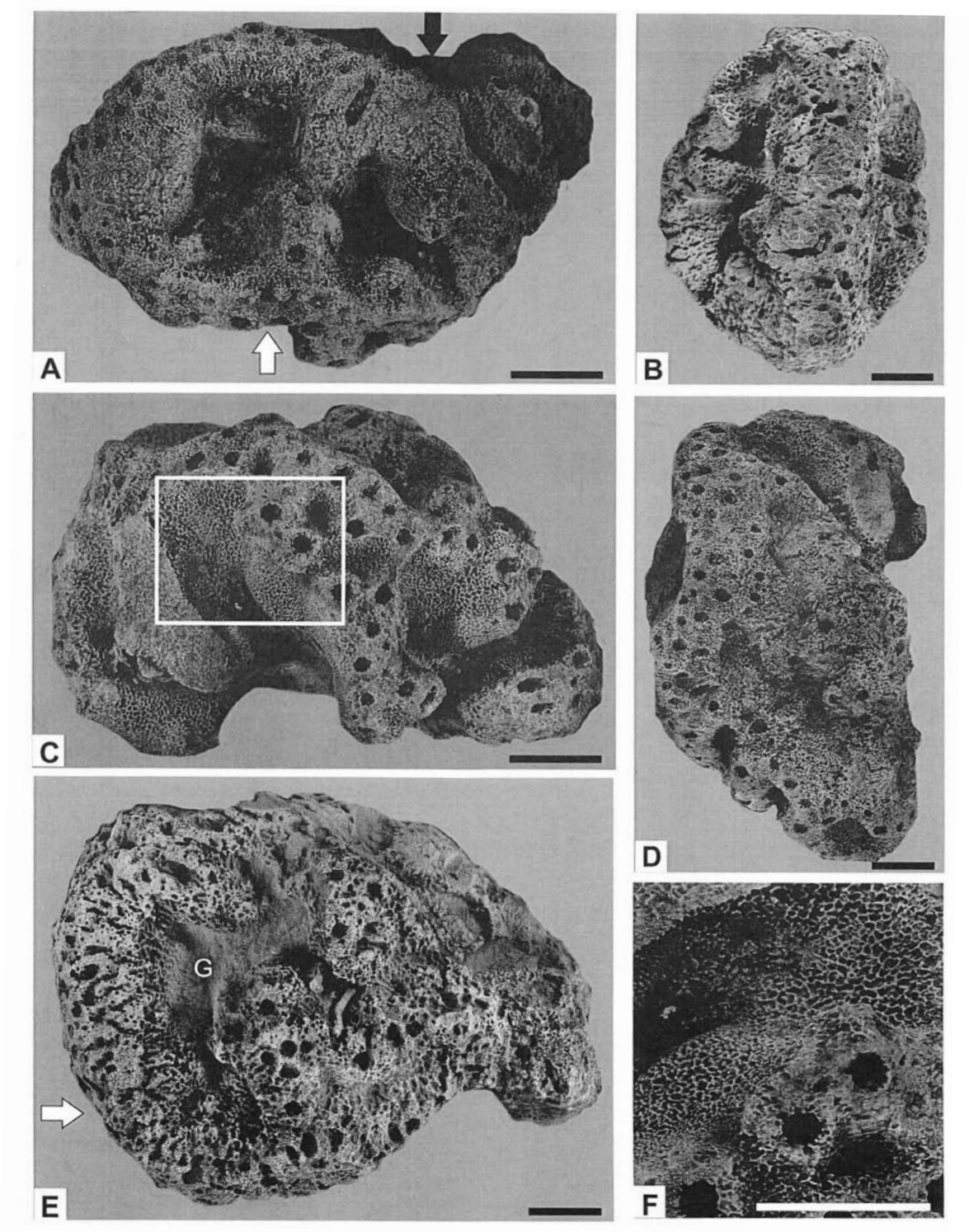

PLATE 8

Figs A, C, D, F - *Dehukia raisossadati* n. sp. from the Upper Jurassic strata of the Shotori Mountains, east-central Iran. Holotype (BSPG 2010 XVII 1/22) from a locality, approximately 15 km northwest of Boshrouyeh. Scale: 10 mm.

A) Thick sponge wall with numerous exhalant canals. The grooves between the irregularly folded walls are composed of reticulate skeletal elements (see Fig. F). The white arrow points to the side of the sponge illustrated in Fig. C. C) Side view (see white arrow in Fig. A) of the same specimen illustrated in Fig. A. For magnification of the rectangle area see Fig. F. D) Side view (see black arrow in Fig. A) showing numerous exhalant openings of the sponge wall. F) Magnification of rectangle area in Fig. C, showing three exhalant canals and a groove in the sponge wall (upper part of photograph). The groove shows reticulate skeletal elements and the interfibre spaces.

Figs B, E - *Dehukia media* n. sp. from the Upper Jurassic strata of the Shotori Mountains, east-central Iran. Holotype (BSPG 2010 XVII 1/23) from Kamar-e Mehdi area.

B) View of the "back-side" showing the grooves (dark area) between the sponge walls. E) Relatively large exhalant canals in the sponge walls. G indicates a groove with coarse skeletal elements between the sponge walls. The arrow indicates the view of the "back-side" illustrated in Fig. B.

