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POROSPHAERA (PORIFERA), A GLOBULAR SPONGE FROM THE UPPER JURASSIC OF THE CENTRAL IRAN

BABA SENOWBARI-DARYAN [1], FRANZ T. FÜRSICH [1] & MARKUS WILMSEN [2]

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Abstract. *Porosphaera*, an abundant small spherical calcisponge, well known from Cretaceous strata of Europe, was found in Middle and Upper Jurassic deposits of east-central Iran. This is the first record of *Porosphaera* from the Jurassic, except for a questionable occurrence of the genus from the Upper Jurassic of Canada, described by Jansa et al. (1982). The following species are new: *P. regularis* n. sp., *P. biporata* n. sp., *P.*? *labyrinthica* n. sp., and *P.*? *asymmetrica* n. sp.

Riassunto. Il genere *Porosphaera*, una piccola calcispongia di forma sferica, è ben nota e abbondante nelle successioni del Cretaceo dell'Europa. Viene qui descritta dal Giurassico Medio e Superiore dell'Iran centro-orientale. Questa è la prima segnalazione di *Porosphaera* nel Giurassico, fatta eccezione per una segnalazione dubbia fatta da Jansa et al. (1982) nel Giurassico Superiore del Canada. Le specie seguenti sono nuove: *P. regularis* n. sp., *P. biporata* n. sp., *P.*? *labyrinthica* n. sp., and *P.*? *asymmetrica* n. sp.

Introduction

Hypercalcified sponges, including the chambered "sphinctozoans", the non-chambered "inozoans", "chaetetids" and "spongiomorphids" are the most abundant sponge groups in Palaeozoic and Mesozoic reefs and shallow-water carbonates, particularly in Upper Triassic strata (archaeocathids and Paleozoic stromatoporoids are not taken into consideration). Due to the end-Triassic mass extinction almost all Norian-Rhaetian "sphinctozoans" disappeared. The stylothalamid sponge *Stylothalamia columnaris* (Le Maitre) is the only species known from Jurassic deposits (Senowbari-Daryan 1990; Senowbari-Daryan & Rigby in press). Precise data about the extinction or survival of "inozoans" and of any of the other sponge groups mentioned above are not available, but most Norian-Rhaetian genera of these groups are also not known from the Lower and Middle Jurassic. The majority (probably all?) of Palaeozoic and Triassic hypercalcified "sphinctozoans" are demosponges, calcispongid "sphinctozoans" have not been documented from this time interval. Calcispongid "sphinctozans" (Sphaerocoeliida Vacelet, 1979), including *Barroisia, Thalamopora, Sphaerocoelia,* and *Mueleritha*lamia, appear in the Late Jurassic and are known from several localities (for references see Senowbari-Daryan 1990). The majority of Triassic "spongiomorphids" are also not known from the Early Jurassic, but similar organisms appear also in the Late Jurassic and are known as "hydrozoans" or "Late Mesozoic stromatoporoids" (Wood 1987; Leinfelder et al. 2005), being abundant in Upper Jurassic reefs and lagoons.

While hexactinellid and lithistid sponges are very rare in Triassic deposits, they are abundant in Upper Jurassic and were described – together with calcispongid representatives – from a number of localities, particularly from Europe (e. g. Lamouroux 1821; Goldfuss 1826-1833; Quenstedt 1878; Hinde 1883; Schrammen 1936, 1937; Pisera 1997). There are rare records from the Early Jurassic hexactinelld sponges, indicating deeper water environments (Delecat & Reitner 2005).

Porosphaera, a calcisponge formerly only known from the Cretaceous, has been collected with other calcispongid, lithistid and hexactinellid sponges from Middle and Upper Jurassic localities of the northern Tabas

1 Geozentrum Nordbayern, FG Paläoumwelt, University of Erlangen-Nürnberg, Loewenichstr. 28, D-91054 Erlangen, Germany. E-mail: basendar@pal.uni-erlangen.de; franz.fuersich@gzn.uni-erlangen.de

2 Senckenberg Naturhistorische Sammlungen Dresden, Museum für Mineralogie und Geologie, Sektion Paläozoologie, Königsbrücker Landstr. 159, 01109 Dresden, Germany. E-mail: markus.wilmsen@senckenberg.de

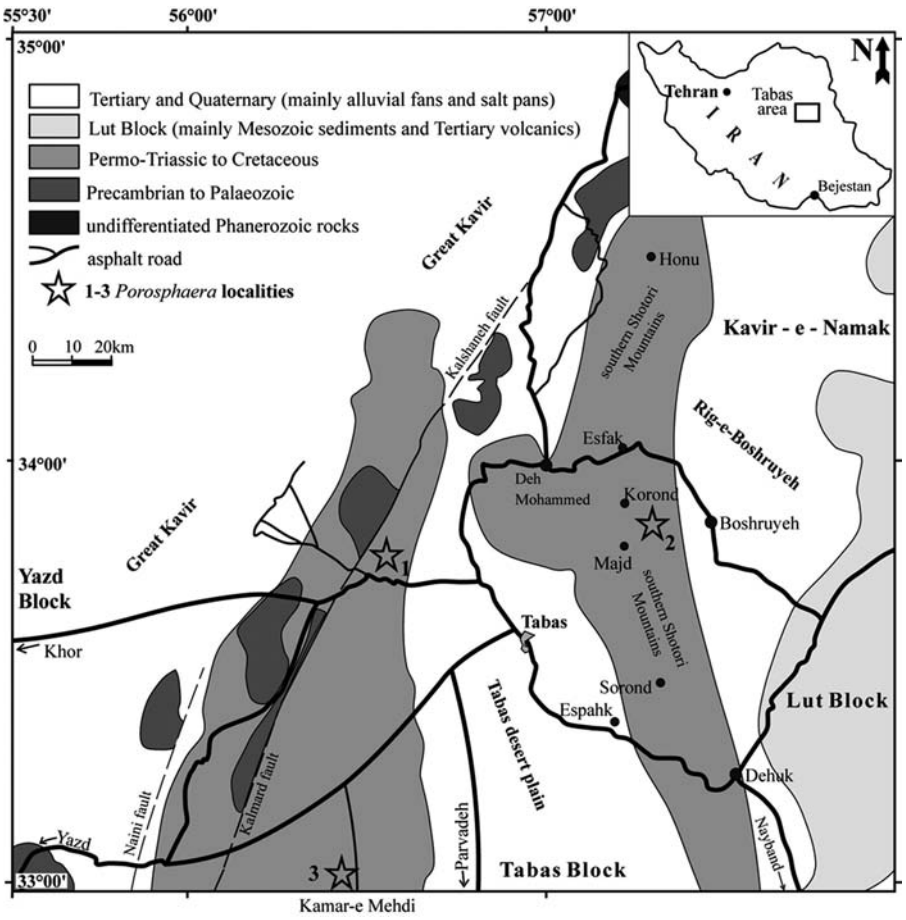

Fig. 1 - Geological sketch map of the Tabas area with position of the three localities at which *Porosphaera* has been collected. 1: Kuh-e Nakhlak; 2: Qal-eh Dokhtar, east of Boshrouyeh; 3: Kamar-e Mehdi.

