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PERMIAN CORALS FROM ABADEH AND JULFA, IRAN, WEST TETHYS

by

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(with 27 plates and 5 text-figures)

Contents

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Abstract

This paper mainly concerns the systematic palaeontology of some Middle to Upper Permian corals from the Abadeh and Julfa regions, Iran. The fauna consists of 35 species of 15 genera belonging to eight families. Two different kinds of faunas are clearly distinguished. One is from the Middle Permian and is characterised by such typically Tethyan elements as waagenophyllids and by several species of *Ufimia* and micheliniids. It is followed by an Upper Permian fauna, terminal phylogenetic representatives of the Rugosa, composed mostly of solitary corals (*Pentaphyllum*). The Permian fauna corresponds well to that of the Transcaucasus, USSR, reported by Iljina (1962, 1965a). Many of the Middle Permian corals are known from South China, whereas Upper Permian corals indicate high endemism.

Each species of *Pentaphyllum* shows a wide range of morphological variation, phylogenetically irrespective of Scleractinia. Inter- and intraspecific variability as well as ontogenetic changes are especially documented to clarify the distinctness of each species.

Introduction

The marine Permian is widely distributed in the Tethys and its stratigraphical succession has been documented by investigation of spatio-temporal distributions of many taxa. The Upper Permian especially has been the object of detailed litho- and biostratigraphical studies focused on Permian-Triassic boundary problems and

mass extinction at the end of the Permian. Various litho- and biostratigraphical works have provided a reliable standard stratigraphy at each locality, and basic stratigraphical frameworks have been well established (*e. g.*, Sheng *et al.*, 1984; Nakazawa and Dickins eds., 1985).

Permian corals are found in various places in the Tethyan realm, and many descriptive treatments have been published (*e. g.*, Waagen and Wentzel, 1886; Huang, 1932; Douglas, 1936, 1950; Fontaine, 1961; Minato and Kato, 1965; Iljina, 1965a). Minato and Kato (1965, 1970) made phylogenetic and palaeogeographical studies on some Permian corals belonging to the Waagenophyllidae and recognised a distinct faunal realm characterised by waagenophyllids.

Permian strata containing many fossil corals are well known in both the Abadeh and Julfa regions, Iran, and the adjacent Dzhulfa region, USSR. Comprehensive litho- and biostratigraphical studies using various invertebrate fossils were reported (*e. g.*, Ruzhentsev and Sarycheva eds., 1965; Stepanov *et al.*, 1969; Teichert *et al.*, 1973; Taraz, 1971, 1973; Iranian-Japanese Research Group, 1981), which laid the foundation for precise interregional correlation and more detailed faunal comparison.

Some descriptive papers have been published on Permian corals from several localities in Iran and adjacent regions (*e. g.*, Abich, 1878; Douglas, 1936, 1950; Heritsch, 1937; Hudson, 1958; Iljina, 1962, 1965a; Flügel, 1964, 1972; Gräf, 1964; Kropatcheva, 1983, 1989). Among them, Iljina's works (1962, 1965a) are the most remarkable and she greatly contributed to knowledge of the faunal characteristics of the Middle to Upper Permian corals. Iljina's phylogenetic hypothesis of the Rugosa and the Scleractinia (*e. g.*, Iljina, 1965a, 1983) is based on specimens from the Upper Permian of the Transcaucasus, and her direct descendant theory has greatly influenced thinking about a possible relation between these two groups.

Ezaki (1989) indicated that no transitional and no derived characters are to be recognised in the Upper Permian corals (plerophyllids). Rugose corals became completely extinct, leaving no descendants. Therefore, the faunal characteristics of the rugose corals from the Upper Permian reveal a terminal phylogenetic history of the group.

This paper focuses on systematic descriptions of the Permian corals mostly from both the Abadeh and Julfa regions, Iran. Faunal composition and its comparison with the other province are discussed. Inter- and intraspecific variability, including ontogenetic morphological changes, are examined, especially in the species of *Pentaphyllum*.

The coral specimens studied in this paper were all collected by members of the Iranian-Japanese Research Group in 1969, 1972, and 1975. They were obtained mostly from the Kuh-e-Hambast area in the Abadeh region and the Kuh-e-Ali Bashi area in the Julfa region, but a few came from the Elikah area in the Alborz Mountains (Text-fig. 1). The three-fold Permian subdivisions are used. The lower boundary of the Dzhulfian is defined by the marked appearance of *Reichelina* and *Codonofusiella* (Ruzhentsev and Sarycheva eds., 1965). Variations in the spelling

Text-fig. 1 Index map showing sampling localities.

Dzhulfa (north of the Arax River in USSR) and Julfa (south of the Arax River in Iran) are preserved from quoted references. Biozones of the Permian in the Abadeh, Julfa, and Dzhulfa regions are mostly from Ruzhentsev and Sarycheva eds., (1965), Stepanov *et al.* (1969), and Iranian-Japanese Research Group (1981). All coral specimens described and illustrated herein are registered with the abbreviation, UHR (Department of Geology and Mineralogy, Faculty of Science, Hokkaido University, Sapporo, Japan) and OCU (Department of Geosciences, Faculty of Science, Osaka City University, Osaka, Japan).

Geological Setting

Permian strata containing various kinds of invertebrate fossils are both extensively and successively exposed in the Abadeh and Julfa regions, Iran. Permian and Triassic strata in the Abadeh region were studied by Taraz (1969, 1971, 1973, 1974) and the Permian sequence was subdivided into seven units. Taraz (1971) proposed the Abadehian Stage (post-Guadalupian and pre-Dzhulfian). Litho- and biostratigraphical correlations by such taxa as ammonoids, fusulinids, smaller foraminifers, and brachiopods were well established by the Iranian-Japanese Research Group (1981). Three formations, Surmaq, Abadeh, and Hambast Formations in

ascending order were lithologically grouped in the Permian strata.

According to the Iranian-Japanese Research Group (1981), the Surmaq Formation, comprising Units 1, 2, and 3, overlies the "Sandstone Group" and is characterised by bedded limestones, commonly accompanied by chert nodules, deposited in swell, basin slope, and restricted shoal environments. Six biozones were established in the formation, which include the interval from the *Darvasites* cf. *ordinatus* Zone to the *Orientoschwagerina abichi* Zone. The Abadeh Formation, including Units 4a, 4b, and 5, consists of black shale intercalated with limestone in the lower part and bedded limestones having shale interbeds in the upper part, deposited in a lagoonal environment. Two fusulinid zones, the *Sphaerulina* sp. Zone below and the *Codonofusiella kwangsiana* Zone above, were discerned. The Hambast Formation is divided into two lithological units (Unit 6 and Unit 7). Unit 6 is composed of alternation of greenish shale and grey massive limestone, whereas Unit 7 consists of thin-bedded brownish-red limestones. Both units contain such peculiar sedimentary structures as birdseyes, mud-balls, and mud-cracks. Vertical variation in litho- and biofacies and in boron and lithium content indicate a transition from an open lagoon to a restricted lagoon accompanied by fresh-water inflow. Ammonoids and conodonts are predominant in the Hambast Formation. Biozones, including the *Araxilevis, Araxoceras* (=*Araxoceras tectum* and *Vedioceras nakamurai* Subzones), *Shevyrevites, Paratirolites-Shevyrevites,* and *Paratirolites* Zones, in ascending order, were established.

No erosional features are superficially observable between the uppermost Permian (Unit 7) and the overlying Triassic (Unit a), but biostratigraphical study indicates the presence of a gap representing a paraconformable relation between these two intervals of geological time (Iranian-Japanese Research Group, 1981).

Abich (1878) produced the first stratigraphical and palaeontological studies of the Transcaucasus. A series of works have been carried out in the Transcaucasus and northern Iran (*e. g.*, Ruzhentsev and Sarycheva, eds., 1965; Stepanov *et al.*, 1969; Teichert *et al.*, 1973). Stepanov *et al.* (1969) investigated the Upper Permian to the Lower Triassic in the Julfa region, Iran. The Permian sequence, including the "Permian-Triassic transition beds", was thoroughly examined. Rostovtsev and Azaryan (1973) considered the "transition beds" in the Transcaucasus to be the uppermost Permian and proposed the Dorashamian Stage. The Dorashamian beds in the Julfa region were researched and the Ali Bashi Formation was proposed (Teichert *et al.*, 1973). The Dzhulfian is characterised by such ammonoids as *Araxoceras* and *Vedioceras*, the Dorashamian by *Phisonites, Iranites, Shevyrevites,* and *Paratirolites.* Correlation with the Abadeh section is well established from both lithological and palaeontological viewpoints (Text-fig. 2), and similar palaeoenvironmental changes are recognised (Iranian-Japanese Research Group, 1981).

Faunal Analysis and Correlation

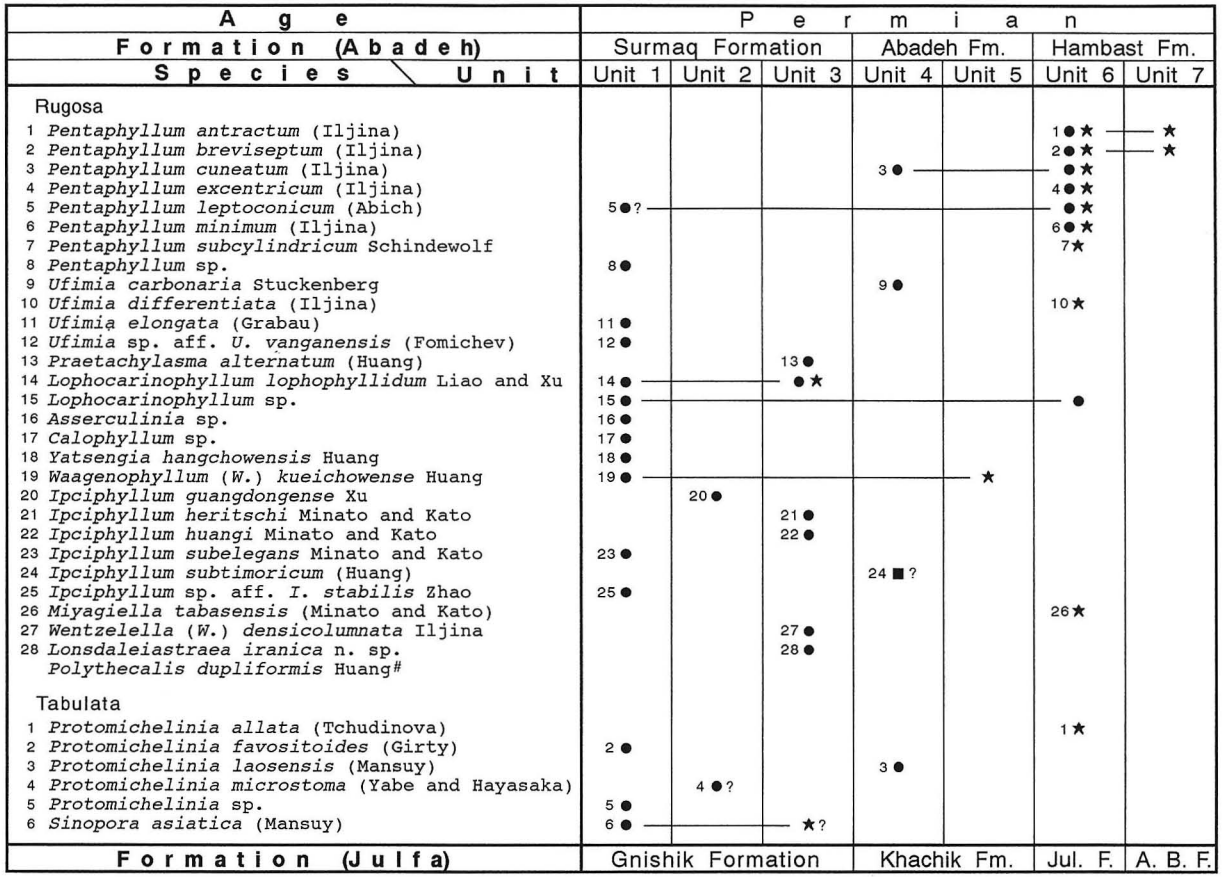
Corals occur at several horizons and are rather sporadically distributed in the Permian. A summary of the stratigraphical occurrence of the corals from the Abadeh and Julfa regions, including the Alborz Mountains, is given in Text-fig. 2.

Many colonial corals, including massive waagenophyllids and tabulate corals, disappear in the lower sequence, whereas solitary forms persist up to the uppermost part of the Permian sequence. Solitary rugose corals are abundant in the Upper Permian (Dzhulfian and Dorashamian). A similar tendency has been noted in the Middle to Upper Permian of various regions (Flügel, 1970; Iranian-Japanese Research Group, 1981; Kato and Ezaki, 1986b). This phenomenon is a reflection of the phylogenetic decline of the Rugosa and palaeoecological control by a shelf habitat that was probably related to global regression.

In the Middle Permian, the fauna is characterised by such solitary corals as *Ufimia* and *Lophocarinophyllum,* several kinds of waagenophyllids, and some tabulate corals. Solitary forms occur in Unit 1 and Unit 3 of the Surmaq Formation, and the lower part of the Abadeh Formation (Unit 4). Such solitary corals as *Ufimia* and *Lophocarinophyllum* are mostly confined to the Surmaq and the Abadeh Formations, but a few are known to survive into the Hambast Formation. Massive waagenophyllids almost disappear in the Surmaq Formation at Abadeh. Among them, *Lonsdaleiastraea iranica* is a newly described species. The tabulate corals are represented by *Sinopora asiatica* and four micheliniid species.

In the Upper Permian, a remarkable difference in faunal composition is observed. The fauna is composed mostly of solitary forms belonging to *Pentaphyllum.* The Upper Permian fauna shows phylogenetically most descendant groups within the Rugosa. Many species of *Pentaphyllum* were established by Iljina (1962, 1965a) on specimens from the Transcaucasus, USSR, and comparable species seldom have been reported outside the Transcaucasus and Iran. Most of Iljina's nominal "species" are found in the materials examined for this report on Iranian corals, although the diagnostic characters of each species are partly revised. *Pentaphyllum leptoconicum* and *P. subcylindricum* were first reported by Abich (1878) and Schindewolf (1942) respectively. According to Iljina (1965a) and Kropatcheva (1983, 1989), a number of species of *Pentaphyllum* occur at several horizons in the uppermost Permian, but *P. breviseptum* and *P. antractum* can be observed among the present materials from the Dorashamian in the Abadeh and Julfa regions. *P. leptoconicum* and *P. cuneatum* occur also in the Middle Permian (Gnishik Formation and Unit 4 respectively) (Text-fig. 2). Some subordinate components of the fauna are such solitary corals as *Ufimia differentiata* and *Lophocarinophyllum* sp., colonial waagenophyllids [*Waagenophyllum* (*W.*) *kueichowense* and *Miyagiella tabasensis*], and a tabulate coral (*Protomichelinia allata*).