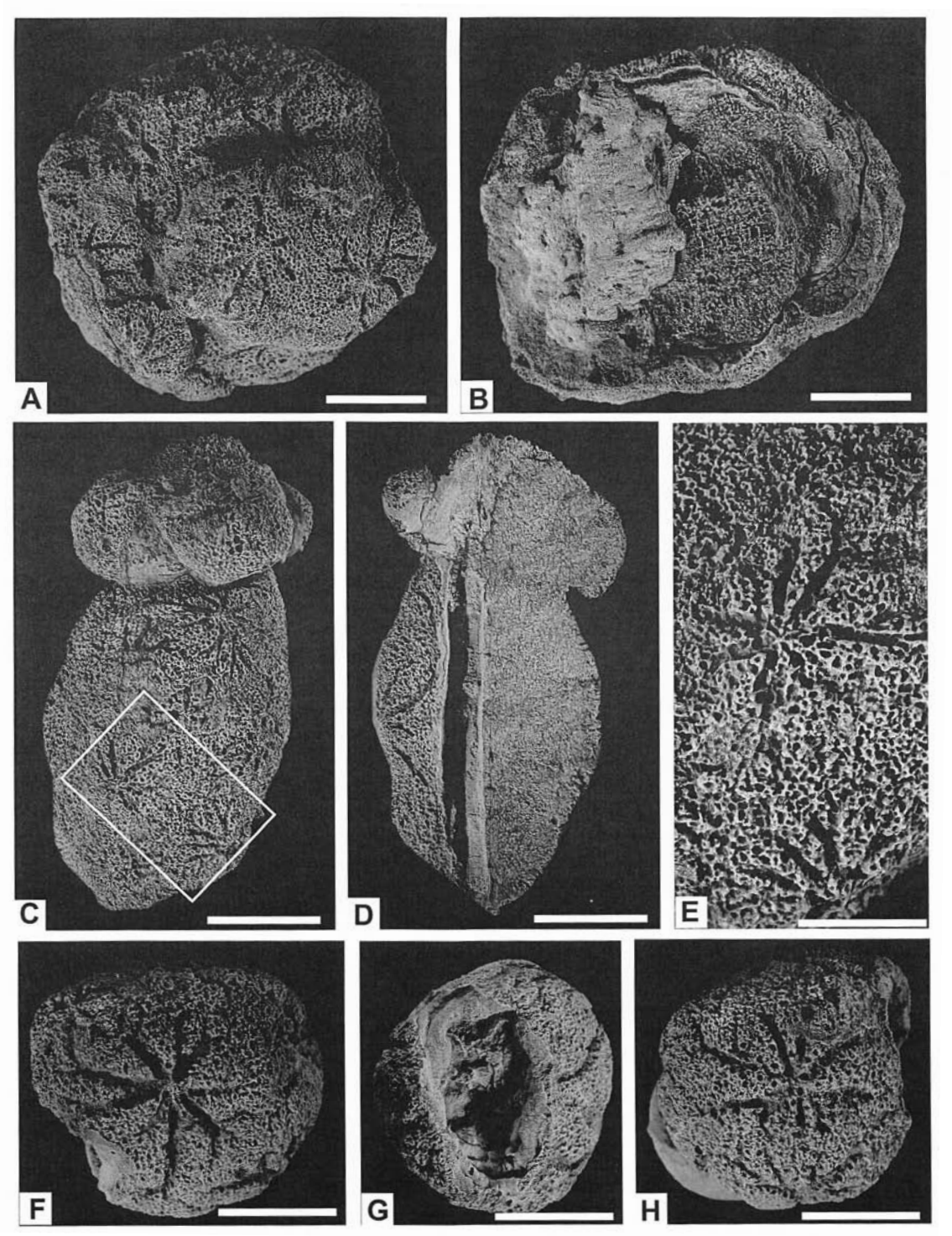

PLATE 9

Figs A-E - *Stellispongia stellata* (Goldfuss) from the basal Korond Formation NW of Esfak. Scale: 10 mm.
A) View of the upper surface of hemispherical specimen (BSPG 2010 XVII 1/24) showing several star-shaped exhalant canals and small interfibre pores representing the inhalant canals. For basal view of the sponge see Fig. B. B) Base of the specimen illustrated in Fig. A. C) View of the upper surface of hemispherical-oval specimen (BSPG 2010 XVII 1/25) clearly showing the star-shaped exhalant canals. For the base of the sponge and for magnification of the area marked with a rectangle see Fig. D and Fig. E. D) Base of specimen in Fig. C, showing a tube-like substrate incrusted by the sponge. The right part of the sponge is naturally broken, but the left part is complete, showing a star-shaped exhalant canal on the side surface. E) Magnification of rectangle in Fig. C, showing the grooves of star-shaped exhalant canals and the small inhalant openings between them.
Figs F-H - *Stellispongia* cf. *St. stellata* (Goldfuss) from the basal Korond Formation NW of Esfak. Scale: 10 mm (F-G) and 5 mm (Fig. H). F) The side view of the spherical sponge (BSPG 2010 XVII 1/26) shows one of several star-shaped exhalant canals. G) Base of the specimen illustrated in Fig. F. H) Side view (opposite side of Fig. F), showing one of the star-shaped exhalant canals and the small pores (inhalant canals) between the grooves of the star.

Remarks. *Tragos stellatum* Goldfuss (1826: 14) is the type species of the genus *Stellispongia*. As noted by Reitner (1992) and Finks & Rigby (2004: 739) *Cnemidium variabilis* Münster, 1841 is given incorrectly as type species of *Stellispongia* by some authors (e. g. Rauff 1938: 205, 208; Dieci et al. 1968: 112).

Lamouroux (1821: 89, pl. 84, figs 12-15) described the species *Spongia stellata* and illustrated it by four specimens. Of these figures only the specimen illustrated in Fig. 13 is listed (with some synonymy) by Hinde (1883: 186) under the genus *Stellispongia*. Hinde (1883: 186) noted that "the spicular structure of the fibres of this species is clearly of the *Sestrostomella* type". Therefore *Spongia stellata* Lamouroux, 1821 cannot be renamed as *Stellispongia stellata* as done by Hinde (1883). The systematic position of other species of *Stellispongia* listed by Hinde has been revised by Rauff (1938; see below).

Stellispongia is one of the most discussed sponge genera. It was reported from the Palaeozoic (Parona 1933; Termier & Termier in Termier et al. 1977) as well as from the Mesozoic era (Münster 1841; Laube 1865; Dieci et al. 1968). Both groups are morphologically characterized by mostly massive, hemispherical to spherical sponges with astrorhiza-like exhalant canals. Representatives of Permian sponges, described as *Stellispongia*, were attributed to the genus *Stellispongiella* by Wu (1991) and Rigby & Senowbari-Daryan (1996). Triassic species, known as *Stellispongia variabilis*, however, possess spicules, which are not comparable with calcareous or siliceous spicules of other sponges (Steinmann 1882: 180). Similar or identical spicules were found also by Rauff (1938: 198) in *St. variabilis.* Further information about the tri- and tetractine spicules of *Stellispongia* has been provided by Dunikowski (1883: 318). Dunikowski's (1883: pl. 4, fig. 5) illustration of the spicular skeleton of *Stellispongia* has been re-illustrated by Finks & Rigby (2004: 740, fig. 4), but Hinde (1883: 186) did not accept the placement of Dunikowski's illustration in *Stellispongia*. According to Dunikowski, tetractine types are limited to the outer layer of the fibre skeleton. According to Reitner (1992: 250) the spicules of *S. variabilis* are of the strongyl type, reaching lengths of 25-60 µm and diameters of 5-10 µm, arranged in bundles. He favoured the placement of *S. variabilis* in the family Petrosiidae.

A detailed discussion of *Stellispongia* and a revision of its species were carried out by Zittel (1878: 39) and later on by Rauff (1938). Rauff listed 69 species described (some of them as uncertain) as *Stellispongia;* three from the Palaeozoic, 13 from Triassic, 26 from Jurassic, and 27 from Cretaceous strata. He noted that not only different calcispongids, but also some lithistids and one hexactinellid sponge were attributed to *Stellispongia*. According to Rauff (1938) only the species of Münster - *Stellispongia variabilis* [(= *Cnemidium variabile* Münster and possibly *S. turbinata* (Münster)] and *S. stellaris* (Münster) – may be classified as *Stellispongia*. d'Orbigny (1849) and Dieci et al. (1968) placed *Cnemidium manon* (Münster, 1841) also in *Stellispongia*, but according to the description of Laube (1865: 238) this species probably is not a *Stellispongia*. Also species described by Laube (1865) do not belong to *Stellisponiga*. Later on, the species *S. subsphaerica* has been established by Dieci et al. (1968: 113) from the Triassic (Carnian) Cassian Formation of the southern Alps, Italy. Therefore, based on morphological criteria, the following species may be classified as *Stellispongia*: *S. stellata* (= *Tragos stellatum* Goldfuss, 1826: 14, pl. 30, fig. 2), *S. variabilis* (= *Cnemidium variabile* Münster, 1841: 30, pl. 1, figs. 21-23), *S. turbinata* (= *Cnemidium turbinatum* Münster, 1841: 30, pl 1, fig. 19), *S. subsphaerica* Dieci et al. (1968: 113, pl. 19, figs. 1-3), and possibly *Stellispongia manon* (= *Cnemidium manon* Münster, 1841: 30, pl. 1, fig. 20).