Block, east-central Iran, by the authors. These localities are briefly described in the following.

Localities

The earliest record of *Porosphaera* is from the upper part of the Baghamshah Formation (Callovian) at Kuh-e Nakhlak, NNW of Tabas (Fig. 1). It also occurs in the Qal-eh Dokhtar Formation (Callovian-Oxfordian) at Qal-eh Dokhtar, east of Boshrouyeh, in allochthonous limestones interpreted as debris flows from a neighbouring carbonate platform, represented by the Esfandiar Limestone Formation (Schairer et al. 2000; Fürsich et al. 2003) (Fig. 2). It is also found in a small, autochthonous coral patch reef occurring at a lower stratigraphic level in the same formation and at the same locality.

A third lithological unit and locality is the Kamar-e Mehdi Formation (Callovian-Oxfordian) of the Kamar-e Mehdi area. The formation has been interpreted as a shelf lagoon, situated west of the Esfandiar carbonate platform (Wilmsen et al. 2010). Small *Nanogyra*-sponge patch reefs occur at various levels, particularly in the lower part of the formation and contain some individuals of *Porosphaera*.

Detailed information about the stratigraphy, biota and depositional environments of the Jurassic formations of the Tabas Block of east-central Iran can be found in Wilmsen et al. (2003, 2009).

All specimens and thin sections, illustrated in this paper are deposited in " Bayerische Staatssammlung für Paläontologie und historische Geologie, München (Inventary-Nr. BSPG 2010 XX1-XX20)".

Systematic palaeontology

Class **Calcarea** Bowerbank, 1864

Order **Lithonida** Doederlein, 1892

Family Minchinellidae Dendy & Row, 1913

Genus *Porosphaera* Steinmann, 1878

Type species: *Millepora globularis* Phillips, 1829

Further species: *P. arrecta* Hinde, 1904, *P. nuciformis* (= *Ceriopora nuciformis* Hagenow, 1842), *P. patelliformis* Hinde, 1904, *P. plana* Stolley, 1892, *P. pileolus* (Etheridge cf. Hinde 1904), and *P. woodwardi* (= *Millepora woodwardi* Carter, 1878: see Hinde 1904). (*Porosphaera subglobosa* in Welter 1911: 82, Fig. 25 is an error, it should be *Porosphaerella subglobosa*).

Diagnosis: See Finks & Rigby (2004: 756).

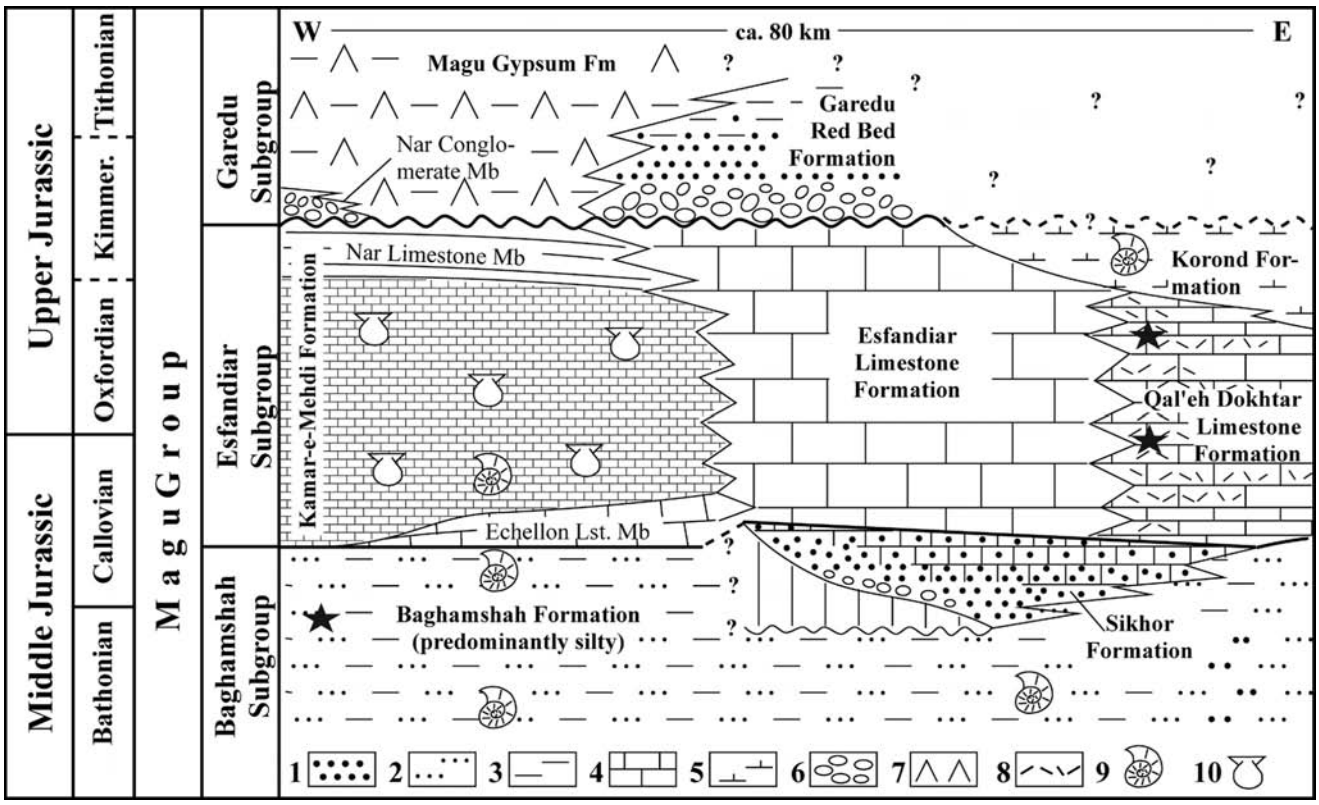

Fig. 2 - Stratigraphic framework of the Upper Jurassic rocks of the northern Tabas Block. Modified from Wilmsen et al. (2003). 1: sandstone; 2: siltstone; 3: clay; 4: limestone; 5: marl; 6: conglomerate; 7: gypsum; 8: bioclasts; 9: ammonites; 10: bivalves. Asterisks indicate the stratigraphical levels, where *Porasphaera*-specimens were collected.