The Middle Permian fauna from the Abadeh region is characterised by waagenophyllids accompanied by tabulate and small solitary corals. The fauna seems to be comparable to those from the other regions, including the Julfa (Gräf,



Text-fig. 2 Stratigraphical occurrence of Permian corals from Abadeh (●), Julfa (★), and Alborz (■) regions. Correlation of the Permian between Abadeh and Julfa is after Stepanov *et al.* (1969) and Iranian-Japanese Research Group (1981). Jul. F.: Julfa Formation, A. B. F.: Ali Bashi Formation. # horizon unknown.

1964; Flügel, 1971), Dzhulfa (Iljina, 1962, 1965a, b; Kropatcheva, 1983, 1989), and Alborz (Gräf, 1964; Flügel, 1964, 1968). Such species as follows are commonly observed between the Abadeh and Dzhulfa regions: *Ufimia elongata, Praetachylasma alternatum, Waagenophyllum* (*W.*) *kueichowense,* and *Wentzelella* (*W.*) *densicolumnata.*

Strong faunal similarity is observed between Iran and South China, judging from the coral assemblages. Many species of massive corals (*e. g.*, *Ipciphyllum subtimoricum, I. guangdongense,* and *I. huangi*) and fasciculate species [*Waagenophyllum* (*W.*) *kueichowense* and *Yatsengia hangchowensis*] are known from the Permian of South China. A tabulate coral (*Protomichelinia microstoma*) also occurs in the Chihsia Limestone of South China (Huang, 1932). In addition to the above mentioned forms, such solitary corals as *Ufimia elongata, Praetachylasma alternatum,* and *Lophocarinophyllum lophophyllidum* from the lower sequence at Abadeh are comparable to the Chinese forms. The Surmaq Formation is considered to be roughly equivalent in age to the Chihsian to Maokouan of China. This is well compatible with the correlation by fusulinid zonation (Iranian-Japanese Research Group, 1981). There is also similarity of brachiopod assemblages in the Middle Permian between Iran and South China (Nakamura *et al.*, 1985). All of these should be valuable for reconstruction of Permian palaeogeography and palaeoenvironment.

In the Upper Permian, the presence of faunal similarity is safely concluded between the Abadeh and Julfa regions. Iljina (1962, 1965a), Tchudinova (1965) and Kropatcheva (1983, 1989) showed the faunal features of the Upper Permian corals from the Transcaucasus. The Iranian coral fauna seems to be well comparable to that from the Transcaucasus. The fauna is, however, of less value for interregional correlation, because it is mostly occupied by rather endemic species. Moderate species diversity and distinct provincialism are characteristic of the species of *Pentaphyllum* in the Upper Permian.

Although the Upper Permian faunas are known from various places in the Tethyan realm, successive coral occurrences through the stratigraphical sections of the Middle to Upper Permian are rare. Several coral faunas have been reported from the Upper Permian of South China, *e. g.*, Guizhou (Zhao, 1976); Shaanxi (Zhao, 1981); Hunan and Hubei (Xu, 1984a, b); Zhejiang, Guangxi, and Sichuan (Wu and Zhao, 1983). Each fauna is comparatively low to moderate in species diversity and occurs rather sporadically through the stratigraphical successions. In the Upper Permian, two coral assemblage zones were established in each province. Wu and Zhao (1983) noted two assemblages within the Upper Permian corals: the "*Liangshanophyllum wengchengense-Asserculinia pendula* assemblage" in the Wuchiapingian, and the "*Waagenophyllum stereoseptatum-Asserculinia orbiculata* assemblage" in the Changhsingian. They mentioned the mutual faunal relations between Transcaucasus or Iran and South China, and considered the "*Waagenophyllum stereoseptatum-Asserculinia orbiculata* assemblage" to be higher in stratigraphical position than the Dorashamian assemblage in USSR and Iran. The distribution of

the corals was, however, so localised that faunal connexion in the uppermost Permian was limited. Some disrupted faunal provinces in the Tethyan realm might have existed, on the basis of the faunal assemblages and their mutual relationship. The author, therefore, does not consider that the coral faunas themselves are useful for stratigraphical correlation in the present case. Even if the uppermost Permian faunas show close similarity at the generic level, each fauna may be composed of its own endemic species, showing the peculiar terminal phylogenetic pattern.

Systematic Palaeontology

Morphological terminology is mostly from Hill (1981). Septal terms (protosepta, metasepta, and catasepta) are based on formative modes of septa (Ezaki, 1989). The number of septa, especially in plerophyllids indicates the total number of protosepta and metasepta (not major septa) if nothing is specified. The septal formula is presentd as two ratios, being the number of metasepta in each quadrant, in the following order: left counter/left cardinal, right counter/right cardinal. The four directive septa (cardinal, counter, and two alars) are not counted. Growth stages such as early and late, or pre-mature and mature stages are ordinarily used in describing ontogenetic changes and for comparing specimens at the same ontogenetic stage.

Class Anthozoa Ehrenberg, 1834
Subclass Rugosa Milne-Edwards and Haime, 1850
Order Stauriida Verrill, 1865

Family Plerophyllidae Koker, 1924
Genus *Pentaphyllum* de Koninck, 1872

Type species: *Pentaphyllum armatum* de Koninck, 1872.

Remarks: The plerophyllids have been classified into several taxonomic ranks based on many criteria such as the timing of septal appearance, the length and the morphology of major septa, and the arrangement of septa. For historical reviews see Weyer (1972), Fedorowski (1973), and Iljina (1977, 1984).

Iljina (1965a) described and illustrated the Late Permian plerophyllids and some doubt was cast on subdividing the family Plerophyllidae on the ground that the two types of development ("pentaphylloid" and "zaphrentoid") are not clearly separated in early ontogeny. Weyer (1972) and Iljina (1977) clearly discussed the morphological features and taxonomical implication of the phenomenon called septal reduction. They exemplified a wide range of morphological variation caused by septal reduction and insisted that the "pentaphylloid" and the "zaphrentoid" types may alter from one to the other.

Ezaki (1989) studied the Late Permian plerophyllids from Iran and noted that five major septa (cardinal, two alars, and two counter-laterals) are developed from

the early ontogeny, whereas the other major septa are less well developed and of uneven length, sometimes owing to structural (morphogenetical) constraints. Major septa adjacent to the well developed septa tend to remain short.

In this case, the counter septum, which is present between the well developed counter-lateral septa, tends to be restricted in length. The author at present does not necessarily consider the features of the counter septum and the arrangement of septa to be taxonomically significant. The following systematic descriptions of some plerophyllids will present the evidence. He prefers to accept the outline of the taxonomic framework of Iljina (*e. g.*, 1977, 1984) and Weyer and Iljina (1979).

The subfamily Tachylasmatinae is placed in synonymy with the family Plerophyllidae, and the genera *Pentaphyllum* and *Plerophyllum* are regarded as synonyms. *Pentaphyllum* is generically separable from *Ufimia* in having a longer cardinal septum. At present the author does not necessarily consider an amplexoid feature is taxonomically valid.

Following is a key to the species of *Pentaphyllum* from the Upper Permian of the Abadeh and Julfa regions:

I. Major septa thin and flexuose, weakly differentiated in length
 (1) Major septa numerous; wall thin ..... *P. excentricum* (Iljina)
 (2) Major septa slightly rhopaloid; wall thick ..... *P. antractum* (Iljina)

II. Major septa much differentiated in length
 (1) Corallites ceratoid to cylindrical, showing thick wall with cuneiform major septa and rudimentary or short minor septa ..... *P. cuneatum* (Iljina)
 (2) Moderate to large-sized corallites showing variably dilated septa; cardinal fossula may be formed ..... *P. leptoconicum* (Abich)
 (3) Corallites comparatively small with thick wall showing prominent minor septa; calice deep ..... *P. breviseptum* (Iljina)
 (4) Corallites cylindrical, showing quite thick wall .... *P. subcylindricum* Schindewolf
 (5) Corallites comparatively small with thin wall showing very short or rudimentary minor septa ..... *P. minimum* (Iljina)

Pentaphyllum excentricum (Iljina, 1962)
(Pl. 1, fig. 1a-k; Pl. 2, fig. 1a-n)

1962 *Plerophyllum excentricum* Iljina, p. 73, pl. 1, fig. 2.
1965a *Plerophyllum excentricum* Iljina; Iljina, p. 40, pl. 2, figs. 3a-e, 4a-c; text-figs. 12a-c, 13a-f.
1965b *Plerophyllum excentricum* Iljina; Iljina, p. 334, pl. 11, fig. 8.
1984 *Pentaphyllum excentricum* (Iljina); Iljina, p. 87, pl. 12, fig. 4; text-fig. 2j.
1989 *Pentaphyllum excentricum* (Iljina); Ezaki, p. 277, fig. 2C.

Holotype: PIN, No. 1820/585, Palaeont. Inst., USSR Acad. Sci.; left bank of

the Arax River, Dorasham 2, Dzhulfa, Nakhichevan; Upper Permian, Dzhulfa Formation, *Araxilevis* to *Araxoceras* Beds.

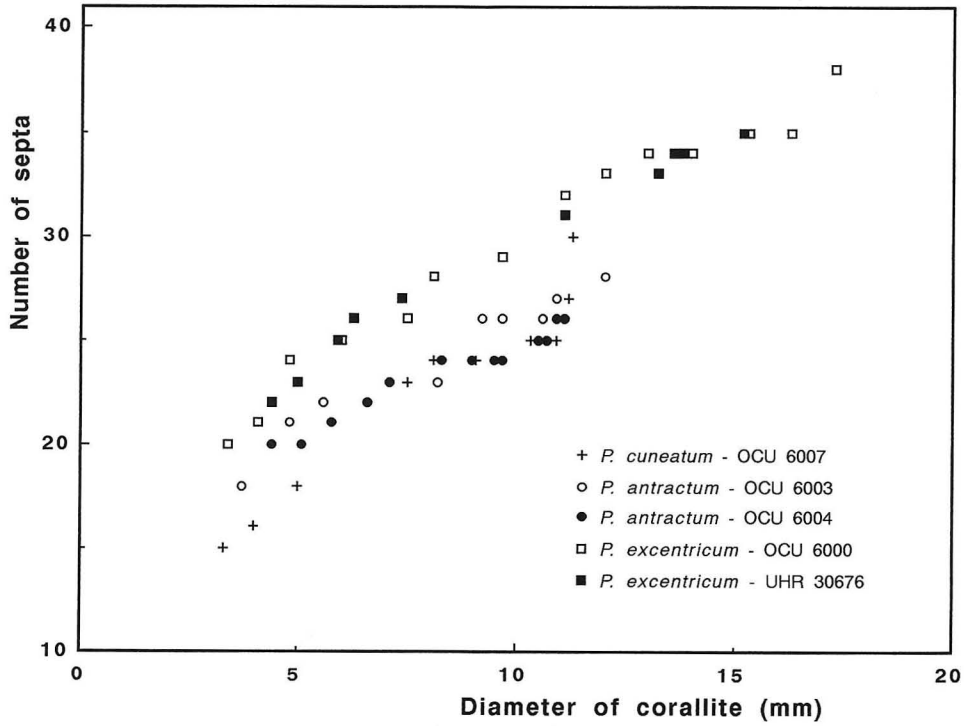
Material studied: Four specimens (UHR 30676, OCU 6000-6002); middle part of Unit 6 of the Hambast Formation (*Araxoceras tectum* Subzone), Kuh-e-Hambast, Abadeh; middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa.

Diagnosis: *Pentaphyllum* having comparatively large corallites with weakly differentiated major septa in length. The majors numerous, slender and flexuose. Wall relatively thin. No distinct fossular depression formed.

Description: Comparatively large corallites exhibit gentle to strong curvature, having the cardinal septum ordinarily located on the convex side. The largest specimen attains a length of 28.0 mm and a diameter of 17.3 mm. The exterior bears longitudinal interseptal ridges and sharply incised septal grooves, and prominent transverse wrinkles and closely spaced growth lines. The epitheca shows no attachment processes.

In transverse section, corallites are almost circular, sometimes elliptical to subovate. The wall attains about 1.2 mm in the thickest part. Septa are arranged in radial pattern, but they may become flexuose and conjoin eccentrically in the later stages. The number of septa at a particular diameter of corallite is shown in Text-fig. 3. The septal formula (9/6, 8/7) is shown at a diameter of 13.8 mm. The five particular major septa (cardinal, two alars, and two counter-laterals) are distinguishable in being slightly thicker and longer. The other majors are weakly differentiated in length. The counter septum is variable in length throughout ontogeny. Septa and wall in the counter quadrants, which are ordinarily located on the concave side of the corallite, may be dilated temporarily. The axial ends of major septa are laterally contiguous, especially in the vicinity of the intersection of tabulae and septa (Pl. 1, fig. 1i). Minor septa (catasepta) appear as low ridges or wedges between the majors. Very fine fibres are perpendicularly arranged from the central part of the septum (Pl. 2, fig. 1n). The dark zone is more or less sinuous and disrupted, sometimes showing the marked axial twisting and frontal zones. Transversely cut edges of tabulae are concentrically arranged. They are thickened outwards by stereoplasm.

Ontogeny: In the earlier stages (Pl. 1, fig. 1b-d), being approximately 4.4 to 5.9 mm in diameter, major septa are platy and extend to the central part, where some major septa are slightly curved and twisted. The five specific major septa are discernible by being somewhat thicker than the others. The counter septum also reaches the centre, although it is slightly thinner than the counter-lateral septa. Minor septa (catasepta) are recognisable within a thin wall. As the corallite grows, some major septa, including the counter septum, do not meet at the centre or conjoin eccentrically (Pl. 1, fig. 1e, f). The majors are slightly and irregularly differentiated in length. Major septa situated at the middle of each quadrant are generally longer than the others. At a later growth stage (Pl. 1, fig. 1g, h), the length of major septa becomes less variable, and major septa do not extend to the



Text-fig. 3 Relationship between diameter of corallite and number of septa in *Pentaphyllum cuneatum* (Iljina), *P. antractum* (Iljina), and *P. excentricum* (Iljina).

axial region, leaving a wide open space. In this case, the five definite majors are slightly longer than the others. Tabulae are often intercepted concentrically and laterally. In the fully grown stage (Pl. 1, fig. 1i-k), major septa show an asymmetrical arrangement and some major septa are slightly wavy, especially at their axial ends. Tabular intercepts appear concentrically.