Of the mentioned five species of *Stellispongia* only *Stellispongia stellata* (Goldfuss, 1826) is from Jurassic strata, all others are from the Triassic. Quenstedt (1878: 611) listed several species under the name *Stellispongia*, but none of these species belongs to *Stellispongia*. Senowbari-Daryan (1994) described several sponge species from the Jurassic of Peru, which are characterized by star-like exhalant canals as in the Jurassic representatives of *Stellispongia*. Because of the lack of spicules in Jurassic *Stellispongia* and because of the bush-like morphology of the Peruvian species they have been attributed, with reservation, to *Stellispongiella* (Wu, 1991).

Stellispongia stellata (Goldfuss, 1826)

(non *Stellispongia stellata* Lamouroux, 1821 of Hinde 1883)

(non *Manon stellatum* (Goldfuss, 1826) of Quenstedt 1878: 361)

Pl. 9, figs A-E; Pl. 10, figs A-F; Pl. 11, figs F-G; Pl. 12, figs G; Pl. 14, figs A-C

1826 *Tragos stellatum* nobis – Goldfuss, p. 14, pl. 30, fig. 2

? 1860 *Actinofungia pediculata* – Fromentel: pl. 4, fig. 8

1864-1866 *Stelispongia stellata* Goldfuss – Roemer: 48, pl. 14, fig. 9

Material: At least 8 specimens (illustrated specimens: BSPG 2010 XVII 1/24, BSPG 2010 XVII 1/25, BSPG 2010 XVII 1/27, BSPG 2010 XVII 1/28, BSPG 2010 XVII 1/29, and BSPG 2010 XVII 1/30).

Description. Specimens of this sponge are bun-shaped, ovoid, spherical or irregular with a flattened base as attachment surface. The dermal layer of the base is wrinkled in some specimens. The size of the sponges is highly variable, reaching diameters between 10 and 90 mm. Several spherical nodes may coalesce. The upper

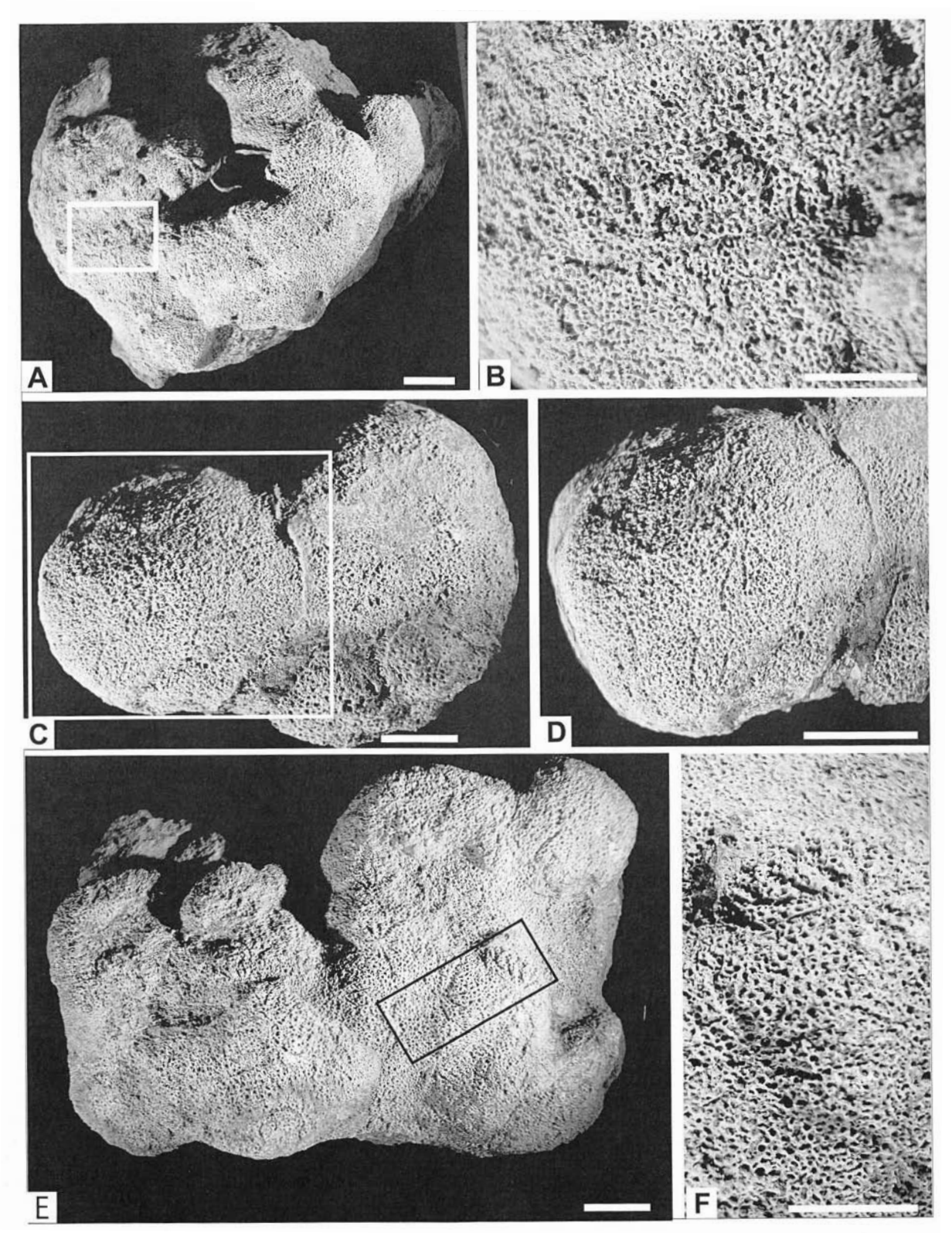

PLATE 10

Stellispongia stellata (Goldfuss) from Upper Jurassic strata of the east-central Iran. Scale: 10 mm (Figs A, C-E) and 5 mm (Figs B, F).
A) View of the upper surface of irregular specimen (BSPG 2010 XVII 1/27) Korond Formation NW of Esfak with indistinct astrorhiza-shaped (weathered?) exhalant canals (For magnification see Fig. B). B) Magnification of rectangular area in Fig. A, showing the fibre skeleton and an indistinct star-shaped exhalant canal. C) View of the upper surface of specimen (BSPG 2010 XVII 1/28) Korond Formation NW of Esfak showing the astrorhiza-shaped exhalant canals (for magnification see Fig. D). D) Magnification of rectangular area in Fig. C, showing some clearly recognizable astrorhiza-shaped exhalant canals. E) View of the upper surface of irregular specimen (BSPG 2010 XVII 1/29) Korond Formation NW of Esfak showing numerous astrorhiza-shaped exhalant canals (for magnification see Fig. F). F) Magnification of rectangular area in Fig. E, showing two astrorhiza-shaped exhalant canals. The pores in the grooves are clearly recognizable.