General remarks. *Porosphaera globularis* (Phillips, 1829) a small, spherical sponge is known from several Upper Cretaceous (Cenomanian) to Lower Paleocene (Danian) localities of Europe. After the type species, five more species were described by later authors (see above). *Porosphaera globularis* is the most abundant species and has been described by several authors (Phillips 1829; Steinmann 1878; Hinde 1904; Hurcewicz 1960; Nestler 1961; Müller 1970; Termier & Termier 1985a, b; Malecki 1989; Reitner 1992). Recently, the species has also been reported by Wilmsen et al. (subm.) from the Maastrichtian of Iran. It is a spherical sponge without any evidence of an attachment area. Almost all specimens show a nearly cylindrical tube (usually hollow, rarely filled) within the skeleton. The origin of this tube was a "mystery", an object of discussion by previous authors. Steinmann (1878) and Hinde (1904) assumed that it was an object, around which the sponge grew. Others, particularly archaeologists, interpreted *Porosphaera* with its hollow center as the oldest known beads (see Rigaud et al. 2009 for further references). The hollow tube in *Porosphaera* was interpreted as a boring by Nielsen-Brünnich (1929), Nester (1961), and Müller (1970). The last author discussed gastropods and worms as possibly producers of the hollow structure. Recent investigations of the hollow structure within *P. globularis* by Neumann et al. (2008) with the description of the new ichnotaxon *Trypanites mobilis* by these authors indicate that it was produced post-mortem by sipunculan worms.

In addition to *P. globularis* from the "Upper Chalk" of Yorkshire (England) the following species of *Porosphaera* were described by Hinde (1904): *P. nuciformis* Hagenow, *P. woodwardi* Carter, *P. pileolus* (Etheridge; cf. Hinde 1904), and the two new species *P. patelliformis* Hinde and *P. arrecta* Hinde.

All specimens of *P. nuciformis* and *P. woodwardi* described by Hinde (1904: pl. 1, figs. 1-18 and pl. 1, fig. 19, respectively) are characterized by radially arranged bifurcating grooves. Such a structure on the sponge surface is characteristic of the genus *Enaulofungia* Fromentel (1860; see also Finks & Rigby 2004: 745). *Porosphaera globularis*, the type species of the genus, however, lacks such bifurcating grooves extending from the highest point downwards. Most probably, *P. nuciformis* and *P. woodwardi* should be excluded from *Porosphaera*.

The patellifrom species *Porosphaera patelliformis* and the bell-shaped species *P. arrecta* described by Hinde (1904) differ morphologically completely from the type species of *Porosphaera*. Again, their assignment to this genus is uncertain.

The systematic position of the genus *Porosphaera* was also controversial. Steinmann (1878) compared *Poro-*

sphaera with *Parkeria* – also a spherical fossil from the Cretaceous, probably a hydrozoan (see Wilmsen 2003) – and placed it into the family Milleporidae. *Porosphaera* was considered to be a foraminifer, bryozoan or sponge by later authors (Hinde 1904, Hurcewicz 1960). Hinde (1904) described different spicules in *P. globularis*, *P. nuciformis,* and *P. pileolus.* He compared *Porosphaera* with the Tertiary to Recent calcisponges *Plectroninia* and *Petrostroma* and placed it into the Calcispongea (Lithonina). *Porosphaera* was attributed by Laubenfels (1955: 99) to his new family Porosphaeridae within the order Pharetronida (pro Pharetrones Zittel, 1878) and to the Minchinellida by Reitner (1987) and Malecki (1989). It has been assigned to the family Minchinellidae Dendy & Row (1913) within the order Lithonida by Finks & Rigby (2004; see also Termier & Termier 1985a, b). Skeletal elements, composed of different types of spicules in *P. globularis,* were also described by Hurcewicz (1960), Termier & Termier (1985a), Reitner (1987, 1992), and Malecki (1989). A detailed diagnosis of the genus *Porosphaera* is given by Finks & Rigby (2004: 756).

Porosphaera regularis n. sp.

Pl. 1, figs A, D-G; Pl. 4, figs C-D; Pl. 5, figs A-B

Derivatio nominis: *regularis* (lat.) = regular. Named for the uniform perforation of the sponge skeleton.

Holotype: Specimen BSPG 2010 XX-10 illustrated in Pl. 4, Fig. C-D.

Paratypes: Specimens BSPG 2010 XX-17, 19, 20 (Pl. 1, Figs. A, C-D, F-G), Pl. 5, Figs. A-B (thin sections BSPG 2010 XX-1 and BSPG 2010 XX-2).

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

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

Diagnosis: Small spherical sponge with uniform perforation of the skeletal surface. The evenly sized tubes radiate from the center to the outside, ending as pores on the skeletal surface. The walls between the tubes are perforated. Spicules were not observed.

Material: At least eight specimens (illustrated specimens BSPG 2010 XX16 – XX20).

Description. This spherical to ovoid sponge reaches diameters between 7 and 20 mm. The surface of the sphere is covered by evenly distributed pores with a diameter of 0.2 mm. These pores extend as tubes to the skeleton center. The tubes radiate symmetrically from the center to the sponge surface (Pl. 4, fig. D). Diameters of the tubes correspond almost to the thickness of the fiber skeleton between them. The walls between the tubes are perforated.

The holotype (Pl. 4, figs C-D) has a diameter of 8 mm. The internal structure of holotype (Pl. 4, fig. D) and of some paratypes is illustrated in and Pl. 5, figs A-B.

Porosphaera biporata n. sp.

Pl. 2, figs A-F; Pl. 4, figs A-B, F

Derivatio nominis: *biporatus* (lat.) = with two pores. Named for the two size classes of pores on the sponge surface.

Holotype: Specimen BSPG 2010 XX-3 illustrated in Pl. 2, Fig. B.

Paratypes: All specimens in Pl. 2, Figs. A, C-F, Pl. 4, Fig. A-B, F (BSPG 2010 XX-2, 4, 5, 9 and 15).

Locus typicus: Qal-eh Dokhtar, W of Boshrouyeh (see Fig. 1).

Stratum typicum: Qal-eh Dokthar Siltstone Member, Qal-eh Dokhtar Formation (Bathonian-Callovian).

Diagnosis: Spherical sponge without distinct attachment area. Surface of the sponge covered with pores of two different sizes. Both types of pores are the openings of internal canals, which run from the surface to the center of the sphere. Spicules were not observed.

Material: At least six specimens.

Description. This spherical sponge reaches a diameter between 10 and 15 mm. An attachment surface is lacking, but some specimens show a flattened area on one side of the sponge (Pl. 2, figs A, F). The surface of the sponge is covered with pores of two distinctly different size classes: the small pores have a maximum diameter of 0.2 mm, the large pores a maximum of 0.5 mm. The small pores occupy the space between the large pores. Some small grooves radiate from the large pores, giving them a star-like appearance (Pl. 2, figs B, D).