Variability: The arrangement, length, and thickness of major septa are variable, even within a corallite. Septa in the counter quadrants may be so thickened as to be axially confused (Pl. 1, fig. 1i, j). Such tendency can be also recognised in the thickness of the wall formed by lateral fusion of the peripheral parts of septa. Specimens show rather large variability in septal length. Once shortened, major septa may extend again. The asymmetrical arrangement, as well as differentiated length and thickness of major septa, are directly correlated with each other. These features seem to be also influenced by the formation of tabulae, the inclination of the tabular (calice) floor, and the resultant corallite curvature.

Remarks: This species is marked by numerous major septa compared to corallite diameter. Major septa are slender and weakly differentiated in length. These features can be clearly recognised from a comparatively early stage. The present species is closely allied to *Pentaphyllum leptoconicum* (Abich), but it is distinguishable from the latter in having numerous and weakly differentiated major septa in

length. A few septa are dislocated at the periphery or near the transverse intercepts of tabulae. But this feature is of no taxonomic importance.

Pentaphyllum antractum (Iljina, 1965)
(Pl. 3, figs. 1a-h, 2a-k)

1937 *Plerophyllum leptoconicum* (Abich); Heritsch (*partim*), p. 9, pl. 12, figs. 12, 13.
1965a *Plerophyllum antractum* Iljina, p. 44, pl. 3, figs. 4a-d, 5a-d, 6, 7a-c, 8; text-fig. 15: 1a, b, 2a, b, 3a, b.
1965b *Plerophyllum antractum* Iljina; Iljina, p. 334, pl. 11, fig. 6.
1984 *Pentaphyllum antractum* (Iljina); Iljina, p. 97, text-fig. 38a, b.

Holotype: PIN, No. 1820/461, Palaeont. Inst., USSR Acad. Sci.; left bank of the Arax River, Dorasham 2, Dzhulfa, Nakhichevan; Upper Permian, Dzhulfa Formation, *Vedioceras* Beds.

Material studied: Four specimens (OCU 6003-6006); middle part of Unit 6 of the Hambast Formation (*Araxoceras tectum* Subzone), Kuh-e-Hambast, Abadeh; middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone) and upper part of the Ali Bashi Formation (*Paratirolites* Zone), Kuh-e-Ali Bashi, Julfa.

Diagnosis: Moderate-sized *Pentaphyllum* having slender, flexuose and somewhat rhopaloid major septa weakly differentiated in length. Wall comparatively thick.

Description: Moderate-sized and slightly curved ceratoid corallite attains a length of about 28.5 mm and a diameter of 12.8 mm. The epithca is marked longitudinally by faint ridges and septal grooves. Broad wrinkles and growth lines run transversely across the corallite.

In transverse secion, corallites are circular to somewhat ovate. The wall is relatively thick, attaining about 0.8 mm in the thickest part and shows distinct septal wedges. Major septa are slender and slightly flexuose. The number of septa at a particular diameter of corallite is shown in Text-fig. 3. The septal formula (6/4, 5/5) is shown at a diameter of 9.5 mm. Major septa are not so much differentiated in length, except for those in the earlier stages. The five specific major septa are slightly longer and thicker than the others. The axial ends of major septa, repeatedly rhopaloid, reach close to the centre. Some are slightly wavy and bent aside (Pl. 3, figs. 1e, f, 2e-h). Minor septa (catasepta) are distinct but variable in length throughout ontogeny. Septa are composed of a median dark zone and fibres arranged almost perpendicularly to the zone. The dark zone is irregularly undulating and interrupted by successive semicircular zones, especially in the rhopaloid part. They ordinarily form the frontal zones. Transversely cut edges of tabulae appear concentrically to laterally in rather irregular pattern and are sometimes dilated outwards.

Ontogeny: In the earliest stage examined (Pl. 3, fig. 1a), major septa are slender and their axial ends join irregularly. Minor septa (catasepta) are retained only visible in the wall. In the next stage (Pl. 3, fig. 1b-d), some axial ends of major

septa are still elongated so as to meet at the centre. The other majors, including the counter septum, are more or less differentiated in length. The five particular majors are discernible in being slightly thick and long compared to the others. The wall is dilated. In the later stage (Pl. 3, fig. 1e, f), major septa fail to reach the centre and become rhopaloid. Major septa are not so much differentiated in length. The counter septum is as long as the other majors. In the final growth stage (Pl. 3, fig. 1g, h), major septa are slender and slightly flexuose. The cardinal septum is not shortened. Minor septa are distinct.

Variability: Variation in length of major septa is weakly shown, though the five specific majors are ordinarily longer and thicker than the others. The cardinal septum may slightly shorten in the later growth stages (Pl. 3, fig. 2i-k). The length of the minors depends clearly on the ontogenetic growth stage, and becomes longer in the later stages. Wall thickness is variable, although it seems to be rather thick.

Remarks: This species is characterised by slender, rhopaloid major septa of weak differentiation in length, and by a thick wall. The present species is quite similar to *Pentaphyllum excentricum* (Iljina) in showing thin and weakly differentiated major septa. However, *P. antractum* (Iljina) differs in having smaller corallites showing fewer major septa and a comparatively thick wall.

Pentaphyllum cuneatum (Iljina, 1962)

(Pl. 4, figs. 1a-h, 2a, b, 3a, b; Pl. 5, figs. 1a, b, 2a, b)

1962 *Plerophyllum cuneatum* Iljina, p. 80, pl. 2, fig. 3a, b.
1965a *Plerophyllum cuneatum* Iljina; Iljina, p. 58, pl. 9, fig. 6a, b; pl. 10, figs. 1a-e, 2a-g; text-fig. 22.
1965b *Plerophyllum cuneatum* Iljina; Iljina, p. 336, pl. 12, fig. 5.
1984 *Pentaphyllum cuneatum* (Iljina); Iljina, p. 101, pl. 11, fig. 3; pl. 12, fig. 7a, b; text-fig. 2k.

Holotype: PIN, No. 1820/815, Palaeont. Inst., USSR Acad. Sci.; left bank of the Arax River, Dorasham 2, Dzhulfa, Nakhichevan; Upper Permian, Dorasham Formation, *Paratirolites* Beds.

Material studied: Twenty-three specimens (OCU 6007-6029); middle part of Unit 6 of the Hambast Formation (*Araxoceras tectum* Subzone) and lower part of the Abadeh Formation (*Sphaerulina* sp. Zone), Kuh-e-Hambast, Abadeh; middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa.

Diagnosis: Small to moderate-sized *Pentaphyllum* showing ceratoid to cylindrical corallites. Major septa extremely dilated in earlier stages and cuneiform in later. Minor septa rudimentary or short in fully grown corallite. Wall generally thick.

Description: Corallites are slightly curved ceratoid to cylindrical with a maximum length of over 31.5 mm, and a diameter of 14.8 mm. The exterior is abraded, and no definite longitudinal markings, such as septal grooves and interseptal ridges, are detectable.

In transverse section, corallites are almost circular. The wall is generally thick, attaining 1.1 mm in the thickest part. Septa show a seemingly radial arrangement in two orders, having the five preferentially long major septa. Major septa are much dilated in the earlier stages and later retreat from the centre. They are cuneiform, more or less thickened near the bases, tapering towards the axial ends. The number of septa at a particular diameter of corallite is shown in Text-fig. 3. The septal formula (6/4, 7/4) is shown at a diameter of 10.3 mm. Minor septa (catasepta) are confined to stereozone or are observed only as low ridges. Tertiary septa do not appear. Septa are composed of a median dark zone and fibres almost perpendicular to diagonal to the dark zone (Pl. 4, fig. 3b). The zone may be discontinuous and show the frontal zones, particularly in the axial parts.

In longitudinal section, tabulae are domed, having flat to slightly concave tops and peripheral troughs. Tabulae at the periphery arch moderately to steeply from the wall.

Ontogeny: In the earlier stages (Pl. 4, fig. 1a-c), major septa are greatly thickened without leaving any interseptal spaces. During further growth (Pl. 4, fig. d), the amount of stereoplasm is reduced, and some major septa are more differentiated in length. The majors, just next to the five developed septa, remain short. The counter septum is shorter than the others. In the subsequent growth stage (Pl. 4, fig. 1e), the corallite has a wide, free axial area, and some major septa are more or less subequal in length. Transversely cut edges of tabulae are thickened towards the periphery. Major septa are again prolonged, where they fuse on the top of tabulae (Pl. 4, fig. 1f). Major septa then withdraw slightly from the axial region (Pl. 4, fig. 1g). The majors are cuneiform and become wedge-shaped in the wall. In the final stage (Pl. 4, fig. 1h), minor septa (catasepta) are present, though rather rudimentary. The cardinal septum is not shortened.

Variability: This species shows a rather narrow range of variation among individuals, because they are characterised by simply formed structures. A thick wall equipped with peripherally dilated major septa is a peculiarity of this species. Minor septa (catasepta) are ordinarily inconspicuous, but they may be distinct in the later stages. Although a marked variation in size among individuals occurs, the essential features noted above remain unchanged.

"Amplexoid retreat" of major septa appears repeatedly throughout growth and is distinctly related to tabular formation. The cardinal septum may become short, only in the fully grown corallite. The counter septum ordinarily remains short, but is sometimes as long as the other majors.

Remarks: This species is quite common in the lower part of the Hambast Formation (Unit 6) in the Abadeh region, but according to Iljina (1965a), it also occurs in the uppermost Permian (*Paratirolites* Beds) in the Dzhulfa region. The present species is closely allied to *Pentaphyllum leptoconicum* (Abich), but it is separable from the latter in having a thick wall with cuneiform major septa and no prominent minor septa.

Pentaphyllum leptoconicum (Abich, 1878)

(Pl. 5, figs. 3a-g, 4a-i ; Pl. 6, figs. 1a, b, 2, 3a-c, 4a-d, 5 ; Pl. 7, fig. 1a-k ; Pl. 8, figs. 1a-g, 2a, b, 3)

1878 *Clisiophyllum leptoconicum* Abich, p. 87, pl. 11, fig. 7, 7a.
1900 *Zaphrentis* (? *Pentaphyllum* ?) *leptoconica* (Abich) ; Arthaber, p. 287, text-fig. 52a-d.
1937 *Plerophyllum leptoconicum* (Abich) ; Heritsch (*partim*), p. 9, pl. 2, figs. 8-11, 14-21.
1941 *Plerophyllum leptoconicum* (Abich) ; Soshkina, Dobrolyubova, and Porfiriev, p. 78, pl. 6, fig. 7a-d.
1962 *Plerophyllum clavatum* Iljina, p. 72, pl. 1, fig. 1a-d.
1962 *Plerophyllum dzhulfense dzhulfense* Iljina, p. 76, pl. 1, figs. 4, 5.
1962 *Pleramplexus leptoconicum* (Abich) ; Iljina, p. 81, pl. 2, figs. 4a-c, 5.
1965a *Plerophyllum clavatum* Iljina ; Iljina, p. 36, pl. 1, figs. 1a, b, 2a-g, 3 ; pl. 2, figs. 1a-c, 2 ; text-figs. 8a, b, 9-11.
1965a *Plerophyllum dzhulfense* Iljina ; Iljina (*partim*), p. 47, pl. 3, fig. 9 ; pl. 4, figs. 1-3, 4a-e, 5a, b, 6a, b, 8, 9, 11a, b ; pl. 5, figs. 1a, b, 2a, b, 3a, b, 4, 5a-c ; text-figs. 16 : 1a, b, 2a, b, 3a, b, 18a-g.
1965a *Plerophyllum differentiatum* Iljina ; Iljina (*partim*), p. 52, pl. 6, figs. 2, 3a, b, 4a-d, 5 ; pl. 7, figs. 1a, b, 2, 3, 4a-c, 5, 7, 8a, b ; pl. 8, figs. 2-4 ; text-fig. 19 : 1, 2.
1965a *Pleramplexus leptoconicus* (Abich) ; Iljina (*partim*), p. 60, pl. 11, figs. 1, 2a, b, 3, 4, 5a, b, 6 ; pl. 12, figs. 1a-d, 2a, b, 3a, b, 4a-d ; pl. 13, figs. 1a-c, 2a-d, 3a-d, 4a-c, 5 ; pl. 14, figs. 1-5, 7 ; text-figs. 23-28.
1965b *Plerophyllum dzhulfense* Iljina ; Iljina, p. 334, pl. 11, fig. 5.
1965b *Plerophyllum clavatum* Iljina ; Iljina, p. 334, pl. 11, fig. 7.
1965b *Pleramplexus leptoconicus* (Abich) ; Iljina, p. 336, pl. 12, fig. 1.
1968 *Plerophyllum* (*Plerophyllum*) *dzhulfense* Iljina ; Flügel, p. 286, text-figs. 3 : 1-4, 4.
1968 *Pleramplexus leptoconicus* (Abich) ; Flügel, p. 289, pl. 25, fig. 3 ; text-fig. 5 : 1-3.
1969 *Pleramplexus leptoconicus* (Abich) ; Stepanov, Golshani, and Stöcklin, p. 69, pl. 4, figs. 1, 2.
1969 *Plerophyllum clavatum* Iljina ; Stepanov, Golshani, and Stöcklin, p. 69, pl. 4, fig. 3a, b.
1971 *Plerophyllum* (*Plerophyllum*) *dzhulfense* Iljina ; Flügel, p. 111, pl. 6, fig. A1-6.
1971 *Pleramplexus leptoconicus* (Abich) ; Flügel, p. 117, pl. 5, figs. 1, 2 ; pl. 6, fig. B1-10.
1973 *Plerophyllum dzhulfense* Iljina ; Teichert, Kummel, and Sweet, p. 394, pl. 1, figs. 1-7.
1973 *Pleramplexus leptoconicus* (Abich) ; Teichert, Kummel, and Sweet (*partim*), p. 395, pl. 2, figs. 1, 2.
?1974 *Plerophyllum dzhulfense* Iljina ; Wu and Wang, p. 298, pl. 156, figs. 12, 13.
non 1974 *Pleramplexus leptoconicus* (Abich) ; Iljina, p. 213, text-fig. 2 : 3a-d.
?1975 *Pleramplexus leptoconicus* (Abich) ; Nakazawa *et al.*, p. 40, pl. 3, fig. 2a, b.
1977 *Plerophyllum dzhulfense* Iljina ; Iljina (*partim*), p. 80, text-fig. 3a-g.
?1978 *Plerophyllum dzhulfense* Iljina ; Fan, p. 151, pl. 50, fig. 3a, b.
1979 *Pentamplexus leptoconicus* (Abich) ; Weyer and Iljina, p. 1316. pl. 1, fig. 1a, b ; text-fig. 4 : 1-9.
1983 *Pentaphyllum araxense* Kropatcheva, p. 145, pl. 12, figs. 1a-d, 2a, b.
1984 *Pentaphyllum dzhulfense* (Iljina) ; Iljina, p. 86, pl. 6, figs. 1, 2 ; pl. 12, figs. 1-3 ; text-figs. 2c, 34a-g.
1984 *Pentaphyllum clavatum* (Iljina) ; Iljina, p. 96, pl. 12, figs. 5a-c, 6 ; text-figs. 2l, m, 6a, b.
1984 *Pentaphyllum differentiatum* (Iljina) ; Iljina (*partim*), p. 99, text-figs. 18a-e, 39g.
1984 *Pentamplexus leptoconicus* (Abich) ; Iljina, p. 117, pl. 30, fig. 1 ; text-figs. 2d-f, 47a-e.
?1984b *Plerophyllum dzhulfense* Iljina ; Xu, p. 179, pl. 17, fig. 7a, b.
1989 *Pentamplexus leptoconicus* (Abich) ; Ezaki, p. 277, fig. 2A, B.
1989 *Pentaphyllum* sp. B ; Ezaki, p. 277, fig. 2J-P.
1989 *Pentaphyllum differentiatum* (Iljina) ; Ezaki, p. 279, fig. 3A-M.