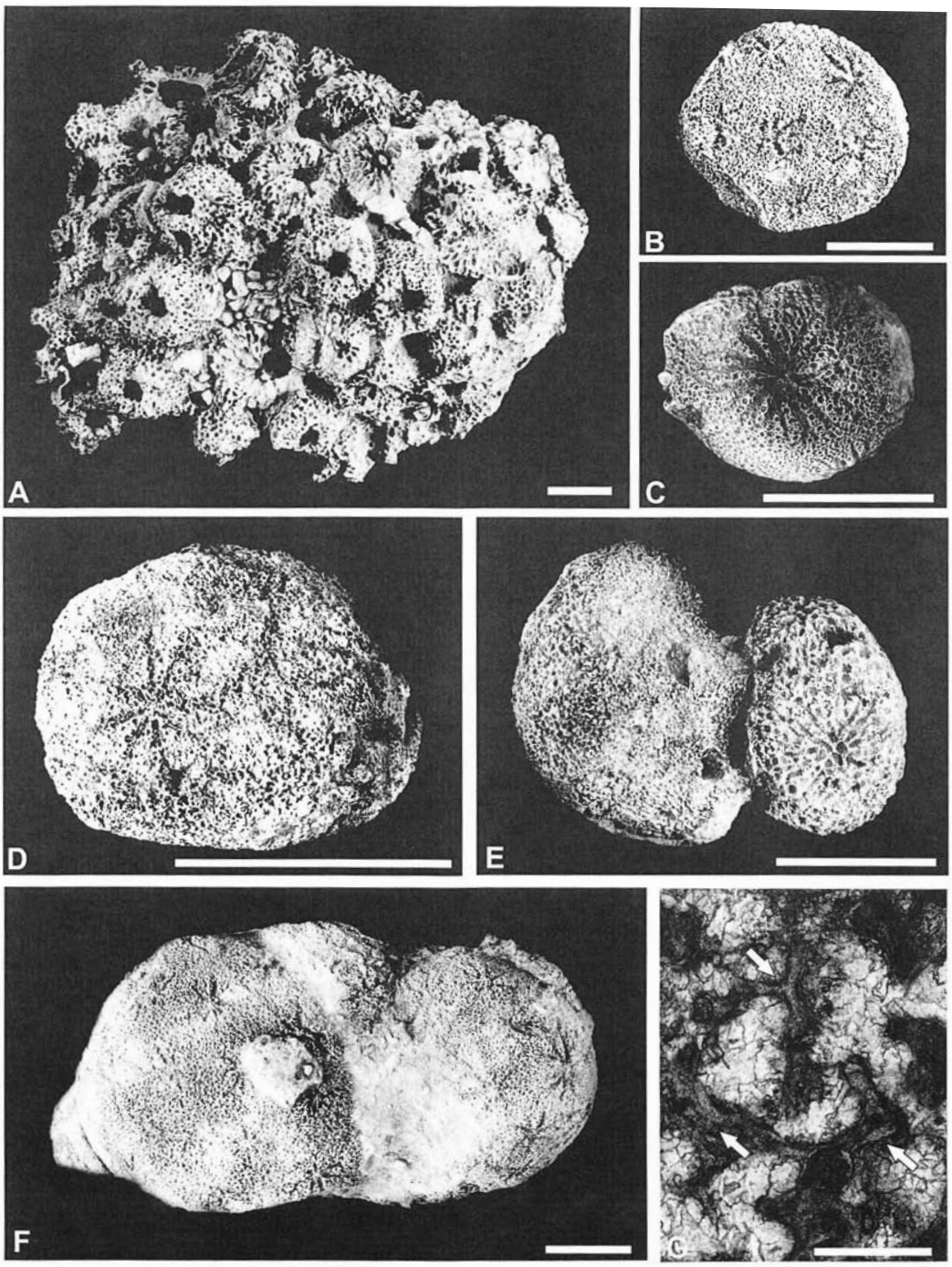

PLATE 11

Fig A - *Mammillopora iranica* n. sp. from Upper Jurassic strata of the Shotori Mountains, east-central Iran. Scale: 10 mm. View of specimen (BSPG 2010 XVII 1/6) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area with numerous nipple-shaped individuals. The top of each nipple contains an osculum. Some osculi are surrounded by small radiating grooves.

Figs B, D, E? - *Stellispongia* sp. 2 from Upper Jurassic strata of the Shotori Mountains, east-central Iran. Scale: 10 mm.

B) Surface of globular specimen (BSPG 2010 XVII 1/34) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area with numerous star-shaped exhalant canals. D) View of globular specimen (BSPG 2010 XVII 1/32) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area with several star-shaped exhalant canals, one of which is clearly recognizable. E) View of specimen (BSPG 2010 XVII 1/33) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area with two globular individuals. The star-shaped exhalant canal of one individual is clearly visible. Maybe two sponge specimen are fused together.

Fig. C - *Stellispongia* sp. 1 from Upper Jurassic strata of the Shotori Mountains, east-central Iran. Scale: 10 mm. Side view of small and globular specimen (BSPG 2010 XVII 1/31) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi are showing the star-shaped exhalant canal system. The small pores on the ribs between the grooves are clearly recognisable.

Figs F, G - *Stellispongia stellata* (Goldfuss) from Upper Jurassic strata of the Shotori Mountains, east-central Iran. Scale: 10 mm (Fig. F) and 1 mm (Fig. G).

F) View of the top of massive specimen (BSPG 2010 XVII 1/30) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area with numerous star-shaped exhalant canals. G) Thin section photograph from the same specimen illustrate in Pl. 10, Fig. E shows the triactine spiculae (arrows) imbedded with the rigid skeleton.

surface of the sponge bears several star-shaped (astrorhiza-like) exhalant canals. The stars are composed of grooves radiating from a central point. The space between the grooves is broader than the grooves. The number of grooves is 6-10. Both, grooves and interspaces carry numerous small pores. The grooves may branch dichotomously or even ternary at their ends. The space between the individual stars is filled with fibre skeleton and small and irregular interfibre pores.

The specimen illustrated in Pl. 10, fig. E has been cut parallel to the illustrated surface and the corresponding thin-section is figured in Pl. 14, figs A-C. The fibre skeleton is relatively well preserved and consists of numerous narrow tubes ending at the sponge surface (Pl. 14, fig. C). Numerous thin cross-partitions ("tabulae") occur within the tubes. The astrorhiza-like system appears as indistinct star-shaped elements where the tubes converge. The majority of spicules are most probably recrystallized, but in some areas triactine spicules were observed (Pl. 11, fig. G; Pl. 14, figs A-B; arrowed). The triactine spicules of our specimen, however, differ from those illustrated in *S. stellata* Godfuss by Dunidowski (1883: pl. 40, fig. 5). Maybe this is the reason, why Hinde (1883: 186) listed Dunikowski's spicules as "non *Sellispongia stellata*" in his synonymy list of *Stelligspongia stellata*.

Remarks. Quenstedt (1878: 611) listed six species of *Stellispongia*, among them *Stelligspongia stellata* (= *Manon stellatum* Goldfuss, 1826: pl. 1, fig. 9). *Manon stellatum* of Quenstedt cannot be attributed to *Stellispongia* and is not a synonym of *Stellispongia stellata* (= *Tragos stellatum* Goldfuss) as assumed by Quenstedt. Fromentel (1860: 49) described the genus *Actinofungia* [(=?*Actinospongia* d'Orbigny, 1849 (pars?)] from the Neocomian of Germany and on pl. 4, fig. 8 illustrated a sponge with the species name *A. pediculata*. The morphology and especially the astrorhiza-shaped exhalant canals of this sponge are very similar to *Stellispongia stellata*.