The holotype (Pl. 2, fig. B) is a moderately large specimen with a diameter of 11 mm and shows clearly the perforation pattern of the sponge surface and the size differences between the two groups of pores.

One specimen has been polished and illustrated in Pl. 4, fig. F. The two different-sized pores run as tubes into the sphere and extend up to the centre are clearly recognizable.

Comparison. *Porosphaera biporata* n. sp. differs from the preceding species, *Porosphaera regularis* n. sp. by displaying two distinct size classes of pores on the surface. This difference is also clearly recognizable internally by two different-sized tubes (compare Pl. 4, fig. D: *P. regularis* with Pl. 4, fig. B or F: *P. biporata*).

Porosphaera? labyrinthica n. sp.

Pl. 3, figs A-F; Pl. 5, fig. C

Derivatio nominis. *Labyrinthus* (lat.) = labyrinth, meander. Named for the labyrinth-like structured sponge surface.

Holotype: Specimen BSPG 2010 XX-6 illustrated in Pl. 3, Figs. A-B.

Paratypes: Pl. 3, Figs. C-F, Pl. 5, Fig. C (BSPG 2010 XX-3, 7, 8).

Locus typicus: Kamar-e Mehdi Formation of the Kamar-e Mehdi area, about 100 km southwest of Tabas (see Fig. 1).

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

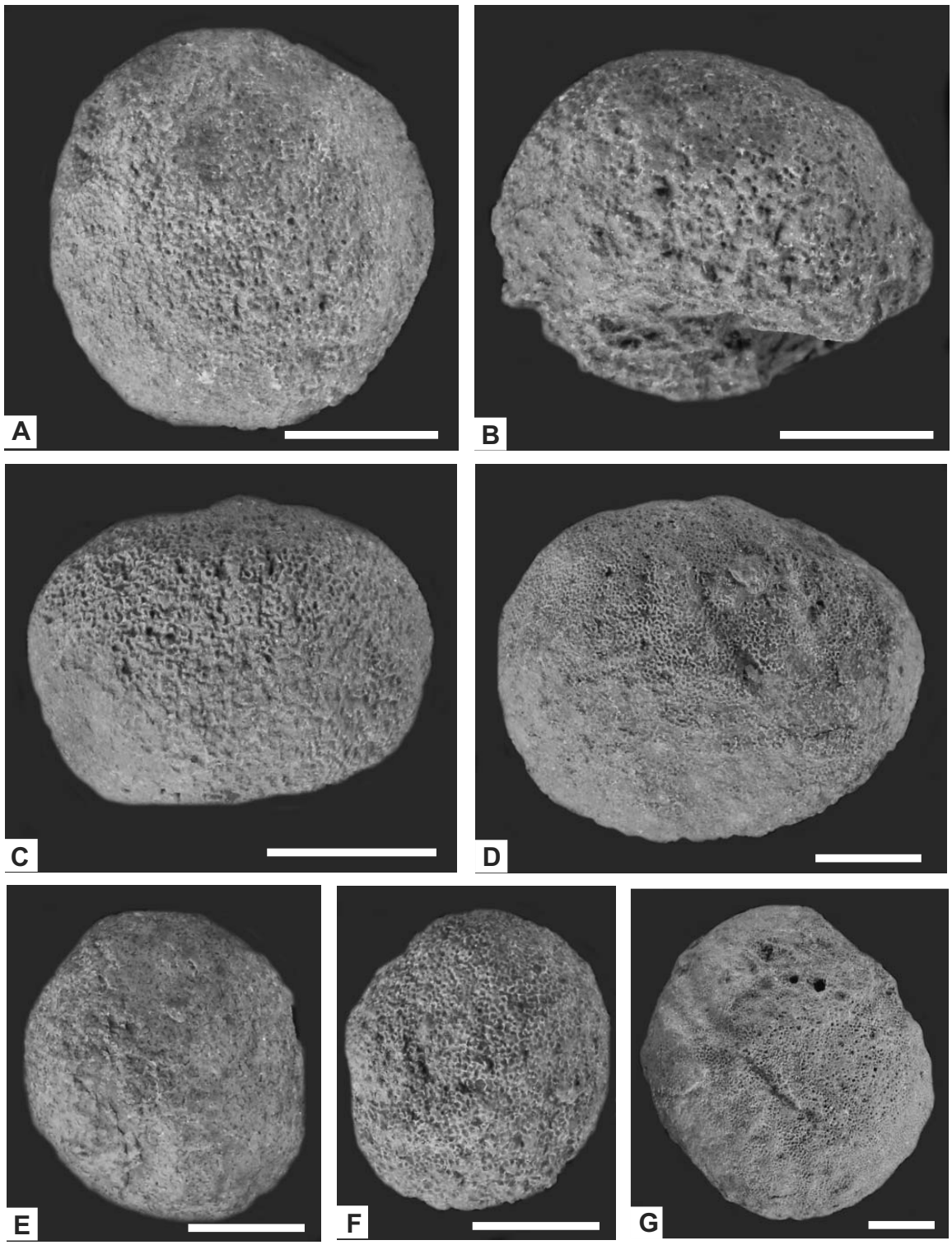

PLATE 1

Figs A, D-G - *Porosphaera regularis* n. sp. Scale: 5 mm.
A) View of the surface of specimen BSPG 2010 XX-25. The uniform pores are evenly distributed over the sponge surface. Kamar-e Mehdi Formation of the Kamar-e Mehdi area. D) Specimen BSPG 2010 XX-17 similar to Fig. A. The "lateral" view of the specimen is illustrated in Fig. G. E) Specimen (BSPG 2010 XX-16) similar to Fig. C. Kamar-e-Mehdi Formnation of the Kamar-e-Mehdi area. F) The surface the sponge BSPG 2010 XX-19 shows clearly the evenly distributed uniform pores. Qal-eh Dokhtar Formation at Qal-eh Dokhtar. G) "Lateral" view of the specimen illustrated in Fig. D showing some large openings, which are interpreted as borings. Kamar-e-Mehdi Formation of the Kamar-e-Mehdi area.
Figs B-C *Porosphaera asymmetrica* nov. sp. Scale: 5 mm.
B) Holotype BSPG 2010 XX-18. The "base" of the specimen is flattened possibly indicating the attachment surface. C) View of an ovoid specimen BSPG 2010 XX-20 showing the evenly distributed, regular pores. The sponge has a slit on its "base" indicating the possibly attachment surface. Kamar-e Mehdi Formation of the Kamar-e Mehdi area. Fig.