Holotype : No 119/99, Museum of the Leningrad Mining Inst. ; left bank of the Arax River, Dorasham, Dzhulfa, Nakhichevan ; Upper Permian, Dzhulfa Forma-

tion.

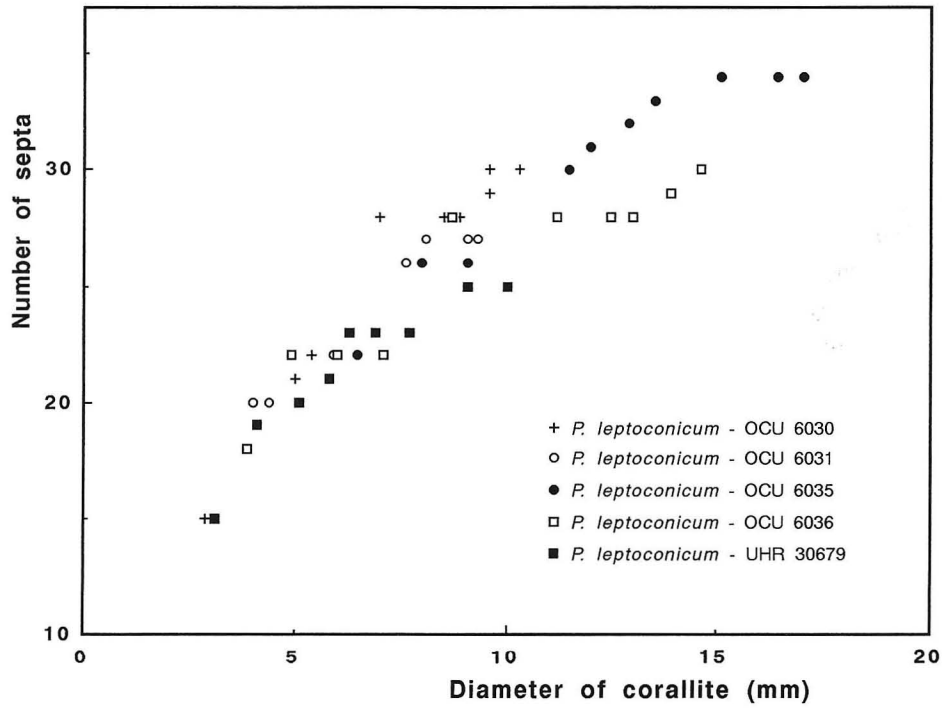
Material studied: Sixty-four specimens (UHR 30674, 30675, 30678, 30679, 30689, 30690, OCU 6030-6087); lower part of the Hambast Formation (Dzhulfian), Kuh-e-Hambast, Abadeh; Gnishik Formation and Julfa Formation (*Araxilevis-Orthotetina* Zone, *Pseudogastrioceras-Permophricodothyris* Zone, and *Haydenella-Pseudowellerella* Zone), Kuh-e-Ali Bashi, Julfa. Specimens show no apical ends. Some are entirely embedded in limestone matrix.

Diagnosis: Moderate to large-sized *Pentaphyllum* having variably dilated major septa, sometimes clavate to rhopaloid. Major septa much differentiated in length and minor septa variable in length, not so prominent in earlier stages. Cardinal fossula may be weakly developed. Wall generally thick.

Description: Corallites are gently curved cylindrical to trochoid, showing a maximum observed length of 61.2 mm and a diamete of 22.1 mm. Some corallites are more or less curved, particularly in the lower parts, sometimes in the cardinal-counter plane. The epitheca bears faint septal grooves and ridges, and transverse markings consisting of numerous growth lines and low wrinkles. No such definite attachment structures as talons, rootlets, and flattenings are observed.

In transverse section, corallites are circular to somewhat elliptical. The corallite wall is variable in thickness, attaining 2.0 mm in the thickest part, dilated by lateral fusion of major and minor septa and by stereoplasmic deposits. The number of septa at a particular diameter of corallite is shown in Text-fig. 4. The septal formula (8/5, 8/5) is shown at a diameter of 14.6 mm. Major septa are more or less dilated, especially in the earlier stages, resulting in the complete filling of interseptal spaces (Pl. 8, fig. 1a-d). The five major septa are preferentially developed long and thick from the early growth stage, sometimes showing clavate to rhopaloid. The other major septa are rather differentiated in length in each quadrant and may show an alternate arrangement of long and short major septa. Major septa sometimes withdraw from the centre to produce an amplexoid appearance. The cardinal septum may later become thin and short. The slightly shortened cardinal septum in the fully grown corallite is located in a faint fossula (Pl. 8, fig. 3). The counter septum seems to be variable in length throughout ontogeny, even within a corallite. It is ordinarily as long as the other major septa or shorter than the others. Minor septa (catasepta) are mostly detectable, but sometimes completely contained in the wall and appear only as faint ridges between the majors. No tertiary septa are present. The median dark line and fibres are observable in the septa. The dark line sometimes becomes sinuous and invisible. It is interrupted to form a series of dots, when it shows the frontal zones (Pl. 6, figs. 4d, 5). The fibres are ordinarily arranged perpendicular to the lateral sides or more or less curved convex axially. They show a zigzag pattern, especially in the dilated part. Successive growth lamellae may be deposited (Pl. 6, fig. 5). One to three rows of transversely cut edges of tabulae are clearly noticed and some are arranged concentrically to laterally.

In longitudinal section, corallites are occupied by complete or incomplete



Text-fig. 4 Relationship between diameter of corallite and number of septa in *Pentaphyllum leptoconicum* (Abich).

tabulae, which moderately to steeply arch from the wall and flatten or slightly slope axially. Some tabulae are thickened by stereoplasm. Longitudinally cut septa are detectable, indicating distinct septal growth lines.

Ontogeny: At a diameter of 3.1 mm (Pl. 5, fig. 4a), the five specific major septa are fused axially. The other majors are variably developed in length. Some minor septa (catasepta) are not inserted, being entirely contained in the wall. The counter septum remains short. No tabular intercepts are present. In the next stage (Pl. 5, fig. 4b-e), the five majors are still connected axially, whereas the others are poorly developed, variable in length. Relatively long and short major septa are alternately arranged, showing an apparent radial symmetry. Major septa are not dilated, although the five septa are slightly thicker than the others. In the later stage (Pl. 5, fig. 4f-h), major septa certainly extend to the centre, but do not unite directly, leaving a free axial area. The length of major septa is irregularly differentiated, but the majors at the middle of each quadrant are longer. Some metasepta are incipient on both sides of the cardinal septum and/or counter sides of the alar septa. The axial ends of major septa are slightly sinuous. Tabulae are intercepted, sometimes showing a concentric arrangement. In the final stage (Pl. 5, fig. 4i), major septa do not retreat in an amplexoid fashion. Minor septa are present, alternating with the majors. No distinct fossula having a short cardinal se-

ptum is present.

In another corallite (Pl. 8, fig. 1a-g), major septa are so thickened as to fill interseptal spaces in the earlier stages (Pl. 8, fig. 1a-d), when the five specific major septa are longer and thicker than the others. They are axially fused and the counter septum is temporarily prolonged. Minor septa (catasepta) are observed in the wall. On further growth (Pl. 8, fig. 1e), the five major septa still remain long and thick, especially at their axial ends, whereas the others are short and much differentiated in length. Th counter septum becomes quite short between the well developed counter-lateral septa. In the subsequent stage (Pl. 8, fig. 1f), the majors are rather variable in length and are dilated along their length. Longer major septa are recognised at the middle of each quadrant. Minor septa are present as low ridges. In the final stage (Pl. 8, fig. 1g), the cardinal septum becomes slightly thin and short, lying in a faint fossula. Major septa are subequal in length to show an amplexoid morphology, although at least the four septa (two alars and two counter-laterals) are still longer. Minor septa are always discernible without being entirely contained in the wall.

Variability: Septal dilation of major septa is irregularly variable. In the earlier stages, septal thickening is ordinarily most prevalent (Pl. 8, fig. 1a-d). In the later stages, individual variation in amount and site of thickening seems rather large, although this has a close relation to the formation of tabulae and also to the ontogentic stage. When combined with the surface of tabulae, the axial ends of major septa seem to be thickened and laterally joined (Pl. 7, fig. 1i). The degree of septal dilation in a corallite is also variable from site to site. Major septa in the counter quadrants may tend to be thickened to fuse axially. This tendency is closely related to the corallite curvature which results from the change of calice direction.

The timing and degree of septal withdrawal exhibit a wide range of variability. Some major septa once become amplexoid and fuse axially again, according to the behaviour of tabulae. The length of the cardinal septum, which is longer and slightly thicker than the neighbouring majors in the earlier stages, may be slightly reduced. The length of the counter septum varies throughout ontogeny of a single corallite. Minor septa (catasepta) are rather variable in length, sometimes appearing only as low ridges between the majors. They may be completely restricted to the dilated wall.

Remarks: *Pentaphyllum leptoconicum* was established by Abich (1878), originally as *Clisiophyllum leptoconicum*. Since then, some workers have described this species from the Permian. The specimens upon which their descriptions were based seem to be corallites in various growth stages. Further, poor information concerning the type specimen makes it difficult to evaluate features characteristic of the species. The illustration presented by Abich (1878, pl. 11, fig. 7a) shows numerous major septa undifferentiated in length, although the corallite is comparatively small in diameter. These features, however, do not seem to match the generally accepted specific concept for *Pentaphyllum leptoconicum* (Abich). The con-

cept may be derived from the specimen illustrated by Arthaber (1900, p. 287, fig. 52c, d) under the name of *Zaphrentis* (?*Pentaphyllum*?) *leptoconica* (Abich). The present author thinks it better to retain Abich's specific name but reinvestigation of Abich's specimen, should be made.

Iljina (1962) placed the present species within the genus *Pleramplexus* on the ground that the species was characterised by acquiring an amplexoid feature in the mature stage. Iljina at the same time established a new species *Plerophyllum dzhulfense* from the Upper Permian (Dzhulfa Formation). The species seems to show the quite similar ontogeny to that of *Pentaphyllum leptoconicum* (Abich) and to be separable by the absence of amplexoid feature.

Weyer and Iljina (1979) admitted the amplexoid feature taxonomically valid, showing practical clues for its identification. The morphology, however, shows variable appearance from corallite to corallite and repeatedly appears throughout the corallite growth. Each corallite may assume a quite similar appearance in various growth stages. Some assessment of the taxonomical significance of the amplexoid feature is required. Comprehensive ivestigation of the morphological variability from the ecological and morphogenetical viewpoints seems to be particularly necessary.

At any rate, it is too difficult to generically separate *Pentaphyllum leptoconicum* (Abich) from the other species of *Pentaphyllum*. At present the author considers that *Pentaphyllum dzhulfense* (Iljina) is synonymous with *P. leptoconicum* (Abich).

As already mentioned, this species shows a wide range of variability in septal thickness. Although *Pentaphyllum clavatum* (Iljina) was characterised by having clavate major septa, the degree of septal dilation varies great among corallites and within a corallite. It is quite difficult to specifically discriminate the species from *P. leptoconicum* (Abich).

Kropatcheva (1983) proposed a new species *Pentaphyllum araxense* based on materials from the Upper Permian (*Araxoceras latissimum* Zone) of Nakhichevan. The species was thought to be characterised by poor development of septa in the cardinal quadrants. The feature seems to be common in the present species and investigation of its variability should be necessary. At present the author includes Kropatcheva's species in *Pentaphyllum leptoconicum* (Abich).

Iljina (1962, 1965a, 1984) especially noted the abnormal insertion of septa, violating "Kunth's rule" in some corallites. She regarded those corals as direct ancestors of the Scleractinia or a "transitional group". She therefore favours the "direct theory" in the origin of Scleractinia. However, as Ezaki (1989) pointed out, a wide range of morphological variation is produced among the Upper Permian corals without changing the mode of septal formation characteristic of the Rugosa. The peripheral parts of septa may be disrupted and dislocated to show seemingly two independent septa. Such a feature is an obviously temporary and rather accidental trait of no taxonomic importance (Ezaki, 1989).

Pentaphyllum breviseptum (Iljina, 1962)

(Pl. 9, figs. 1a-e, 2a-e, 3a-e, 4a-d)

1937 *Plerophyllum* sp.; Heritsch, p. 11, pl. 2, fig. 24.
1962 *Plerophyllum breviseptum* Iljina, p. 74, pl. 1, fig. 3a, b.
1965a *Plerophyllum breviseptum* Iljina; Iljina, p. 42, pl. 3, figs. 1a-c, 2a, b, 3a-e; text-fig. 14 : 1, 2.
1965a *Plerophyllum dzhulfense* Iljina; Iljina (*partim*), p. 47, pl. 4, figs. 7a-c, 10a-d; text-fig. 17a-t.
1965a *Plerophyllum differentiatum* Iljina; Iljina (*partim*), p. 52, pl. 5, fig. 6a, b.
1965b *Plerophyllum breviseptum* Iljina; Iljina, p. 336, pl. 12, fig. 2.
1968 *Plerophyllum* (*Plerophyllum*) ? *breviseptum* Iljina; Flügel, p. 287, pl. 25, figs. 4, 5.
1971 *Cryptophyllum* (*Cryptophyllum*) *breviseptum* (Iljina); Flügel, p. 118, pl. 7, figs. 1-8.
1973 *Ufimia* sp.; Teichert, Kummel, and Sweet, p. 395, pl. 2, figs. 3, 4, 7, 8.
1973 *Pleramplexus leptoconicus* (Abich); Teichert, Kummel, and Sweet, p. 395, pl. 2, figs. 5, 6.
1974 *Plerophyllum dzhulfense* Iljina; Iljina, p. 213, text-fig. 2 : 4a-h.
1977 *Plerophyllum dzhulfense* Iljina; Iljina, p. 80, text-figs. 1a-j, 2a-d.
1977 *Pleramplexus minimus* Iljina; Iljina, p. 81, pl. 1, fig. 3a-e; text-fig. 4a-l.
1977 *Plerophyllum breviseptum* Iljina; Iljina, p. 83, pl. 1, fig. 2a-c.
1984 *Pentaphyllum breviseptum* (Iljina); Iljina, p. 85, pl. 4, figs. 3a-c, 4, 5a-c, 6; text-figs. 4e, 9.
1984 *Pentamplexus minimus* (Iljina); Iljina (*partim*), p. 114, pl. 16, fig. 3a-e; text-figs. 8a, 45a-l.