Stellispongia cf. **Stellispongia stellata** (Goldfuss, 1826)

Pl. 9, figs F-H

Material: A single specimen (BSPG 2010 XVII 1/26) from debris flow within the basal Korond Formation NW of Esfak, Shotori Mts.

Description. This spherical sponge with a flattened base is covered on all sides with strongly developed astrorhiza-shaped exhalant canals. The grooves do not have any pores, in contrast to the preceding species where they are clearly recognizable in grooves. Also, the fibre skeletal elements are moderately coarser than in *S. stellata*.

Stellispongia sp. 1

Pl. 11, fig. C

Material: A single specimen (BSPG 2010 XVII 1/31) from debris flow within the basal Korond Formation NW of Esfak, Shotori Mts.

Remarks: The spherical specimen is differentiated from the preceding species by astrorhiza-shaped exhalant canals with a greater number of radiating grooves. As a result the spaces between the grooves are narrower and are covered only with one row of pores (Pl. 11, fig. C).

Stellispongia sp. 2

Pl. 11, figs B, D-E?; Pl. 12, figs E-F

Material: Three (four?) specimens (BSPG 2010 XVII 1/32, BSPG 2010 XVII 1/33, BSPG 2010 XVII 1/34, and BSPG 2010 XVII 1/44) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area.

Remarks. The small-sized species differs from the preceding species by the small but very well developed astrorhiza-system with short grooves.

Subfamily Holcospongiinae Finks & Rigby, 2004

Genus *Holcospongia* Hinde, 1893

Type species: *Spongia floriceps* Phillips, 1829

Further species: *H. bella* Hinde, 1893; *H. contorta* Hinde, 1893; *H. glomerata* (= *Spongites glomeratus*) (Quenstedt, 1858); *Holcospongia liasica* (= *Spongites liasicus*) (Quenstedt, 1878); *H. mitrata* Hinde, 1893; *H. polita* Hinde, 1893, and H. *sulcata* Hinde, 1893.

Diagnosis. See Hinde (1893: 225-226), and Finks & Rigby (2004: 745).

Remarks. For discussion about the validity of the genus *Holcospongia* see the remarks on *Enaulofungia* below.

Holcospongia glomerata (Quenstedt, 1858)

Pl. 15, figs A-I

1858 *Spongites glomeratus* Quenstedt, p. 695, pl. 84, figs. 10-11.

1893 *Holcospongia glomerata* (Quenstedt) – Hinde, p. 228-229, pl. 17, fig. 1-1c (cum synonymy).

Material: Nine specimens (illustrated specimens: BSPG 2010 XVII 1/35, BSPG 2010 XVII 1/36 BSPG 2010 XVII 1/37 BSPG 2010 XVII 1/38, and BSPG 2010 XVII 1/39).

Description. This irregular sponge is composed of two to several individuals with a common flattened base. Only one specimen (Pl. 15, figs I-H) is mushroom-shaped with an indistinct groove system on its surface and sides. The individuals either have nipple-shaped protuberances (Pl. 15, figs A-D) or their surface is moderately flat (Pl. 15, figs E-G). Individuals are rounded at their top. From the top of each individual a groove system radiates downward. The diameter of the grooves is less than 1 mm. The tops are without a

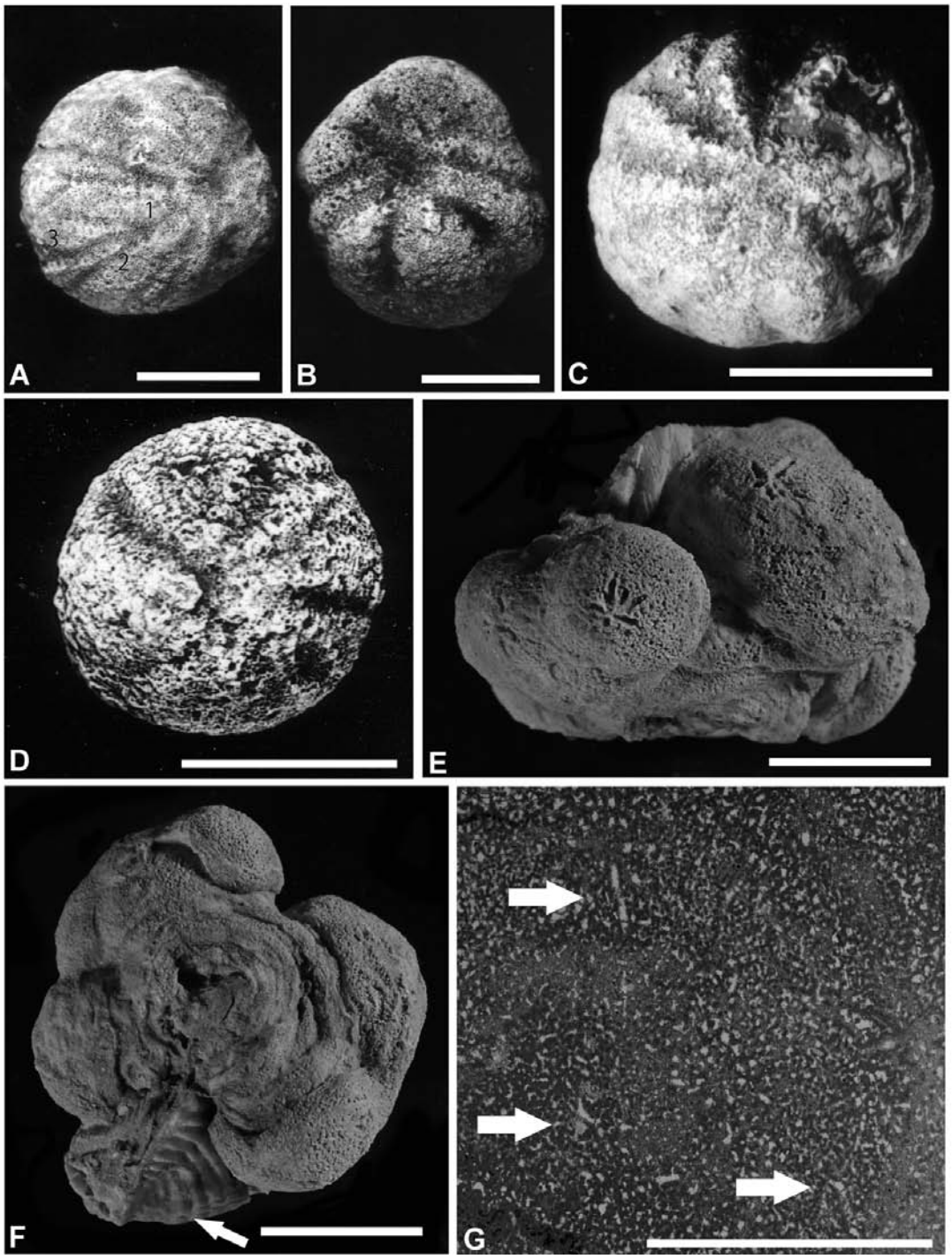

PLATE 12

Fig. A - *Enaulofungia* sp. from Upper Jurassic strata of the Shotori Mountains, east-central Iran. Scale: 10 mm. The view of the flattened and asymmetrical specimen (BSPG 2010 XVII 1/43) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area showing the narrow and multibranched grooves (three order) and the fine perforation of the sponge surface.

Figs B-D - *Enaulofungia sphaerica* n. sp. from Upper Jurassic strata of the Shotori Mountains, east-central Iran. Scale: 10 mm.