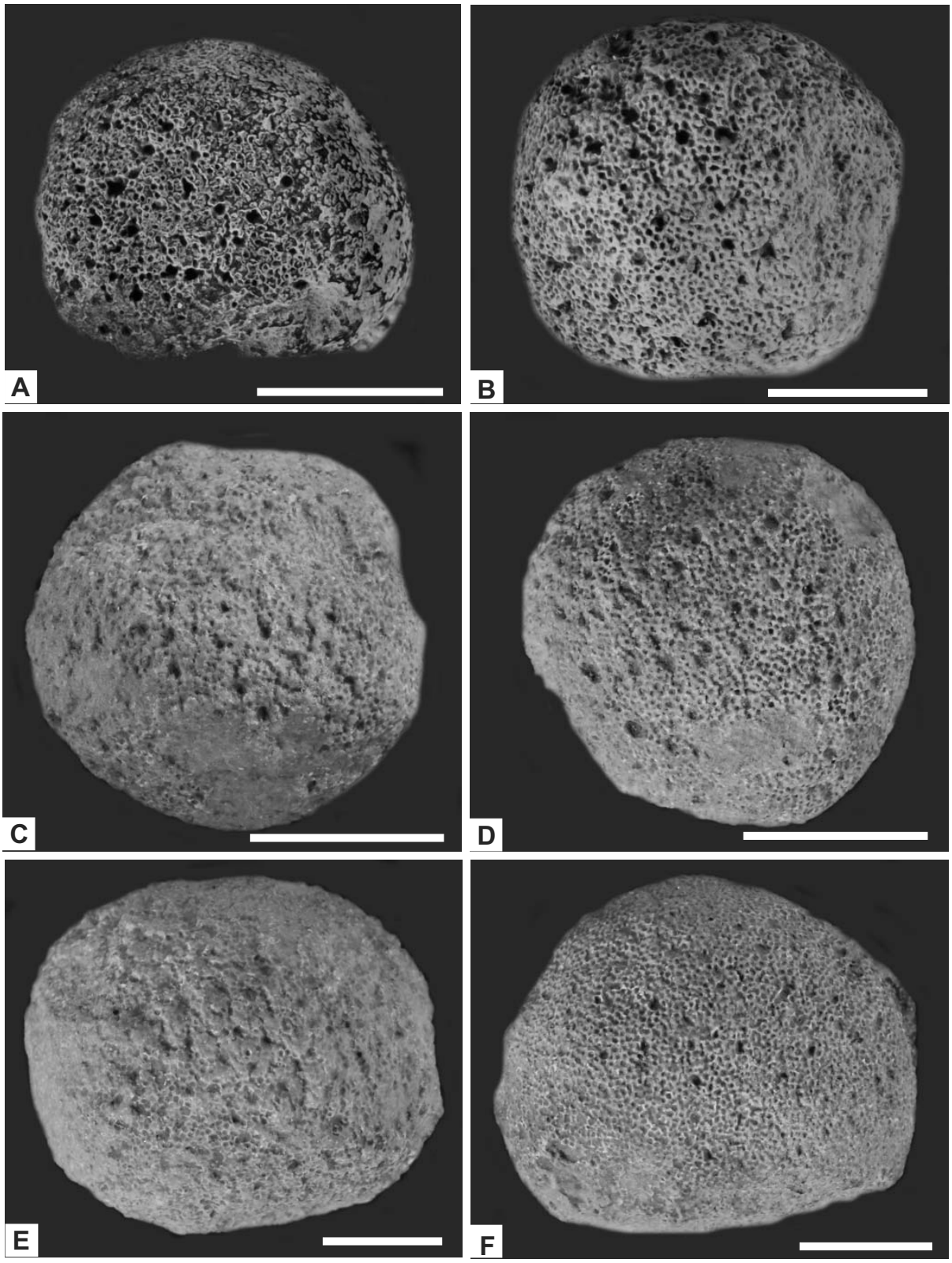

PLATE 2

Figs A-F - *Porosphaera biporata* n. sp. Scale: 5 mm.
A) View of the surface of almost spherical specimen BSPG 2010 XX-2 showing the relatively large openings and small pores between them. For the internal structure see Pl. 4, Fig. F. Kamer-e Mehdi Formation in Kamer-e Mehdi area. B) Holotype (BSPG 2010 XX-3). View of the surface of the spherical specimen showing clearly the large openings and small pores between them. Upper part of the Baghamshah Formation of Kuh-e Nakhlak. C) View of poorly preserved specimen BSPG 2010 XX-4 showing the large openings and small pores in part. Kamer-e Mehdi Formation of the Kamer-e Mehdi area. D) Specimen showing similar features as Fig. B. Qal-eh Dokhtar Formation at Qal-eh Dokhtar. E) Specimen BSPG 2010 XX-5 showing similar features as Fig. C. Qal-eh Dokhtar Formation at Qal-eh Dokhtar. F) Specimen BSPG 2010 XX-15 showing similar features as Fig. D. Qal-eh Dokhtar Formation at Qal-eh Dokhtar.