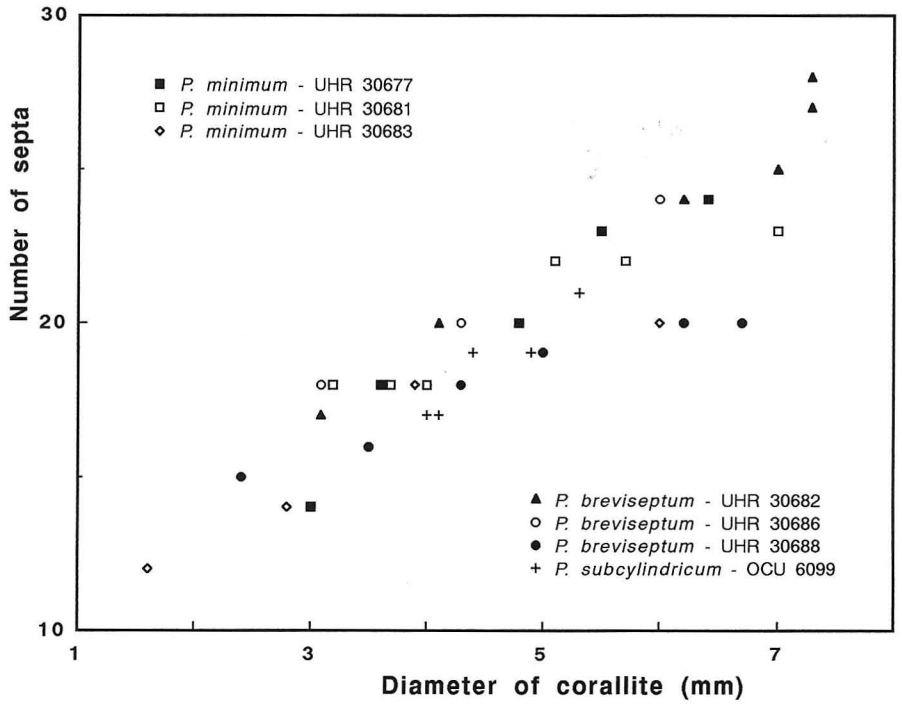
Holotype: PIN, No. 1820/525, Palaeont. Inst., USSR Acad. Sci.; left bank of the Arax River, Dorasham 2, Dzhulfa, Nakhichevan; Upper Permian, Dzhulfa Formation, lower part of the *Vedioceras* Beds.

Material studied: Fifteen specimens (UHR 30682, 30686-30688, OCU 6088-6098); lower part of the Hambast Formation (Dzhulfian), Kuh-e-Hambast, Abadeh; middle and upper parts of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone and *Haydenella-Pseudowellerella* Zone) and upper part of the Ali Bashi Formation (*Paratirolites* Zone), Kuh-e-Ali Bashi, Julfa.

Diagnosis: Comparatively small-sized *Pentaphyllum* having thick wall and prominent minor septa. Five particular major septa thin, whereas other major septa poorly developed, rather differentiated in length. Calice deep.

Description: Corallites are trochoid to erectly ceratoid, attaining 9.8 mm in length and 7.1 mm in diameter. The epitheca is marked by very fine growth lines and low wrinkles, without showing prominent longitudinal ridges and septal grooves. There are no definite attachment structures. The calice is comparatively deep.

In transverse section, corallites are almost circular. The wall is comparatively thick, attaining about 0.5 mm. Two orders of septa are visible and septal wedges can be seen in the wall (Pl. 9, fig. 4d). Septa are more or less wavy axially and slightly dilated peripherally. The number of septa at a particular diameter of corallite is shown in Text-fig. 5. The septal formula (6/5, 6/4) is shown at a diameter of 7.0 mm. The five specific majors are thin, but prominently long from the early growth stage. Their axial ends are fused in the beginning and then separate to show a slightly rhopaloid shape. The other majors are more or less reduced in length and thickness, and are quite variable in length. Major septa generally retreat from the axial region, but few specimens attain an amplexoid morphology. The cardinal septum is seldom shortened, whereas the counter septum is as long as



Text-fig. 5 Relationship between diameter of corallite and number of septa in *Pentaphyllum minimum* (Iljina), *P. breviseptum* (Iljina), and *P. subcylindricum* Schindewolf.

the others. Minor septa (catasepta) are rather prominent. Tertiary septa are not formed. Septa are fibrous in their fine skeletal structure. The median dark zone partly becomes obscure and slightly sinuous. It shows a marked twisting and is irregularly disrupted by semicircular lamellae, showing the frontal zones. Some tabular intercepts are present.

In longitudinal section, tabulae arch gently to steeply from the wall and are convex upwards. The wall is fairly thick.

Ontogeny: In the early stage (Pl. 9, figs. 1a, 3a), the five specific major septa are elongated and axially connected. The other majors are much restricted in growth to leave a wide open space. Major septa are not thickened and minor septa (catasepta) are mostly inserted. In a slightly later stage (Pl. 9, fig. 3b), a corallite reveals still axially fused major septa. Their axial ends are slightly sinuous. Another corallite shows axially free major septa, becoming rhopaloid (Pl. 9, fig. 1b, c). The other majors are restricted in growth. The wall is still dilated, showing distinct minor septa. In the mature stage (Pl. 9, figs. 1d, 3c, d), major septa ordinarily do not meet at the centre and taper. Minor septa are distinct. The wall is conspicuously thick.

Variability: The length of minor septa (catasepta) exhibits a slight range of variability among individuals and throughout ontogeny, although minor septa are

generally prominent from the earlier stages. In some sections (Pl. 9, fig. 1d, e), minor septa are quite conspicuous, like the majors. The timing of septal withdrawal from the axial region slightly varies. The difference in length of major septa is variable from corallite to corallite. Some metasepta are rather restricted in length (Pl. 9, fig. 2b, c, e). And the amount of thickening of wall seems to be variable, although the wall is generally thick.

Remarks: Teichert *et al.* (1973) described some corals from the Ali Bashi Formation under the name of *Ufimia* sp. and *Pleramplexus leptoconicus* (Abich). Each corallite has a thick wall with distinct minor septa and is transferred to *Pentaphyllum breviseptum* (Iljina). This species may be related to *Pentaphyllum leptoconicum* (Abich), but it has comparatively small corallites with prominent minor septa and a deep calice. In a growth stage (Pl. 9, fig. 4d), seemingly two independent septa occur next to each other (septal dislocation), but this is an obviously temporary trait caused by the specific behaviour of the septal pocket (Ezaki, 1989). This feature is also shown by some specimens from the uppermost Permian.

Pentaphyllum subcylindricum Schindewolf, 1942
(Pl. 9, fig. 5a-f)

1942 *Pentaphyllum* (*Pentaphyllum*) *subcylindricum* Schindewolf, p. 183, pl. 29, fig. 2a-d; text-fig. 76a-c.

Holotype: Geol. Landesmuseum, Berlin. The specimen described by Schindewolf (1942, p. 183, pl. 29, fig. 2a-d); Upper? Permian of Basleo, Timor.

Material studied: A single specimen (OCU 6099); upper part of the Julfa Formation (*Haydenella-Pseudowellerella* Zone), Kuh-e-Ali Bashi, Julfa. The corallite is entirely embedded in limestone matrix and the proximal tip is missing.

Diagnosis: Comparatively small-sized *Pentaphyllum* showing slender, cylindrical corallites with extremely thick wall. Five definite major septa thin, and other majors restricted in length. Minor septa distinct.

Description: In transverse section, the almost circular corallite has a thick wall, attaining about 0.8 mm, ordinarily dilated either by stereoplasmic deposits or by lateral fusion of septa at their bases. The number of septa at a particular diameter of corallite is shown in Text-fig. 5. The septal formula (4/4, 4/3) is shown at a diameter of 4.3 mm. The five long and slender majors are distinguished. The other major septa are weakly developed, slightly differentiated in length. The cardinal septum is long, whereas the counter septum remains short. Minor septa (catasepta) occur as low ridges. In the final growth stage (Pl. 9, fig. 5d, e), major septa taper, more thickened towards the periphery. The septal fine structure is fibrous and is characterised by rather regularly superimposed semicircular zones, particularly in the axial parts, showing the frontal zones (Pl. 9, fig. 5f). A single row of concentric tabular intersects is recognised.

Remarks: The present form is characterised by a small cylindrical corallite hav-

ing a well developed wall and fewer major septa. Unfortunately, the earlier growth stages are not known because of the scantiness of the specimen. According to Schindewolf (1942), the corallite is rather slender, subcylindrical and somewhat irregularly bent. In the comparatively early stage, the five major septa are distinguished, and show no axial connexion. *Pentaphyllum breviseptum* (Iljina) also shows a remarkable brevi-septal appearance, but *P. subcylindricum* Schindewolf clearly shows an extremely thick wall.

Pentaphyllum minimum (Iljina, 1965)
(Pl. 10, figs. 1a-f, 2a-g, 3a, b, 4a-f)

1937 *Plerophyllum* sp.; Heritsch, p. 11, pl. 2, figs. 25, 26.
1965a *Pleramplexus leptoconicus* (Abich); Iljina (*partim*), p. 60, pl. 14, fig. 6a-d.
1965a *Pleramplexus minimus* Iljina, p. 69, pl. 14, figs. 8a-f, 9, 10a, b, 11a, b, 12; pl. 15, figs. 1a-e, 2a, b; text-fig. 29 : 1a, b, 2.
1965b *Pleramplexus minimus* Iljina; Iljina, p. 334, pl. 11, fig. 4.
1968 *Pleramplexus minimus* Iljina; Flügel, p. 291, text-figs. 6 : 1-10, 7 : 1-6.
1968 *Pleramplexus minimus* Iljina?; Flügel, p. 293, text-fig. 8 : 1-5.
1968 *Pentamplexus*? sp.; Flügel, p. 298, text-fig. 10 : 1-10.
1974 *Pleramplexus leptoconicus* (Abich); Iljina, p. 213, text-fig. 2 : 3a-d.
non 1977 *Pleramplexus minimus* Iljina; Iljina, p. 81, pl. 1, fig. 3a-e, text-fig. 4a-l.
1984 *Pentamplexus minimus* (Iljina); Iljina (*partim*), p. 114, pl. 16, figs. 2, 4a-c; text-figs. 2g-i, 8b.
1989 *Pentaphyllum* sp. A; Ezaki, p. 277, fig. 2D-I.
1989 *Pentaphyllum minimum* (Iljina); Ezaki, p. 280, fig. 4A-H.

Holotype: PIN, No. 1820/1403, Palaeont. Inst., USSR Acad. Sci.; left bank of the Arax River, Dorasham 2, Dzhulfa, Nakhichevan; Upper Permian, Dorasham Formation, *Tompophiceras* to *Bernhardites* Beds.

Material studied: Twenty-three specimens (UHR 30677, 30680, 30681, 30683-30685, OCU 6100-6116); lower part of the Hambast Formation (*Araxoceras tectum* Subzone), Kuh-e-Hambast, Abadeh; middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa.

Diagnosis: Comparatively small-sized *Pentaphyllum* having very short or rudimentary minor septa and comparatively thin wall.

Description: Corallites are small and slightly curved ceratoid to cylindrical, having an average length of 13.6 mm. The exterior is marked by faint low ridges and shallow septal grooves that are crossed by fine growth lines and low wrinkles. Specific attachment scars are not observed.

In transverse section, corallites are generally small, ranging from 4.0 to 9.1 mm in diameter. The wall is comparatively thin, consisting of short fibres that are perpendicular to the epitheca. Major septa are generally thin and slightly sinuous. The number of septa at a particular diameter of corallite is shown in Text-fig. 5. The septal formula (5/4, 5/4) is shown at a diameter of 5.7 mm. The five specific major septa are thickened in the earlier stages, and are axially fused (Pl. 10, fig. 2a-d). The other majors are more or less differentiated in length. The cardinal

septum remains long and thick even at maturity. The counter septum is variable in length. Major septa sometimes become amplexoid. Minor septa (catasepta) are very short or rudimentary when present. They may be entirely contained in the wall. The fine structure of septa is fibrous. The dark zone is sometimes tortuous and discontinuous by the presence of successively arranged semicircular zones, especially in the axial portions, where they show the frontal zones. Transversely cut edges of tabulae are sparse and consist of a dark line and outwardly directed fibres.

In longitudinal section, tabulae rise steeply from the wall and slightly sag axially. The tabular floors are generally tall.

Ontogeny: In the earlier stage (Pl. 10, fig. 2a), the five major septa are prominent and fused axially. Some dark lines are directly continuous. The other major septa and minor septa (catasepta) are barely inserted. The counter septum is not developed. In this stage, septa and wall are rather dilated. Septal wedges are distinct in the wall. In the succeeding section (Pl. 10, fig. 2b), major septa except for the five definite majors are quite restricted in length. Septa and wall remain thick. Later, the five majors are still axially connected, but their dark lines are ordinarily not confluent (Pl. 10, fig. 2c, d). The other majors are poorly developed, appearing only as low ridges. Minor septa are rudimentary. Tabulae are partly intercepted. During further growth (Pl. 10, fig. 2e, f), the axial ends of major septa start retreating to become axially free, although some are connected by the cut edges of tabulae. The other majors are thin and irregularly differentiated in length. They may show an alternate arrangement of relatively long and short major septa. Minor septa are present only as low ridges. The wall is particularly thin, about 0.1 mm in thickness. In the last stage (Pl. 10, fig. 2g), major septa are not so distinctly shortened, leaving a free axial area as wide as that in the preceding stage. Rejuvenescence is recognised.

Variability: The degree of septal and wall dilation varies slightly among corallites and throughout growth. Major septa are slightly dilated in the earlier stages, and when coupled with the top of tabulae. "Amplexoid retreat" of major septa appears repeatedly throughout the corallite growth. Variation in length of the counter septum is remarkable. In a certain corallite (Pl. 10, fig. 1a), the septum is almost absent for a while, and then prolonged to be axially connected to the counter-lateral septa (Pl. 10, fig. 1b). The septum may be kept short throughout ontogeny. Quite short minor septa (catasepta) are ordinarily observable, but some minors are absent, temporarily obscured in the wall.