B) Holotype (BSPG 2010 XVI 1/40) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area. Top view showing the deep grooves separated by broad ribs. The relatively large pores on the ribs are clearly recognizable. C) Top view of paratype (BSPG 2010 XVII 1/42) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi are showing the wide grooves and ribs. D) Top view of paratype (BSPG 2010 XVII 1/41) from the Kamar-e Mehdi Formation of the Kamar-e Mehdi area.

Fig. E-F - *Stellispongia* sp. 2 from the Echellon Member, Korond Formation NW of Esfak. Scale: 10 mm.

E) Top view of specimen (BSPG 2010 XVII 1/44) showing the well developed astrorhiza-system with short and deep grooves. F) View of the base of the specimen illustrated in Fig. E, with wrinkled dermal layer. Arrow points to a bivalve, which serves as substrate for the sponge.

Fig. G - S*tellispongia stellata* (Goldfuss) from Upper Jurassic strata of the Shotori Mountains, east-central Iran. Scale: 10 mm. Thin section photograph from the same specimen illustrated in Pl. 10, Fig. E. Arrows indicate the star-like exhalant canals in cross section.

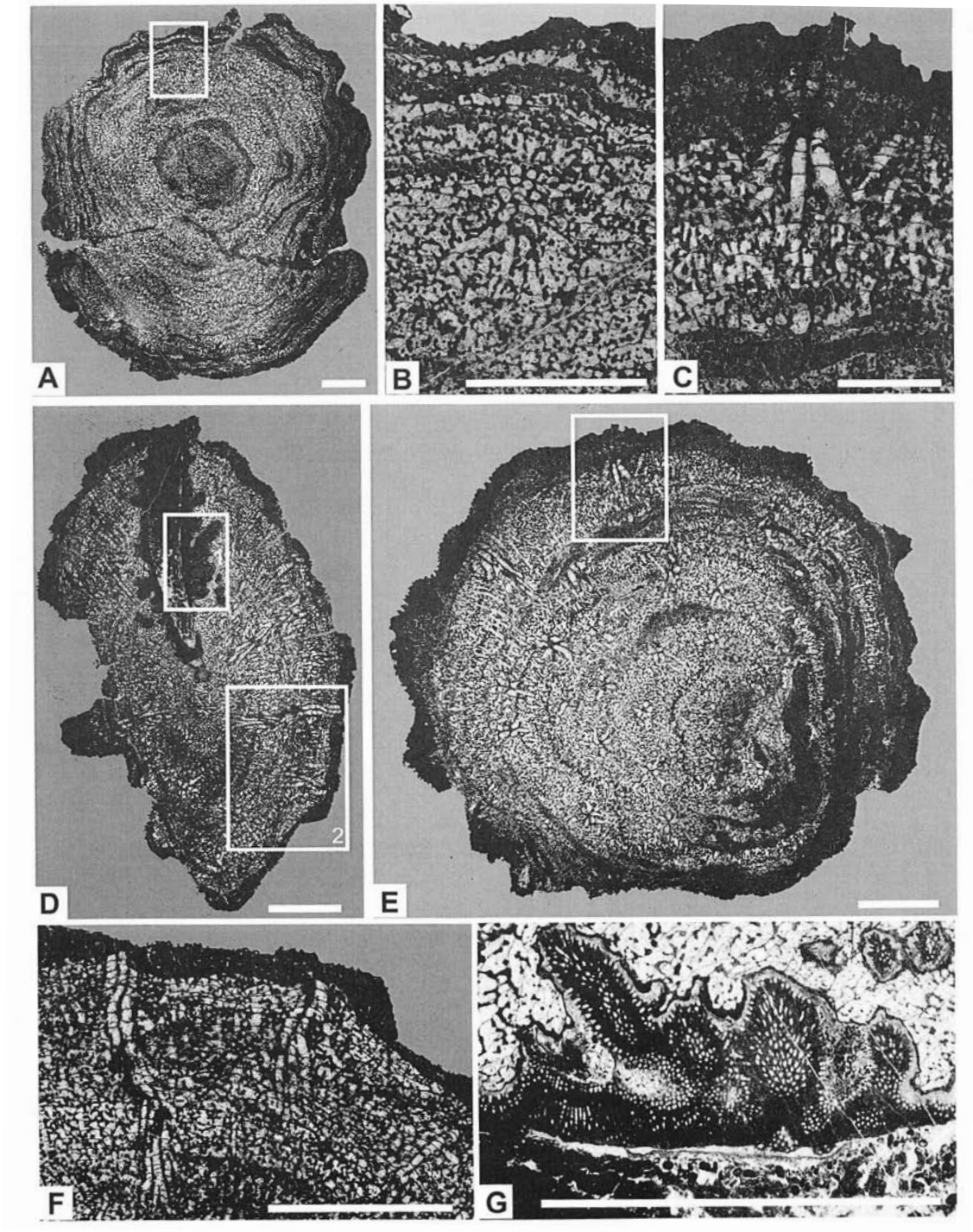

PLATE 13

Tremospongia pulvinaria (Goldfuss) (thin-sections) from Upper Jurassic strata of the east-central Iran. Scale: 10 mm.
A) Section perpendicular to the growth direction of specimen (BSPG 2010 XVII 1/13) from the Korond Formation, NW of Esfak, exhibiting irregular concentric lines (growth stages) and the reticulate fibre skeleton between them. Several osculi are cut obliquely. For magnification of the osculum marked with a rectangle see Fig. B. B) Magnification of rectangular area in Fig. A, showing one of several osculi, cut obliquely and composed of several individual tubes or openings. C) Magnification of rectangular area in Fig. E, showing an osculum composed of several tubes, which end at the sponge surface. Note the tabulae-like elements within the individual tubes. D) Oblique section through specimen (BSPG 2010 XVII 1/15) from the Korond Formation NW of Esfak. A tubular object in the centre is completely overgrown by a chaetetid, which, in turn, is encrusted by *Mammillopora*. For magnification of rectangle 1 see Fig. G, of rectangle 2 see Fig. F. E) Section perpendicular to the growth direction through hemispherical specimen (BSPG 2010 XVII 1/14) from the Korond Formation NW of Esfak showing the irregular concentric lines (growth stages), the fibre skeleton between them, and numerous osculi cut in different directions. For magnification of the area marked with a white rectangle see Fig. C. F) Magnification of rectangle 2 in Fig. D, showing three osculi with several tubes and the fibre skeleton of the sponge. Note the tabulae-like elements within the tubes of the osculi. G) Magnification of rectangle 1 in Fig. D, showing the central tube surrounded by a chaetetid sponge, which is completely encrusted by *Tremospongia pulvinaria* (Goldfuss).