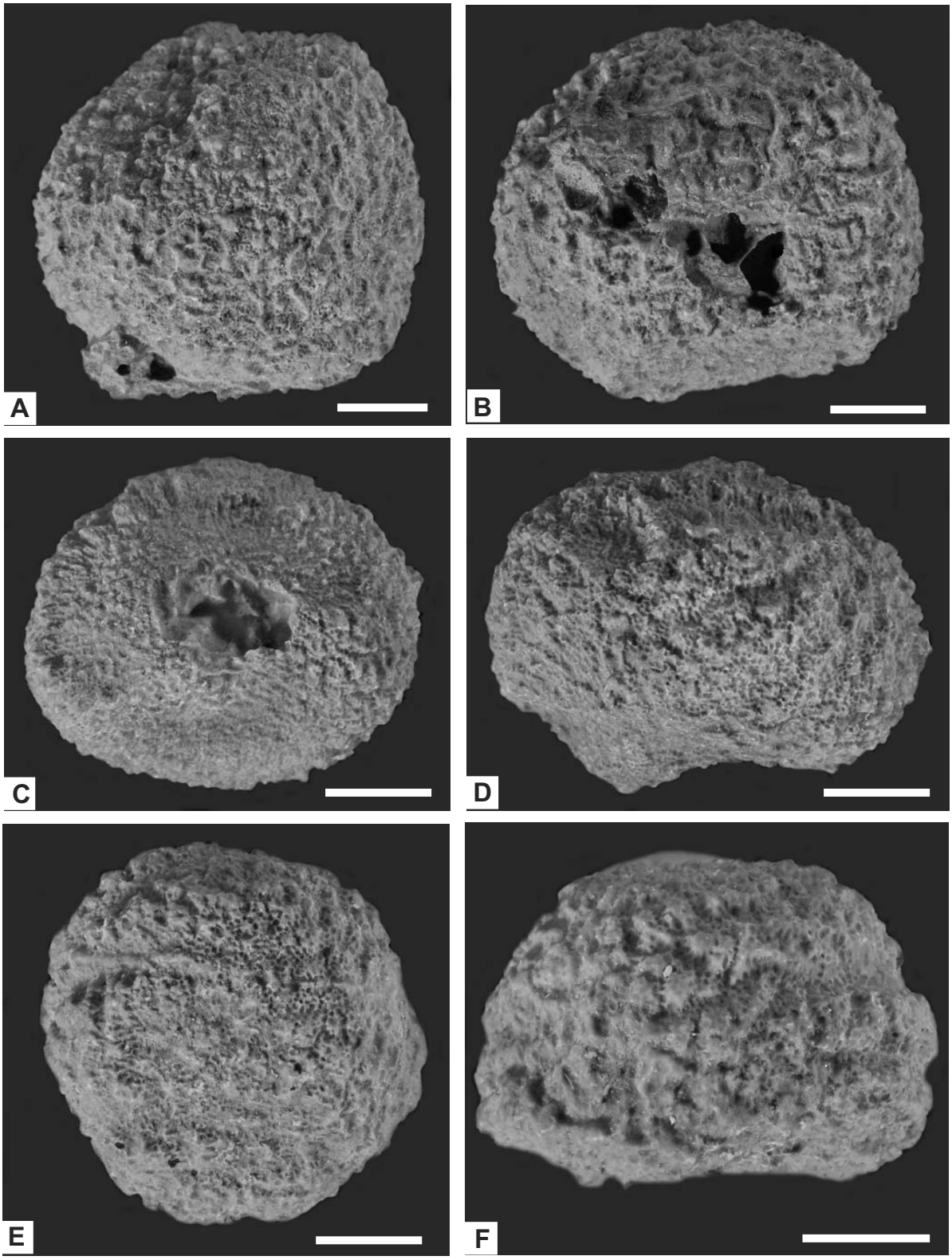

PLATE 3

Figs A-F - *Porosphaera*? *labyrinthica* n. sp. Scale: 5 mm.
A) Holotype (BSPG 2010 XX-6). View of the surface showing clearly the "grooves" with small pores and the "ribs" between them. For the opposite side see Fig. B. Kamar-e Mehdi Formation of the Kamar-e Mehdi area. B) Holotype (BSPG 2010 XX-6). Opposite view ("base") as in Fig. A showing the large openings, "grooves" and "ribs". C) The "top?" of specimen BSPG 2010 XX-7 showing a large opening and the "grooves" and "ribs" between them. For the internal structure of the specimen see Pl. 4, Fig. E. Kamar-e Mehdi Formation of the Kamar-e Mehdi area. D) Side view of the specimen illustrated in Fig. C showing clearly the "grooves" with pores and "ribs" between them. E) The "top" of specimen BSPG 2010 XX-8 whose side view is illustrated in Fig. F. Qal-eh Dokhtar Formation at Qal-eh Dokhtar. F) Side view of the same specimen as in Fig. E shows clearly the "grooves" with pores and the "ribs" between them. Qal-eh Dokhtar Formation at Qal-eh Dokhtar.

Diagnosis: Small spherical, ovoid to flattened sponge with labyrinth-like structured surface consisting of grooves and ribs. Small pores are located in the grooves, ribs are without or with only very rare pores. A large opening, composed of several individual pores, may occur into which numerous pores end. Pores of the surface extend as tubes into the sphere center. Spicules were not observed.

Material: At least four specimens.

Description. The spherical to ovoid, in some specimens on one side flattened sponge reaches diameters between 10 and 20 mm. The sponge surface is labyrinth-like structured being composed of irregularly arranged grooves and ribs. The grooves are covered by pores of 0.2 mm in diameter. Pores are lacking or are very rare on the ribs. Two specimens show (Pl. 3, figs B-C) a large opening that seems to be composed of several small pores.

The holotype (Pl. 3, figs A-B) is a moderately large specimen, 20 mm in diameter, and shows one (or two?) large openings like the paratype BSPG 2010 XX-7 illustrated in Pl. 3, figs C-D. A thin-section from one of the specimens shows the internal structure of the sphere. Numerous tubes of the same diameter, which corresponds to the diameter of the surface pores, extend to the center (Pl. 5, fig. C). A small object is embedded in the center of this specimen. For the interpretation of this object see the discussion below.

Comparison. Because of the presence of a large opening in some specimens it is uncertain whether this species belongs to the genus *Porosphaera*. *P.? labyrinthica* differs from *P. regularis* n. sp. and *P. biporata* n. sp. by the labyrinth-like structured surface composed of grooves and ribs. The pores on the sponge surface are uniform and not of two different-sizes as in *P. biporata*. The internal structure is similar to that of *P. regularis*.

The Cretaceous species *P. woodwardi* Carter, 1878 (see Hinde 1904) is characterized by the presence of grooves, as in *P. labyrinthica*. However, *P. woodwardi* differs from *P. labyrinthica* by the presence of grooves which radiate from a center and are not irregularly labyrinth-like. The placement of *P. woodwardi* and other species described by Hinde (1904) in the genus *Porosphaera* has been discussed above. The comparison of *P. labyrinthica* with other known species is highly desirable.

Porosphaera? asymmetrica n. sp.

Pl. 1, figs B-C; Pl. 4, fig. E; Pl. 5, fig. D

Derivatio nominis: Because of the asymmetric construction of the species.

Holotype: Specimen BSPG2010 XX-18 illustrated in Pl. 1, Fig. B.

Paratypes: Specimens in Pl. 1, Fig. C, Pl. 4, Fig. E; Pl. 5, Fig. D (BSPG2010 XX-4, 7, 20).

Locus typicus: Qal-eh Dokhtar, W of Boshrouyeh (see Fig. 1).

Stratum typicum: Qal-eh Dokhtar Siltstone Member, Qal-eh Dokhtar Formation (Bathonian to Callovian).

Diagnosis: Spherical to hemispherical sponge, flattened or with a slit on one side. Surface of the sponge, structure of the internal tubes, and the wall between them are similar to *P. regularis*. The tubes originate from the "base" and diverge towards of the sponge surface.

Material: At least three specimens.

Description. The asymmetrical shape of this species is produced by the flattened side or by the possession of a slit on one side which can be recognized from the outside (Pl. 1, fig. B). The surface of the species contains numerous small pores, similar to *P. regularis* nov. sp. The pores of the surface continue as small tubes into the specimen. They originate from the "base" and diverge towards the surface of the sponge (Pl. 5, fig. D). The thickness of the walls between the pores is nearly the same as the pore diameter. The walls are pierced by small openings (Pl. 5, fig. D). The diameter of the surface pores, corresponding to the diameter of the tubes, is about 0.2 mm.