Remarks: The specific name was proposed by Iljina (1965a) on specimens from the Upper Permian (*Tompophiceras* to *Bernhardites* Beds). Iljina considered that the species might be distinguished by a dwarfed form of *Pleramplexus leptoconicus* (Abich). Detailed knowledge of ontogeny and intraspecific variability shows that the species is well founded, characterised by small corallites with rudimentary minor septa and a comparatively thin wall. Those features may indicate a paedomorphic nature of progenetic origin. The present species is closely allied to

Pentaphyllum leptoconicum (Abich), but it is separable in having quite small corallites with rudimentary minor septa and a comparatively thin wall. The species is similar to *Pentaphyllum breviseptum* (Iljina), but it is distinguished in having a thin wall and rudimentary minor septa. Some specimens show septal dislocation, but the feature itself is of no taxonomic significance.

Pentaphyllum sp.
(Pl. 10, fig. 5a-d)

Material studied: A single corallite (OCU 6117); uppermost part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. The apical part is missing.

Description: In transverse section, the corallite is circular. The wall is characteristically thin. Major septa are comparatively thin, having 22 in number (5/4, 5/4) in the mature corallite. The five definite major septa are discernible in being slightly longer and thicker than the others. Major septa withdraw from the centre to leave a wide open space (Pl. 10, fig. 5a). Some axial ends of major septa are then temporarily in contact with each other, sometimes fusing in several bundles (Pl. 10, fig. 5b). Major septa are slightly rhopaloid, without being connected to each other (Pl. 10, fig. 5c). The counter septum is variable in length. Major septa situated immediately on the counter sides of two alar septa may be short. Minor septa (catasepta) are completely invisible, even in the microstructure of the wall, or are rudimentary when present. Septa show a median dark zone and fibrous parts. The former is partly tortuous and discontinuous to form the frontal zones. A few transverse intercepts of tabulae are observed.

Remarks: Although this form cannot be fully evaluated because of the scantiness of the material, it seems to be characterised by having thin and slightly differentiated major septa in length. The thin wall having quite rudimentary minor septa is also characteristic. The present species is similar to *Pentaphyllum antractum* (Iljina), but it is clearly separable from the latter in having a thin wall and rudimentary minor septa.

Genus *Ufimia* Stuckenberg, 1895

Type species: *Ufimia carbonaria* Stuckenberg, 1895.

Ufimia carbonaria Stuckenberg, 1895
(Pl. 11, figs. 1a-g, 2a-f, 3a, b, 4a, b, 5)

1895 *Ufimia carbonaria* Stuckenberg, p. 27, pl. 2, figs. 2a-d, 3; pl. 3, fig. 3.
1973 *Ufimia carbonaria* Stuckenberg; Fedorowski, p. 111, text-fig. 11: 1a, b, 2, 3.
1984 *Ufimia carbonaria* Stuckenberg; Iljina, p. 104, pl. 11, figs. 4a-d, 5; pl 13, figs. 1, 2a-c, 3a, b, 4; text-fig. 40a-d.
1984 *Ufimia carbonaria* Stuckenberg; Ivanovsky, p. 15, pl. 12, fig. 4.
1987 *Ufimia carbonaria* Stuckenberg; Ivanovsky, p. 13, pl. 6, fig. 1.

Lectotype: LGI, No. 21/45, Museum of the Leningrad Mining Inst.; Urals; Lower Permian (Artinskian).

Material studied: Forty-five specimens (OCU 6118-6162); basal part of Unit 4 of the Abadeh Formation, Kuh-e-Hambast, Abadeh. Most corallites are fragmentary, showing no apical ends and are partly silicified. The external surface is more or less abraded to show peripheral edges of septa.

Description: In transverse section, corallites are almost circular to somewhat elliptical. The wall is slightly dilated, where septa may be laterally fused. Wall thickness varies considerably, attaining about 0.9 mm in the thickest part. Major septa are fused axially in several bundles, showing the irregularly "zaphrentoid" pattern in the earlier stages (Pl. 11, fig. 1a, b). The number of septa is 26 (7/4, 7/4) at a diameter of 7.4 mm. The four specific major septa (two alar and two counter-lateral septa) are preferentially long and thick from the early ontogeny. The other major septa are somewhat differentiated in length. The cardinal septum remains long in the beginning and becomes short to form a fossula towards the mature stage. Minor septa (catasepta) are variable in length between the majors. Septa sometimes appear distinctly cuneiform, providing a conspicuous septotheca at the periphery. Septa are composed of a median dark zone and perpendicularly arranged fibres. Their axial parts sometimes show the frontal zones and are covered with successive growth lamellae. Transversely cut edges of tabulae are recognised concentrically and laterally. Tabulae may lean on the quite shortened cardinal septum (Pl. 11, fig. 1e-g).

In longitudinal section, tabulae are complete or incomplete. They arch moderately to steeply from the wall and are slightly sloping axially.

Ontogeny: In the earliest section (Pl. 11, fig. 2a), major septa are so thickened as to fill interseptal spaces. They are axially connected and/or contratingent on the adjacent septa. In the subsequent sections (Pl. 11, fig. 2b, c), some major septa still show the contratingency and the axial fusion, whereas the other majors are temporarily restricted in growth. The counter septum is shorter than the others. In the later stage (Pl. 11, fig. 2d), the four specific major septa do not meet at the centre and are generally uniformly thickened. The other major septa are not prominently differentiated in length. Minor septa (catasepta) are only rudimentary or appear as slight projections. The wall is thickened either by stereoplasmic deposits or by lateral fusion of septa at the periphery. Tabulae are intercepted concentrically in one to three rows. In the final stage (Pl. 11, fig. 2e, f), the cardinal septum is shortened, while the four definite majors are still thicker and longer. They are axially dilated and rhopaloid. The other majors are variable in length and taper. Minor septa are conspicuous between the majors.

Variability: Morphological variation is comparatively large among individuals and throughout ontogeny. The timing and degree of the shortening of the cardinal septum may vary to some extent. It also depends on the ontogenetic stage, but at any rate, the septum becomes short in the adult stage. The minors become con-

spicuous in the later stages. Major septa show rather variable septal patterns, ordinarily "zaphrentoid", especially in the earlier stages. The corallite wall is variably dilated either by lateral fusion of septa or by stereoplasmic deposits.

Remarks: The species shows comparatively long minor septa in the later stages. This Iranian *Ufimia* is similar to *U. lopingensis* (Grabau) in having fewer major septa with a rhopaloid shape, but the former has a thicker wall and longer minor septa. The present species resembles *"Plerophyllum" xintanense* described by Xu (1984b) from the Upper Permian of South China (Wuchiapingian), but it is separable from the latter in having a thick wall.

Ufimia differentiata (Iljina, 1962)
(Pl. 12, fig. 1a-f)

1962 *Plerophyllum dzhulfense differentiatum* Iljina, p. 77, pl. 2, fig. 1a, b.
1962 *Plerophyllum armenicum* Iljina, p. 79, pl. 2, fig. 2.
1965a *Plerophyllum differentiatum* Iljina; Iljina (*partim*), p. 52, pl. 6, figs. 1a-e, 6a-f; pl. 7, figs. 6a, b, 9, 10a, b; pl. 8, fig. 1a-c; text-fig. 20: 1, 2.
1965a *Plerophyllum armenicum* Iljina; Iljina, p. 56, pl. 8, fig. 5a, b; pl. 9, figs. 1a-d, 2, 3a, b, 4, 5a-e, 6a, b; text-fig. 21.
1965b *Plerophyllum armenicum* Iljina; Iljina, p. 336, pl. 12, fig. 3.
1965b *Plerophyllum differentiatum* Iljina; Iljina, p. 336, pl. 12, fig. 4.
1971 *Plerophyllum* (*Ufimia*) *iljinae* Flügel, p. 113, pl. 1, fig. A1-10.
1971 *Plerophyllum* (*Ufimia*) *stepanovi* Flügel, p. 114, pl. 3, figs. 1-20; pl. 4, figs. 1-18.
1971 *Plerophyllum* (*Ufimia*) *variabile* Flügel, p. 115, pl. 1, fig. B1-7.
1983 *Ufimia iljinae* (Flügel); Kropatcheva, p. 183, pl. 12, figs. 3a-c, 4a, b, 5a, b, 7.
1983 *Ufimia stepanovi* (Flügel); Kropatcheva, p. 183, pl. 12, fig. 6a-d.
1984 *Pentaphyllum armenicum* (Iljina); Iljina, p. 98, text-fig. 38c, d.
1984 *Pentaphyllum differentiatum* (Iljina); Iljina (*partim*), p. 99, text-figs. 18f, 39a-f.

Holotype: PIN, No. 1820/956, Palaeont. Inst., USSR Acad. Sci.; left bank of the Arax River, Dorasham 2, Dzhulfa, Nakhichevan; Upper Permian, Dorasham Formation, *Paratirolites* Beds.

Material studied: Three specimens (OCU 6163-6165); middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa.

Description: Corallites are slightly curved ceratoid to cylindrical, attaining a length of 22.7 mm and a diameter of 9.3 mm. The exterior is marked by prominent interseptal ridges and septal grooves, and by faint transverse growth lines and wrinkles.

In transverse section, corallites are circular and moderate-sized. The wall is more or less dilated by stereoplasmic deposits, attaining 0.7 mm in thickness. Septa number 24 (6/4, 6/4) at a diameter of 8.5 mm. Major septa are slightly thick, axially twisted and fused, especially in the earlier stages. The majors are more or less rhopaloid, with the exception of some shorter major septa, and may be axially carinated. The four definite major septa are slightly longer and thicker. The other majors are rather restricted in length, and relatively long and short majors are alternately arranged. The majors at the middle of each quadrant are

generally longer. The cardinal septum is elongated to fuse axially with some majors in the earlier stages (Pl. 12, fig. 1a, b). It distinctly withdraws from the centre to attain about two-fifths of the corallite radius in the later growth stages (Pl. 12, fig. 1e). The counter septum shows no remarkable shortening. Minor septa (catasepta) are detectable at least as low ridges and become more conspicuous as the corallite grows. Septa are composed of a median dark zone and fibres. The dark line may be slightly twisted and interrupted by successively superimposed semicircular zones. They form the frontal zones, particularly in the slender septa as well as in the axial portions of septa. Distinct growth lamellae may be observed in the dilated part. Some transversely cut edges of tabulae are recognised, sometimes dilated towards the periphery.

In longitudinal section, tabulae rise moderately from the wall and are convex upwards. The wall is comparatively thick.

Remarks: Weyer and Iljina (1979) placed *"Plerophyllum" differentiatum* Iljina within the genus *Ufimia* on the ground that some specimens illustrated by Iljina (1965a) reveal a short cardinal septum. The present author recognises that some corallites, including the holotype, actually show the short cardinal septum and should be transferred to *Ufimia*.

Iljina (1962) proposed a new species *Plerophyllum armenicum* characterised by showing axially dilated major septa and long minor septa. Those features are, however, variable among corallites and throughout growth. Flügel (1971) proposed three new species *Plerophyllum* (*Ufimia*) *iljinae*, *P.* (*U.*) *stepanovi*, and *P.* (*U.*) *variabile* based on specimens from the Upper Permian of Julfa. Flügel considered the length of metasepta in the specific sites and the degree of septal thickening to be valid for taxonomy. However, as repeatedly mentioned, they often vary great from corallite to corallite and throughout ontogeny. The present species is similar to *Pentaphyllum leptoconicum* (Abich), but the former shows the rather shortened cardinal septum in the mature stage.

Ufimia elongata (Grabau, 1922)

(Pl. 12, figs. 2, 3a-d, 4a, b)

1922 *Tachylasma elongata* Grabau, p. 37, pl. 1, fig. 13a-c.
1928 *Tachylasma elongatum* Grabau; Grabau, p. 69, pl. 1, fig. 13a, b.
1932 *Tachylasma elongatum* Grabau; Huang, p. 18, pl. 1, figs. 3-5.
1953a *Tachylasma elongatum* Grabau; Fomichev, p. 93, pl. 3, figs. 1a-d, 2, 3a, b, 4a-c, 5, 6.
1963 *Tachylasma elongatum* Grabau; Yü *et al.*, p. 21, pl. 8, fig. 3a-c.
1965a *Ufimia elongata* (Grabau); Iljina, p. 72, pl. 15, figs. 3a-e, 4a-c, 5, 6a, b; text-figs. 30, 31.
1965b *Ufimia elongata* (Grabau); Iljina, p. 338, pl. 13, fig. 6.
?1979 *Tachylasma elongatum* Grabau; Li and Liao, p. 19, pl. 20, fig. 16.
1982 *Tachylasma elongatum* Grabau; Zhu *et al.*, p. 114, pl. 32, fig. 6.
1983 *Tachylasma elongatum* Grabau; Cao *et al.*, p. 53, pl. 18, fig. 9a, b.
1984 *Ufimia elongata* (Grabau); Iljina, p. 111, text-fig. 43a-c.
1984a *Tachylasma elongatum* Grabau; Xu, p. 617, pl. 1, fig. 6a, b.
1984b *Tachylasma elongatum* Grabau; Xu, p. 178, pl. 17, fig. 6a, b.

Holotype: Cat. No. 154, Geol. Surv. China; Middle Permian at Fengcheng in Kiangsi Province.

Material studied: Forty-three corallites (OCU 6166-6208); upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. Most specimens are fragmentary. Their external surfaces are more or less abraded and the proximal parts are missing.

Description: This species comprises moderate-sized ceratoid to cylindrical corallites that reach a diameter of 11.8 mm in an observed length of 30.4 mm. The exterior bears longitudinal septal grooves and interseptal ridges and transverse markings consisting of fine growth lines and low wrinkles.

In transverse section, the wall is generally thin. Major septa are in weakly bilateral arrangement. Bilaterality may be shown by the four prolonged major septa and the quite shortened cardinal septum. As many as 28 septa (7/5, 7/5) are present at a diameter of 9.1 mm. Some major septa may be more or less sinuous, sometimes slightly curved towards the counter direction, and rhopaloid. The four specific major septa are longer and thicker than the others. The other majors are rather variable in length, even within a corallite. The cardinal septum becomes distinctly short to form a fossula. The counter septum remains nearly equal in length to the others or is slightly shorter. Minor septa (catasepta) are ordinarily short and appear as low ridges between major septa. The septal fine structure is completely obscured. Tabular intercepts are concentrically arranged between the majors in one to three rows. They may lean on the short cardinal septum.

In longitudinal section, the tabular floors are more or less domed, sometimes with a gentle axial depression. Tabulae rise gently to steeply from the wall. Vertically cut septa may be visible, showing septal growth lines.

Remarks: Thickening of the axial ends and differentiation in length of major septa are variable from corallite to corallite. Major septa vary in septal arrangement, bilaterally to almost radially, throughout ontogeny. The Iranian species is identical with the specimens described by Iljina (1965a) under the name of *Ufimia elongata* (Grabau). This species is comparable to *Ufimia exceptata* (Soshkina), but it is distinguishable from the latter in having larger corallites with more numerous major septa.