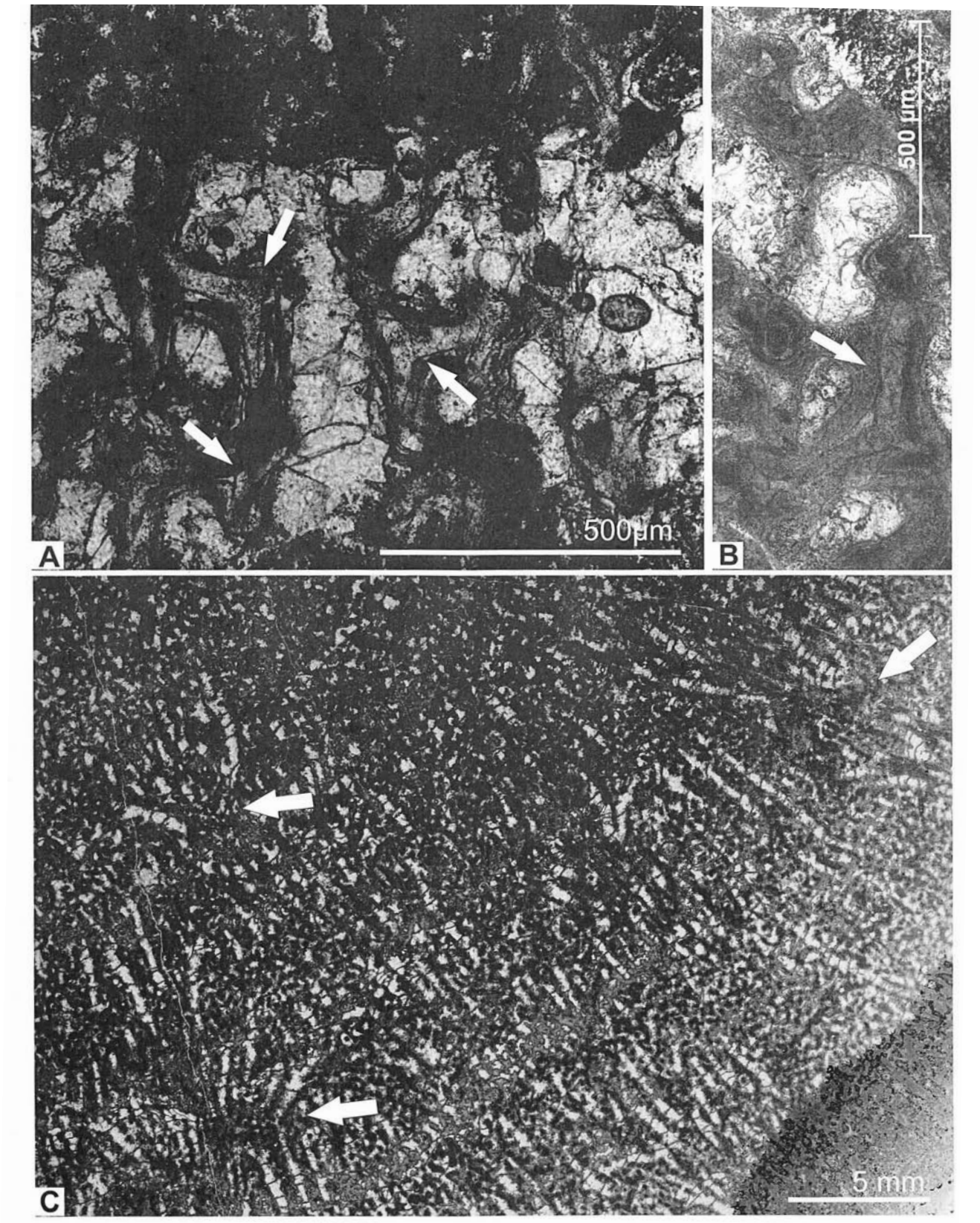

PLATE 14

Stellispongia stellata (Goldfuss) (thin-sections) from Upper Jurassic strata of the east-central Iran. All three photographs are from a thin section, made from the specimen (BSPG 2010 XVII 1/29) illustrated in Pl. 10/E-F.
A) Skeleton with some triactine spicules (arrowed) embedded within the fiber skeleton. B) Arrow points to a spicular skeletal element embedded within the fiber skeleton. C) View of rigid skeleton showing numerous tubes ending at the sponge surface. The tubes are divided by abundant thin tabulae. The astrorhiza-like system appears as indistinct stars, where the tubes converged (arrows).