Comparison. *P.? asymmetrica* differs from other species, described before by the asymmetrical construction of the species, especially recognizable in cross-sections through the sponge skeleton. Based on asymmetrical construction of this species its attribution to *Porosphaera* is doubtful.

Discussion

Porosphaera is a globular sponge without any attachment area. Species described here as *P. regularis* n. sp., *P. biporata* n. sp., and *P.? labyrinthica* n. sp. do not show any attachment areas although the last one shows a large opening. Spherical construction among sessile organisms without an attachment area is known also from corals called "rolling stones" Glynn (1974), "coral balls" Lozouet & Maestrati (1992) or "floating corals" (Weigelt 1938). Such "rolling stones" are known both in fossil [Jurassic: pers. observ.; Oligocene: e.g., *Delheidia* Weigelt (1938), Cherchi & Schroeder (1989); Eocene: e. g. *Stylocoenia polytropostyla* (Darga 1992)] and modern corals [Ortmann (1892), Glynn (1974), Dullo & Hecht (1990)]. Also other sessile organisms exhibit a spherical shape, e.g. the Cretaceous hydrozoan *Parkeria sphaerica* Carter, 1877 (see Wilmsen 2003) or the Upper Triassic hydrozoan *Heterastridium* Reuss (1865) A floating live style has been assumed for most of these spherical corals or hydrozoans. Wilmsen (2003) prefers a mode of life as "benthic drifter" (= rolling stone) on shallow-marine sea-floors for *Parkeria*. The "benthic drifter" life style can be assumed for *Porosphaera* from the Cretaceous and for our specimens from the Jurassic of Iran. However, according to Nestler (1961, 1965), *P. globularis* from the Early Maastrichtian of Rügen (Germany) lived

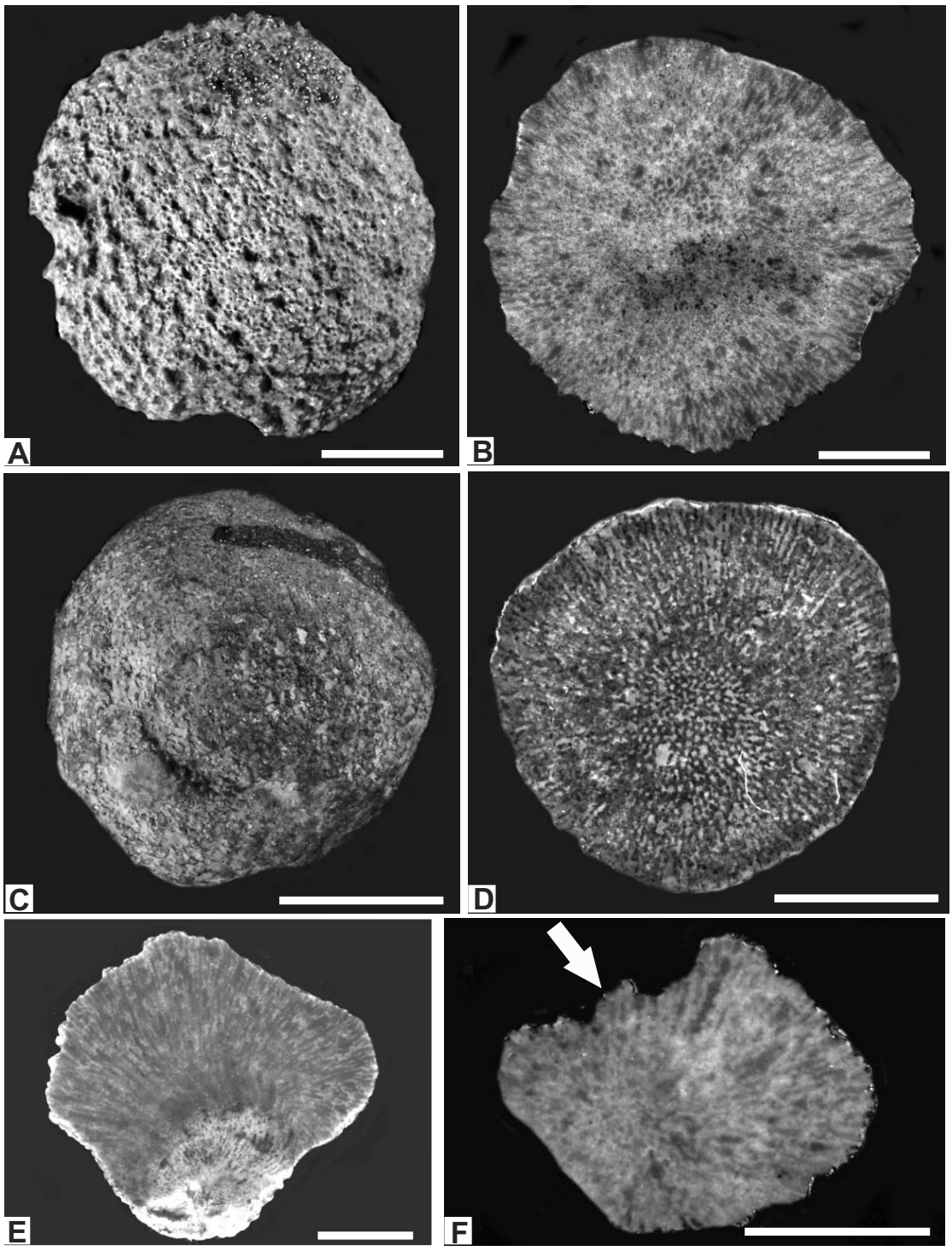

PLATE 4

Different species of the genus *Porosphaera*. Scale: 5 mm.
A) *Porosphaera biporata* n. sp. Surface of specimen BSPG 2010 XX-9 exhibiting an uneven, of meander-like surface. For the internally structure of the specimen see Fig. B. Kamar-e Mehdi Formation of the Kamar-e Mehdi area. B) *Porosphaera biporata* n. sp. Polished slab of the specimen illustrated in Fig. A showing the internal structure and tubes of two sizes. The tubes are extending radially from the center of the sphere. Kamar-e Mehdi Formation of the Kamar-e Mehdi area. C) *Porosphera regularis* n. sp. Holotype (BSPG 2010 XX-10). Surface exhibiting uniformly distributed pores of the same size. For the internal structure of the specimen see Fig. D. Kamar-e Mehdi Formation of the Kamar-e Mehdi area. D) *Porosphaera regularis* n. sp. Holotype. Polished slab of the specimen illustrated in Fig. C showing the internal structure and the uniformly sized tubes extending from the center to the sponge surface. Kamar-e Mehdi Formation of the Kamar-e Mehdi area. E) *Porosphaera*? *asymmetrica* n. sp. Polished slab of the specimen illustrated in Pl. 3, Fig. C showing the asymmetrically arranged internal tubes. The whitish base corresponds the large opening on Pl. 3, Fig. C. The orientation of the tubes in this area is different and related to the large opening. Kamar-e Mehdi Formation of the Kamar-e Mehdi area. F) *Porosphaera biporata* n. sp. Polished slab showing the internal structure of the specimen illustrated in Pl. 2, Fig. A (BSPG 2010 XX-2). Tubes of two sizes are radiating from the center to the sponge surface. Arrow indicates the flattened surface of the specimen figured in Pl. 2, Fig. A. Kamar-e Mehdi Formation of the Kamar-e Mehdi area.