Ufimia sp. aff. *U. vanganensis* (Fomichev, 1953)

(Pl. 13, figs. 1a-h, 2a, b)

Compare:

1953b *Tachylasma vanganense* Fomichev, p. 17, pl. 1, fig. 3a-c; pl. 2, figs. 1, 2.

1984 *Ufimia vanganensis* (Fomichev); Iljina, p. 109, pl. 13, fig. 5a, b; pl. 15, figs. 1a-e, 2, 3a-c; pl. 31, fig. 1a-d, pl. 32, fig. 2a, b; text-fig. 13a, b.

Material studied: Seven spcimens (OCU 6209-6215); upper part of Unit 1 of the

Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. The specimens are fragmentary.

Description: In transverse section, corallites are comparatively large, attaining about 19.8 mm in diameter in the mature stage. The wall is thick, attaining about 1.9 mm in the thickest part. As many as 35 septa (9/6, 10/6) are present. In a certain growth stage (Pl. 13, fig. 1a-c), major septa are rather dilated axially to be laterally joined to each other. They are curved convex to the cardinal septum, especially in the cardinal quadrants. By alternation of relatively long and short major septa, the shorter septa are apt to be taken for minor septa. The cardinal septum is very short, forming a fossula. The counter septum is not long. In the later stage (Pl. 13, fig. 1d), major septa are reduced in thickness to be axially free and ordinarily rhopaloid. The majors at the middle of each quadrant may be longer. As the corallite grows, minor septa (catasepta) appear as low ridges and they form a distinct septotheca accompanied by the peripheral parts of the majors (Pl. 13, fig. e). In the final growth stage (Pl. 13, fig. 1f, g), septa are wedge-shaped at the periphery and contiguously arranged. Major septa are axially flexuose and taper. Septa are composed of a median dark line and almost perpendicularly arranged fibres. The dark line is irregularly sinuous and disrupted (Pl. 13, fig. 1h). Tabulae are intercepted in some rows between the majors.

In longitudinal section, tabulae are complete or incomplete. They rise gently to steeply from the wall and slightly sag axially.

Remarks: The present species is characteristic in having relatively large corallites in which major septa are so dilated axially as to be laterally connected. The majors are curved convex to the cardinal septum and are differentiated in length. The cardinal septum is extremely short, and minor septa become distinct in the relatively late stages, forming a distinct septotheca at the periphery. This species resembles *Ufimia vanganensis* (Fomichev), but the former shows the shorter counter septum and more numerous major septa in the cardinal quadrants. Although these features may be variable among corallites and also throughout ontogeny, the intraspecific variability is not known because of the scantiness of the material. This Iranian species is similar to *Ufimia differentiata* (Iljina), but it differs in having a very short cardinal septum and rudimentary minor septa in the pre-mature stages.

Genus *Praetachylasma* Shi, 1982

Type Species: *Tachylasma* (*Praetachylasma*) *kwangchiense* Shi, 1982.

Remarks: Shi (1982) proposed the subgenus *Praetachylasma* based on the new species *Tachylasma* (*Praetachylasma*) *kwangchiense* from the Middle Permian of South China (Maokouan). He distinguished the subgenus from *Tachylasma* (*Tachylasma*) in having longer minor septa and pinnately arranged septa. Although the four specific major septa (two alars and two counter-laterals) are characteristically as long as those of *Ufimia*, such features as pinnately to allotropiophylloidly arranged septa and fairly long minor septa appear to be adequate for a generic

distinction from *Ufimia*.

Praetachylasma alternatum (Huang, 1932)
(Pl. 12, fig. 5a-c)

1932 *Tachylasma alternatum* Huang, p. 20, pl. 1, fig. 6a, b.
1963 *Duplophyllum alternatum* (Huang) ; Yü *et al.*, p. 11, pl. 5, fig. 8a, b.
1965a *Ufimia alternata* (Huang) ; Iljina, p. 74, pl. 15, figs. 7a, b, 8 ; pl. 16, figs. 1a-e, 2a-c, 3, 4a, b.
1965b *Ufimia alternata* (Huang) ; Iljina, p. 338, pl. 13, fig. 5.
1974 *Tachylasma alternatum* Huang ; Wu and Wang, p. 298, pl. 155, fig. 6.
1984 *Ufimia alternata* (Huang) ; Iljina, p. 111, text-fig. 43d-f.
1989 *Ufimia alternata* (Huang) ; Kropatcheva, p. 157, pl. 13, fig. 5.

Holotype : Cat. No. 3826, Geol. Surv. China ; Liangshan, Hanchung, southern Shensi ; Chihsia Limestone.

Material studied : A single specimen (OCU 6216) ; upper part of the Surmaq Formation (Unit 3), Kuh-e-Hambast, Abadeh. The sample is rather fragmentary with no proximal part and is more or less silicified.

Description : In transverse section, the corallite attains 11.0 mm in short diameter. It is somewhat elliptical owing to the erosion of the peripheral parts. The wall is thin. Two orders of septa are thin. The number of septa is 31 (9/4, 10/4) in the mature stage. Major septa in the cardinal quadrants are slightly curved towards the counter direction, convex to the cardinal, and are axially fused. They are contratingent on the neighbouring majors (Pl. 12, fig. 5b). The majors show a somewhat allotropiophylloid arrangement, especially in the later stage (Pl. 12, fig. 5c), and the septal acceleration in the counter quadrants. The cardinal septum becomes short, whereas the counter septum is as long as the others. The two alars and two counter-laterals are still longer and thicker than the remaining majors. Minor septa (catasepta) attain about one-fifth to three-fifths of the length of the majors. The minors are more or less sinuous and often contratingent on the adjacent majors. The fossula is created by the pinnate arrangement of septa and by the shortened cardinal septum. The fine structure of septa is obscured. Transversely cut edges of tabulae are arranged concentrically and laterally.

Remarks : The present species is peculiar in having numerous thin major septa and relatively long minor septa, often contratingent on the adjacent septa. Further, major septa reveal a somewhat bilateral symmetry in pinnate to allotropiophylloid arrangement, accentuated by the four definite majors and the shortened cardinal septum. The Iranian form is conspecific with Iljina's specimens (Iljina, 1965a, pl. 15, figs. 7, 8 ; pl. 16, figs. 1-4) from the Gnishik horizon, which show a marked ontogenetic change in septal arrangement. A kind of allotropiophylloid arrangement is formed in the mature stage by the eccentrically conjoined axial ends of septa. The type specimen designated by Huang (1932) does not show that kind of appearance, because it is still in the pre-mature stage.

Family Lophophyllidiidae Moore and Jeffords, 1945
Genus *Lophocarinophyllum* Grabau, 1922
Type species: *Lophophyllum* (*Lophocarinophyllum*) *acanthiseptatum* Grabau, 1922.

Lophocarinophyllum lophophyllidum Liao and Xu, 1977
(Pl. 14, figs. 1a, b, 2-4, 5a-d)

1977 *Lophocarinophyllum lophophyllidum* Liao and Xu, p. 126, pl. 43, fig. 5a, b.
1982 *Lophotabularia lophophyllidum* (Liao and Xu); Shi, p. 257, text-fig. 4c, d.
1983 *Lophotabularia lophophyllidum* (Liao and Xu); Yü *et al.*, p. 68, pl. 1, fig. 10a, b.
1984a *Lophocarinophyllum lophophyllidum* Liao and Xu; Xu, p. 617, pl. 1, fig. 12a, b.
1984b *Lophocarinophyllum lophophyllidum* Liao and Xu; Xu, p. 185, pl. 18, fig. 14a-f.

Holotype: IV 38515, Hubei Inst. Geol. Sci.; Hubei Province; Wuchiapingian.

Material studied: Fourteen specimens (OCU 6217-6230); upper part of Unit 1 (*Neoschwagerina margaritae* Zone) and Unit 3 (*Orientoschwagerina abichi* Zone) of the Surmaq Formation, Kuh-e-Hambast, Abadeh; upper part of the Gnishik Formation, Kuh-e-Ali Bashi, Julfa. The external surface is abraded. Specimens are much silicified.

Description: Corallites are conico-cylindrical and slightly curved, having an observed length of 15.8 mm. The exterior is marked by faint low ridges and shallow septal grooves.

In transverse section, corallites are circular. The wall is comparatively thick, attaining about 0.9 mm in thickness. Major septa are slightly flexuose and radially disposed. The number of major septa is 18 to 22 at a diameter of 5.0 to 8.0 mm. Major septa extend to the outer margin of the axial column and some majors protrude into it in the earlier stages. In the subsequent stages, the axial ends of major septa become free from the column, showing a rhopaloid shape. As the corallite grows, their rhopaloid nature is weakened. The counter septum is prolonged axially to form a conspicuous column, whereas the cardinal septum becomes thin and short to form a weak fossula in the late growth stages. Carinae are ordinarily formed to various degrees on the sides of septa, and are sometimes attached directly to the wall. They are forked to hook-like in transverse section (Pl. 14, figs. 1b, 2, 4, 5b). Septa are fibrous, and the fibres are projected almost perpendicularly to diagonally in the direction of the corallite axis from a median dark zone. The dark zone is ordinarily twisted and interrupted to form the frontal zones. Minor septa (catasepta) are quite prominent between the majors and attain about one-fifth to three-fifths of the length of the majors. The peripheral parts of both major and minor septa are dilatd and contiguous to form a prominent septotheca. The axial structure is comparatively large and attains 2.2 mm in diameter, occupying one-fourth to one-third of that of corallite. It is formed by the dilated counter septum having some radiating and sinuous septal lamellae. The structure is rather simple in the earlier stages (Pl. 14, figs. 1a, 5a, b).

In longitudinal section, tabulae are complete and more or less arch. Carinae

are slightly inclined axially. The wall is comparatively thick.

Remarks: The present species is identical with *Lophocarinophyllum lophophyllidum* Liao and Xu in having a well constructed axial structure and distinct carinae. The Iranian specimens resemble *Lophophyllidium cambodgense fontainei* Flügel in having a similarly formed axial structure and rhopaloid major septa. The former is, however, distinguishable from the latter by the smaller corallites showing a prominent septotheca and distinct carinae. The form is akin to *Lophocarinophyllum acanthiseptatum* Grabau in showing prominent carinae and a thick septotheca, but it differs in having smaller corallites and a well developed axial structure.

Lophocarinophyllum sp.
(Pl. 14, figs. 6a-f, 7a, b)

Material studied: Six specimens (OCU 6231-6236); upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone) and lower part of the Hambast Formation (Dzhulfian), Kuh-e-Hambast, Abadeh. Specimens are rather fragmentary.

Description: The corallite is erectly cylindrical. The exterior is marked by slight septal grooves and interseptal ridges.

In transverse section, corallites are ovate to circular. The wall is comparatively thin and septa are embayed into it. Major septa are sinuous and their axial ends are in contact with each other, grouped in several bundles. As many as 17 major septa are present at a corallite diameter of 4.8 mm. Septa are tortuous and carinated with a hook-like to forked appearance. At the periphery, the carinae may be projected directly from the wall. The cardinal septum is shorter than the other majors in the later stages (Pl. 14, fig. 7b). The elongated and thickened counter septum is axially swollen, forming a simple axial structure. It is rather simple in the beginning (Pl. 14, fig. 6a, b). Later, the structure attains about 1.0 mm in diameter, by the addition of septal lamellae. Minor septa (catasepta) may be entirely confined to the wall in the earlier growth stages, and generally one-fifth to one-third of the length of the majors. Fine fibres are perpendicularly arranged from a median dark zone. The line is irregularly undulating and disrupted. The cardinal fossula is weakly formed.

Remarks: The specimens resemble "*Asserculinia*" *fusiformis* Zhao and "*A*". *scutulatiaxis* Zhao from the Middle Permian of South China in having small corallites, a simple axial structure, and carinated septa. Precise specific identification is, however, postponed, because no illustrations of the early ontogeny of the Chinese species were prepared. The Iranian species is akin to *Lophocarinophyllum chandalasicum* Iljina, but it is separable from the latter in showing smaller corallites and a thinner wall. The species is similar to *Lophocarinophyllum minutum* Fomichev, but it is distinguishable from the latter in having a larger axial structure and longer minor septa.

Family Asserculiniidae Fedorowski, 1986
Genus *Asserculinia* Schouppé and Stacul, 1959
Type species: *Asserculinia prima* Schouppé and Stacul, 1959.

Asserculinia sp.
(Pl. 12, fig. 6)

Material studied: A single specimen (OCU 6237); upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. The material is fragmentary, embedded in limestone matrix.

Description: In transverse section, the corallite is relatively small and somewhat elliptical. The corallite wall, 0.8 to 1.0 mm thick, is formed by irregularly zigzag to sinuous fibres. As many as 14 major septa appear in a corallite measuring 5.5 mm in diameter. They are more or less flexuose and axially connected to the columella-like structure. The counter septum is distinguished by being rather thickened and prolonged axially. Each major septum is more dilated near the periphery and shows a cuneiform appearance. "Minor septa" are seemingly variable in length. They may be projected from the bases of major septa and extended to be contratingent on the neighbouring majors. Some are minor septa-like peripheral carinae of Fedorowski (1986) and transversely cut edges of tabulae. The median dark zone and perpendicularly arranged fibres are observed in the septa. The dark part is sometimes spotted to show the frontal zones. The axial structure is formed by the axial elongation and slight dilation of the counter septum, about 0.3 mm in the thickest part.

Remarks: The present form is peculiar in having a much thickened wall and an axial structure formed by the axial elongation of the dilated counter septum. This Iranian specimen is akin to the type species of the genus, *Asserculinia prima,* originally described by Schouppé and Stacul (1959) and thoroughly reinvestigated by Fedorowski (1986). However, the former has distinctly fewer major septa having weakly developed carinae. This Iranian species is similar to *Asserculinia transcarinata* reported by Zhao and Wu (1986) from the lower Upper Permian of Xizang, but it is separable from the latter in having a much thicker wall provided with fewer major septa and a poorly constructed axial structure.

Family Polycoeliidae Fromentel, 1861
Genus *Calophyllum* Dana, 1846
Type species: *Calophyllum donatianum* (King, 1850) (=*Turbinolia donatiana* King, 1848).

Calophyllum sp.
(Pl. 12, fig. 7)

Material studied: A single specimen (OCU 6238); uppermost part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. The specimen is fragmentary.

Description: In transverse section, the corallite attains about 7.0 mm in diameter. The wall is relatively thin, measuring 0.2 mm in thickness. The number of septa is as many as 20 (4/4, 4/4) in a corallite of 6.0 mm in diameter. Major septa are almost straight and taper. The four protosepta are preferentially prolonged and thickened. The other majors are of subequal length in each quadrant. Minor septa are not recognised, entirely confined to the wall. A few cut edges of tabulae are sporadically present. The fine structure of septa is obscured.