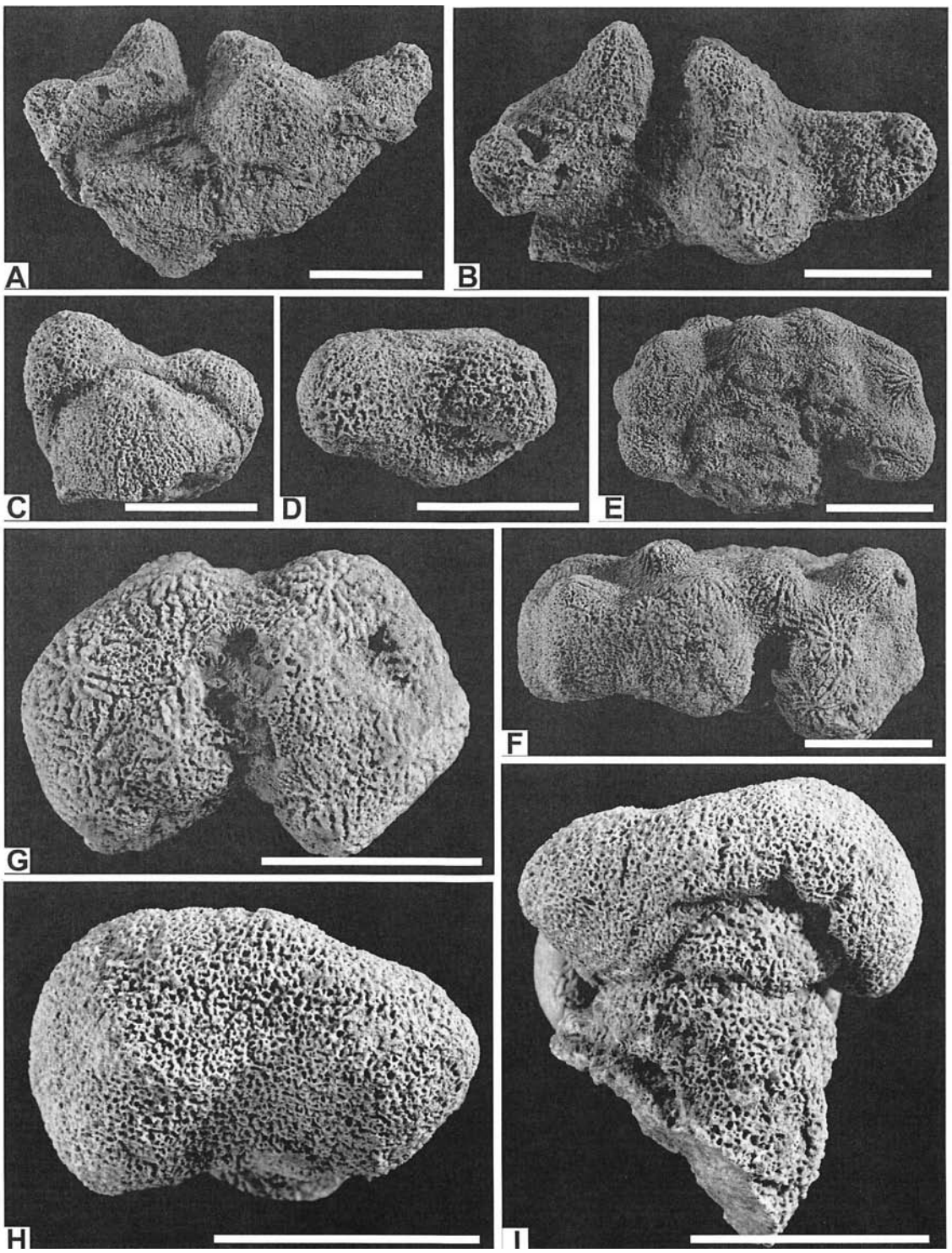

PLATE 15

Holcospongia glomerata (Quenstedt) from the Upper Jurassic of the east-central Iran. Scale: 10 mm.
A) Side view of specimen BSPG 2010 XVII 1/36 from the Kamar-e Mehdi area. The photograph shows the individual nipple-shaped protuberances. Note the radiating grooves extending downwards from the top of the protuberances. B) Top view of the specimen illustrated in Fig. A, showing the individual nipple-shaped protuberances with indistinct grooves extending downward from the top in a radial fashion. C) Side view of specimen BSPG 2010 XVII 1/36 from the Kamar-e Mehdi area. D) Top view of specimen illustrated in Fig. C. The two nipple-shaped protuberances are well recognizable as are the indistinct grooves, which radiate from their top. E) Side view of specimen BSPG 2010 XVII 1/37 from the basal Korond Formation NW of Esfak. The individual protuberances and the downward extending radiating grooves are clearly recognizable. F) Top view of the specimen illustrated in Fig. E, showing clearly the radiating grooves which extend downward from protuberances. G) Top view of specimen BSPG 2010 XVII1/38 from the basal Korond Formation NW of Esfak with radiating grooves extending from the top of the protuberances. H) Top view of specimen BSPG 2010 XVII 1/39 from the Kamar-e Mehdi area showing indistinct grooves. I) Side view of mushroom-shaped specimen illustrated in Fig. H, with some branches of grooves appearing as lines.

depression, osculum or cloaca, features that occur in some other species of the genus.

Remarks. Of the several species of the genus *Holcospongia,* the Iranian specimens fit best *H. glomerata* (Quenstedt, 1858), based on the dimensions of the individuals and on features of the groove system at the top.

Genus *Enaulofungia* Fromentel, 1860

Type species: *Enaulofungia corallina* Fromentel, 1860

Remarks. Hinde (1883: 186) synonymized *E. globosa* Fromentel, 1860 with *E. corallina* Fromentel, 1860, and placed the species into *Stellispongia*. Müller (1984) discussed in detail the position of *Enaulofungia* Fromentel, 1860, *Holcospongia* Hinde, 1893, and *Stellispongia* d'Orbigny, 1849 as independent genera (see also Bizzarini 1990). According to Müller (1984) *Holcospongia* is a junior synonym of *Enaulofungia*, but *Stellispongia* is an independent genus. In contrast, Hurcewicz (1975) favoured the separation of *Enaulofungia* and *Holcospongia*. Finks & Rigby (2004) accepted the classification of Hurcewicz (1975) and listed all three as separate genera. They established even the new Subfamily *Holcospongiinae* with the type genus *Holcospongia*.

In fact, morphologically *Enaulofungia* and *Holcospongia* are similar. The grooves in *Enaulofungia* are, however, much wider and deeper than in *Holcospongia*, where the grooves are indistinct and similar to those in *Stellispongia*. In addition, *Enaulofungia* is a solitary sponge, but in *Holcospongia* several individuals share a common base. These generic characteristics and other features mentioned by Hinde (1893: 225-226) justify to recognize *Holcospongia* as an independent genus. *Stellispongia* differs morphologically from both genera and can be easily recognized. *Astrospongia* Étallon (1859: 151) and *Blastina* Zittel (1878: 42) are also similar to *Enaulofungia*. Müller (1984) described and illustrated several specimens as *Blastinia costata* (Münster). *Blastinia* has, however, been synonymized with *Astrospongia* by Finks & Rigby (2004: 745). Müller's specimens of *Blastinia costata* (Münster) could also be accommodated in *Enaulofungia* Fromentel. Similar sponges were described as *Blastinia insignis* by Opplinger (1929). In conclusion, all these genera are morphologically similar or identical and are in need of a carefully revision.

Enaulofungia sphaerica n. sp.

Pl. 12, figs B-D

Derivatio nominis: Named for the spherical shape of the sponge.

Holotype: Specimen BSPG 2010 XVII 1/40 (Pl. 12, fig. B).

Paratypes: Specimens BSPG 2010 XVII 1/41 and BSPG 2010 XVII 1/42 (Pl. 12, figs C-D).

Locus typicus: Kamar-e Mehdi area, about 100 km SW of Tabas (Fig. 1).

Stratum typicum: Kamar-e Mehdi Formation (Callovian – Oxfordian).

Diagnosis: Small, globular sponge without recognizable surface of attachment. With radiating grooves covering the top of the sponge. The grooves extend downwards and disappear at about the equator of the sphere. Grooves and ribs are covered with pores between the skeletal fibres.

Material: Three specimens (BSPG 2010 XVII 1/41 and BSPG 2010 XVII 1/42) illustrated on Pl. 12, figs B-D.

Description. The diameter of this globular sponge varies between 10 and 20 mm. Two specimens are absolutely spherical and do not show any sign of an attachment area. The concave base of the holotype with a diameter of 20 mm (Pl. 12, fig. B) seems to be broken and is not an attachment surface. There is no wrinkled dermal layer at the base of the specimens in contrast to the type species *corallina* (Fromentel 1860: pl. 3, fig. 11). The top of all specimens is characterized by radiating grooves alternating with ribs. The grooves are running downwards to the equator of the sphere. Both grooves and ribs are covered with interfibre openings of 0.2-0.3 mm in diameter.

Comparison. The sponges have been placed in *Enaulofungia* based on the radiating and bifurcating grooves at their top. *E. sphaerica* n. sp. differs from the type species *Enaulofungia corallina* (Fromentel) not only by its spherical shape, but also by the lack of an attachment area with a wrinkled dermal layer at the base. *E. globosa* Fromentel, 1860 is very similar to *E. corallina* and has been declared as a synonym of *Stellispongia* by Hinde (1883: 186). Hinde (1893) described several species with radiating grooves at the top as *Holcospongia*, but the grooves in all his species are narrower than in *Enaulofungia*. The specimen described as *Enaulofunngia bella* (Hinde) from the Jurassic of Prealpi Venete, Italy, by Bizzarini et al (1987), was described as *Holcospongia bella* by Hinde (1893). This species was incorrectly assigned to *Eunaulofungia* by these athors.

According to Finks & Rigby (2004: 746) *Enaulofungia* is known from the Jurassic of Iran, but details of its occurrence are not given. According to Rigby (pers. comm. 2010) this information (occurrence in Iran) is from an old manuscript of Finks. No further details could be obtained.

Enaulofungia sp.

Pl. 12, fig. A

Material: A single specimen (BSPG 2010 XVII 1/43) from the Kamar-e Mehdi Formation (Callovian – Oxfordian) of the Kamar-e Mehdi area.

Description. The single specimen is a flattened asymmetrical sphere and has a diameter of 20 mm.

The radiating exhalant grooves, which alternate with the ribs, are narrower than in the preceding species. The grooves branch downwards at least twice, producing grooves of first, second, and third orders as indicated by numbers in Pl. 2, fig. A. Like the whole sponge the groove system is asymmetrical. The openings between the fibre skeleton have a maximum diameter of 0.2 mm and are thus moderately smaller than in the preceding species.

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