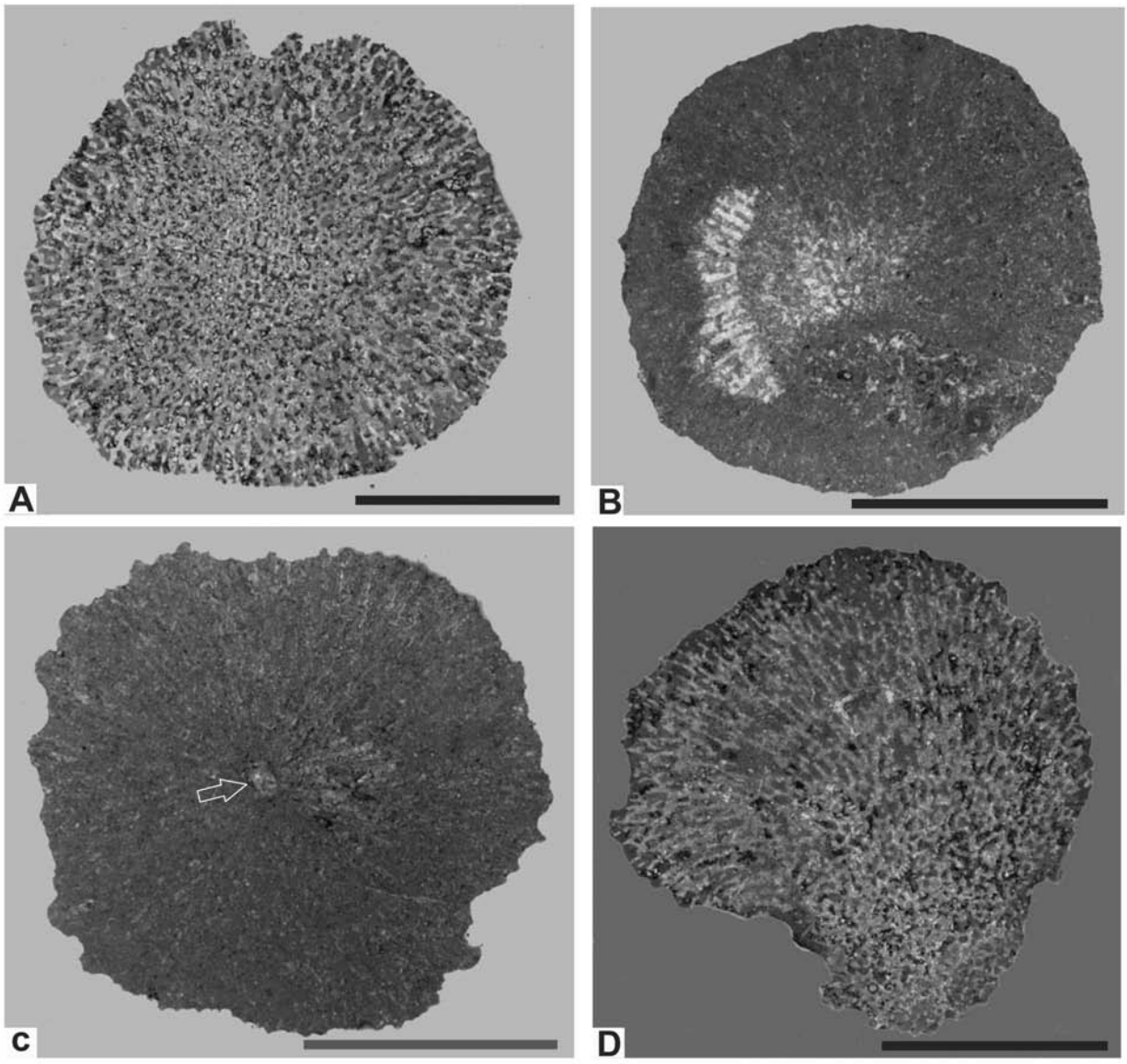

PLATE 5

Fig. A-D - Thin-section photographs of different species of *Porosphaera*. Scale: 5 mm.
A) *Porosphaera regularis* n. sp. Section almost through the center of the relatively well preserved spherical specimen (thin section BSPG 2010 XX-1) showing the fiber skeleton extending from the center to the outside of sphere. Qal-eh Dokhtar Formation at Qal-eh Dokhtar. B) *Porosphaera regularis* n. sp. Section through the center of poorly preserved specimen (thin section BSPG 2010 XX-2). C) *Porosphaera*? *labyrinthica* n. sp. Section through the center of poorly preserved specimen (thin section BSPG 2010 XX-3). The outer surface of the sphere is not smooth, indicating the labyrinth-like structured surface. Arrow indicates a small object in the center of the sponge, around which it grew. Kamar-e Mehdi Formation of the Kamer-e Mehdi area. D) *Porosphaera*? *asymmetrica* n. sp. Section through asymmetrical specimen (thin section BSPG 2010 XX-4) showing the tubes and the skeleton between the tubes diverging from a point at the bottom of the specimen. The skeletal elements are very similar to those of *P. regularis* in Fig. 1.

in sub-photic depth (ca. 100-300 m), and also Reitner (1992) regarded the sponge as a species adapted to low energy, deeper-water conditions. The sponge may also have been anchored to the substrate by a non-calcified dermal tissue, explaining the absence of external attachment scars (Reitner 1992).

All "rolling stones" possess an internal core of carbonate fragments or pebbles of rocks (Dullo & Hecht 1990). We (BSD) found sponge fragments as core in Jurassic "rolling stones". Gastropods, juvenile nautilids (e.g. *Aturia*) or ammonites may form the core of globular hydrozoans (see Chirat 2000; Wilmsen 2003). We (BSD) found small ammonites in Triassic *Heterastridium* and Wilmsen (2003) in Cretaceous *Parkeria*. Also, the core of a specimen of *Porosphaera*? *labyrinthica* is occupied by a small object, possibly a small bivalve (Pl. 5, fig. C). The core (ammonite or other small objects) of such spherical organisms could support the assumption that *Porosphaera* lived floated during the juvenile stage, but later analogous to other examples a

"benthic drifter" mode of life is assumed for these sponges.

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