Remarks: This specimen shows the corallite in the comparatively late growth stage and may not reveal characteristic features of the species. Similar appearance is to be assumed independently among different species. The specimen is somewhat comparable to *Calophyllum tenue brevis* described by Flügel (1972) from the lower Jamal Formation of eastern Iran. However, the present specimen is not assignable to that species, because of little available information for comparison and identification.

Family Yatsengiidae Hill, 1956

Genus *Yatsengia* Huang, 1932

Type species: *Yatsengia asiatica* Huang, 1932.

Yatsengia hangchowensis Huang, 1932

(Pl. 15, fig. 1a, b)

1932 *Yatsengia hangchowensis* Huang in Yoh and Huang, p. 32, pl. 9, fig. 3a-c.
1963 *Corwenia* (*Yatsengia*) *hangchowensis* (Huang); Yü *et al.*, p. 115, pl. 31, fig. 6a, b.
1964 *Yatsengia hangchowensis* Huang; Gräf, p. 390.
1972 *Yatsengia hangchowensis* Huang; Flügel, p. 83, pl. 3, fig. 3.
1981 *Yatsengia hangchowensis* Huang; Yü, Lin, and Huang, p. 278, pl. 2, fig. 3a, b.
1982 *Yatsengia hangchowensis* Huang; Zhu *et al.*, p. 149, pl. 49, fig. 4a, b.

Holotype: Cat. No. 3935, Geol. Surv. China; Chiu-yao-shan, Hangchow, Chekiang; Feilaifeng Limestone.

Material studied: Two coralla (OCU 6239, 6240); upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. They are rather poorly preserved.

Description: The corallum is compound, fasciculate and somewhat dendritic. Corallites are in contact with each other.

In transverse section, corallites are circular to elliptical, ranging from 4.8 to 6.7 mm in diameter. Corallite walls are conspicuously thin. Two orders of septa, alternating with each other, are rather radially arranged. The peripheral parts of septa abut on or are embayed into the wall. There are about 16 major septa in a corallite of 6.0 mm in diameter. Major septa are more or less sinuous and ordinar-

ily touch the axial column, sometimes intruding into it. Minor septa are rather variable in length, attaining about one-fifth to one-third of the length of the majors. The fine structure of septa is of diffuso-trabecular type. The axial column is circular to somewhat elliptical in outline, sometimes free from the axial ends of major septa. The column ranges from 1.3 to 2.2 mm in diameter, occupying about one-fourth to two-fifths of the diameter of corallite. It is constructed of flexuose septal lamellae and axial tabellae, becoming a meshwork structure. It is rather loosely formed in the earlier stages. A medial plate may be discernible. Interseptal spaces have one to two rows of dissepiments with a concentric and herringbone arrangement. An inner wall is formed in the inner surface of the dissepimentarium. Some traces of lonsdaleoid dissepiments are observed.

In longitudinal section, corallites are parallel to partly dendritic in disposition. Corallite walls are more or less undulating, sometimes laterally swollen. One to two rows of globose dissepiments are present, though not persistent throughout growth. The tabularium is clearly differentiated from the dissepimentarium, made up of gently ascending tabulae and tabellae. They may slope gently from the inner wall and then rise to the column. Periaxial tabellae are sometimes present. The axial column is formed by rather steeply domed axial tabellae, sometimes variably superimposed, and septal lamellae. A daughter corallite originates by means of lateral increase. The offsets begin to branch off from the mother corallites at varying angles.

Remarks: Variation in length of minor septa is remarkable. The length of the minors is variable among corallites and also depends on the ontogenetic stage. Flügel (1972) reported compound corals from the upper Jamal Formation (*Parafusulina* Zone to *Neoschwagerina* Zone) of eastern Iran as *Yatsengia hangchowensis* Huang. Although Flügel presented no longitudinal sections of the corallites, the present form is conspecific with Flügel's specimen by showing a loosely formed axial column and flexuose major septa.

Family Waagenophyllidae Wang, 1950

Genus *Waagenophyllum* Hayasaka, 1924

Type species (subsequent designation by Grabau, 1931): *Lonsdaleia indica* Waagen and Wentzel, 1886.

Waagenophyllum (*Waagenophyllum*) *kueichowense* Huang, 1932

(Pl. 16, figs. 1a, b, 2)

1932 *Waagenophyllum indicum* var. *kueichowense* Huang, p. 48, pl. 3, figs. 1a-d, 2a-c; text-fig. 3a, b.
1950 *Waagenophyllum* aff. *indicum* (Waagen and Wentzel); Douglas, p. 9, pl. 1, fig. 1, 1a.
1958 *Waagenophyllum indicum* var. nov.; Hudson, p. 178, pl. 33, figs. 4a, b, 9.
1963 *Waagenophyllum indicum* subsp. *kueichowense* Huang; Yü *et al.*, p. 187, pl. 54, fig. 3a-c.
1965a *Waagenophyllum indicum* (Waagen and Wentzel); Iljina, p. 79, pl. 17, figs. 3a-c, 4a-d, 5; pl. 18, figs. 1-3, 4a, b; text-figs. 34a, b, 35 : 1-5.

1965b *Waagenophyllum indicum* (Waagen and Wentzel); Iljina, p. 336, pl. 12, fig. 6.
1965 *Waagenophyllum* (*Waagenophyllum*) *kueichowense* Huang; Minato and Kato, p. 99, text-fig. 47-1.
1978 *Waagenophyllum indicum* var. *kueichowense* Huang; Wang, p. 175, pl. 56, fig. 1a-c.
?1978 *Waagenophyllum indicum kueichowense* Huang; Fan, p. 201, pl. 73, fig. 2a, b.
1979 *Waagenophyllum* (*Waagenophyllum*) *kueichowense* Huang; Kato, p. 144, pl. 2, figs. 1-4.
non 1981 *Waagenophyllum indicum* var. *kueichowense* Huang; Yü, Lin, and Huang, p. 279, pl. 2, fig. 8a, b.

Holotype: Cat. No. 3856, Geol. Surv. China; Middle Permian of Pahui, Lipohsien, Kueichow, China.

Material studied: Three fragmentary specimens (OCU 6241-6243); uppermost part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh; upper part of the Khachik Formation (*Codonofusiella-Reichelina* Zone), Kuh-e-Ali Bashi, Julfa. Corallites are more or less silicified, particularly at the periphery.

Description: The corallum is compound, fasciculate and dendritic. Corallites are generally separated, but some may be in contact. Faint septal grooves and interseptal ridges, as well as a few transverse wrinkles, are observed on the weathered external surface. They are ordinarily eroded out to show the cut edges of septa.

In transverse section, corallites are circular to somewhat elliptical, ranging from 4.8 to 7.0 mm in diameter. Corallite walls are characteristically thin. Major septa number 17 to 22 and are radially arranged. They are tapering and some axial ends nearly reach the column, sometimes confluent with septal lamellae, particularly in the younger corallites. Major septa are feeble and slightly sinuous, especially at the periphery. Minor septa are also flexuose and variable in length, ranging two-fifths to four-fifths of the length of the majors. Septa are of diffuso-trabecular type in fine structure. The axial column is round to rather elliptical in outline, made up of irregularly disposed septal lamellae and concentrically arranged axial tabellae. A medial plate may be discernible and is directly connected to the cardinal septum. Short diameter of the axial column ranges from 0.8 to 1.6 mm, occupying about one-sixth to one-third of the diameter of corallite. In the premature stages, the axial column is rather simple, formed by the axial elongation of the cardinal septum, with the addition of some axial tabellae. The dissepimentarium is comparatively wide, 0.7 to 1.8 mm in width, having concentrically arranged dissepiments in one to four rows. A few lonsdaleoid dissepiments may be present. An inner wall is partly formed by dilation of the innermost part of the dissepimentarium. A daughter corallite is separated from the mother corallite as a tube-like structure with much stereoplasm.

In longitudinal section, corallite walls are more or less undulating, sometimes swollen laterally. Two to four rows of globose and somewhat elongate dissepiments are irregularly distributed. Elongate dissepiments are more developed in the inner part of the dissepimentarium. Clinotabulae are not clearly differentiated

from the dissepimentarium. They are steeply inclined and irregularly spaced. The axial column is variable in outline. Axial tabellae are gently to steeply ascending towards the centre, forming tent- to dome-like structure. Some septal lamellae and a medial plate are occasionally discernible. They are rather sinuous and intermittent.

Remarks: Although this species is characterised by a comparatively small and well bounded axial column, it exhibits some variability in size, complexity, and relation to the axial ends of major septa, even in a corallite. Some corallites that have a large axial column, independent of the axial ends of the majors, are similar to *Waagenophyllum* (*W.*) *wengchengense* Huang. Other corallites having a simple axial column composed of the axial elongation of the cardinal septum and a few septal lamellae are similar to *Waagenophyllum* (*W.*) *simplex* Wu.

Iljina (1965a) described specimens under the name of *Waagenophyllum indicum* (Waagen and Wentzel). Judging from the smaller axial column, as well as similar dissepimental and clinotabular arrangements, Iljina's species is conspecific with *Waagenophyllum* (*W.*) *kueichowense* Huang.

Genus *Ipciphyllum* Hudson, 1958

Type Species: *Ipciphyllum ipci* Hudson, 1958.

Ipciphyllum subtimoricum (Huang, 1932)

(Pl. 17, fig. 1a, b)

1932 *Wentzelella subtimorica* Huang, p. 59, pl. 4, fig. 1a, b.
?1936 *Wentzelella subtimorica* Huang; Douglas, p. 23, pl. 2, fig. 2; pl. 3, fig. 5.
1939 *Wentzelella subtimorica* Huang; Heritsch, p. 3, pl. 1, figs. 2, 3; pl. 2, figs. 7, 8, 15-17.
1944 *Wentzelella subtimorica* Huang; Minato, p. 105, figs. 1-3.
?1955 *Wentzelella subtimorica* Huang; Flügel, p. 301, pl. 34, figs. 7, 8.
?1955 *Wentzelella subtimorica* Huang; Minato, p. 113, pl. 22, fig. 8; pl. 23, fig. 7; pl. 25, fig. 2; pl. 26, fig. 3; pl. 30, fig. 6; text-fig. 8C.
1958 *Ipciphyllum ipci* Hudson, p. 179, pl. 33, figs. 1-3, 7, 10; pl. 35, fig. 4.
1963 *Wentzelella subtimorica* Huang; Yü *et al.*, p. 172, pl. 49, fig. 1a, b.
1965a *Wentzelella flexuosa* Huang; Iljina, p. 82, pl. 18, figs. 5, 6a, b, 7, 8; pl. 19, fig. 1.
non 1965a *Wentzelella subtimorica* Huang; Iljina, p. 84, pl. 19, fig. 2a-c.
1965b *Wentzelella flexuosa* Huang; Iljina, p. 336, pl. 12, fig. 7.
1972 *Ipsiphyllum* [*sic*] *subtimoricum subtimoricum* (Huang); Flügel, p. 87, pl. 4, figs. 4, 5.
1974 *Ipciphyllum ipci* Hudson; Wu and Wang, p. 297, pl. 155, figs. 3, 4.
1977 *Ipciphyllum ipci* Hudson; Jia *et al.*, p. 233, pl. 91, fig. 1a, b.
non 1978 *Wentzelella subtimorica* Huang; Fan, p. 203, pl. 74, fig. 5a, b.
1978 *Ipciphyllum ipci* Hudson; Fan, p. 205, pl. 75, fig. 5a, b.
1981 *Ipciphyllum subtimoricum* (Huang); Zhao, p. 256, pl. 9, figs. 6a, b, 9a, b; pl. 11, fig. 6.
1983 *Ipciphyllum subtimoricum* (Huang); Cao *et al.*, p. 160, pl. 56, fig. 1a, b.
1986 *Ipciphyllum subtimoricum* (Huang); Wang, p. 233, pl. 57, fig. 3a, b.
1989 *Ipciphyllum subtimoricum* (Huang); Kropatcheva, p. 157, pl. 13, fig. 1a, b.

Holotype: Cat. No. 3862, Geol. Surv. China; Hoshihpa, Tsunihsien, Kueichow; Chihsia Limestone.

Material studied: A single corallum (OCU 6244); Unit 2 of the upper part of

the Nesen Formation [Abadehian according to Nakazawa (1981)], Elikah, Alborz Mountains.

Description: The corallum is compound, massive and cerioid. In transverse section, corallites are rather regularly polygonal, having five to seven sides, approximately 7.0 to 10.5 mm in diameter in the mature stage. They are circular to inflated triangular in shape in the earlier stages. Corallite walls are thin and slightly undulating. Two orders of septa are radially arranged and are sometimes discontinuous by the presence of small lonsdaleoid dissepiments at the corallite corners. As many as 17 to 22 major septa, alternating with the same number of minor septa, are present in the mature corallites. Major septa nearly reach the axial column, but ordinarily do not touch it even in the earlier stages. They are somewhat axially curved. Minor septa are a little shorter and thinner than the majors, protruding well into the tabularium. Septa are of diffuso-trabecular type in fine structure. Somewhat thickened septa in the tabularium coupled with slight dilation of the innermost series of dissepiments form a faint inner wall. The axial column is circular to elliptical in outline and ranges from 1.4 to 2.1 mm in diameter, occupying about one-fifth to one-fourth of the diameter of corallite. It is free from the axial ends of major septa and consists of radially disposed septal lamellae, sometimes showing a prominent medial plate, and several rows of axial tabellae. The tabularium is narrow and annular, 0.4 to 1.3 mm in width. Some transversely cut edges of tabulae are densely arranged concentrically in the interseptal spaces. The dissepimentarium is wide and is filled with several rows of small dissepiments of concentric to angulo-concentric arrangement. At the corallite corners, small and irregularly formed lonsdaleoid dissepiments are present.

In longitudinal section, corallite walls are more or less sinuous. A trizonal arrangement of the skeletal elements, axial column, tabularium, and dissepimentarium, is well discernible. The dissepimentarium is widely occupied by several rows of globose to somewhat elongate dissepiments. The tabularium is comparatively narrow, made up of irregularly spaced tabulae. They are variously inclined towards the column, sometimes almost horizontal and concave upwards. Steeply inclined clinotabulae may unite directly with transverse tabulae. About five tabulae are counted in a vertical distance of 2 mm. The axial column is clearly bounded from the tabularium and shows tent-like to inverted cup-in-cup structure. It consists of a series of successively superimposed, gently to steeply up-arching axial tabellae, septal lamellae, and a medial plate.

Remarks: Although the type specimen of this species seems to show a comparatively small axial column, it is not so small, judging from a longitudinal section (Huang, 1932, pl. 4, fig. 1b). Iljina (1965a) described specimens under the name of

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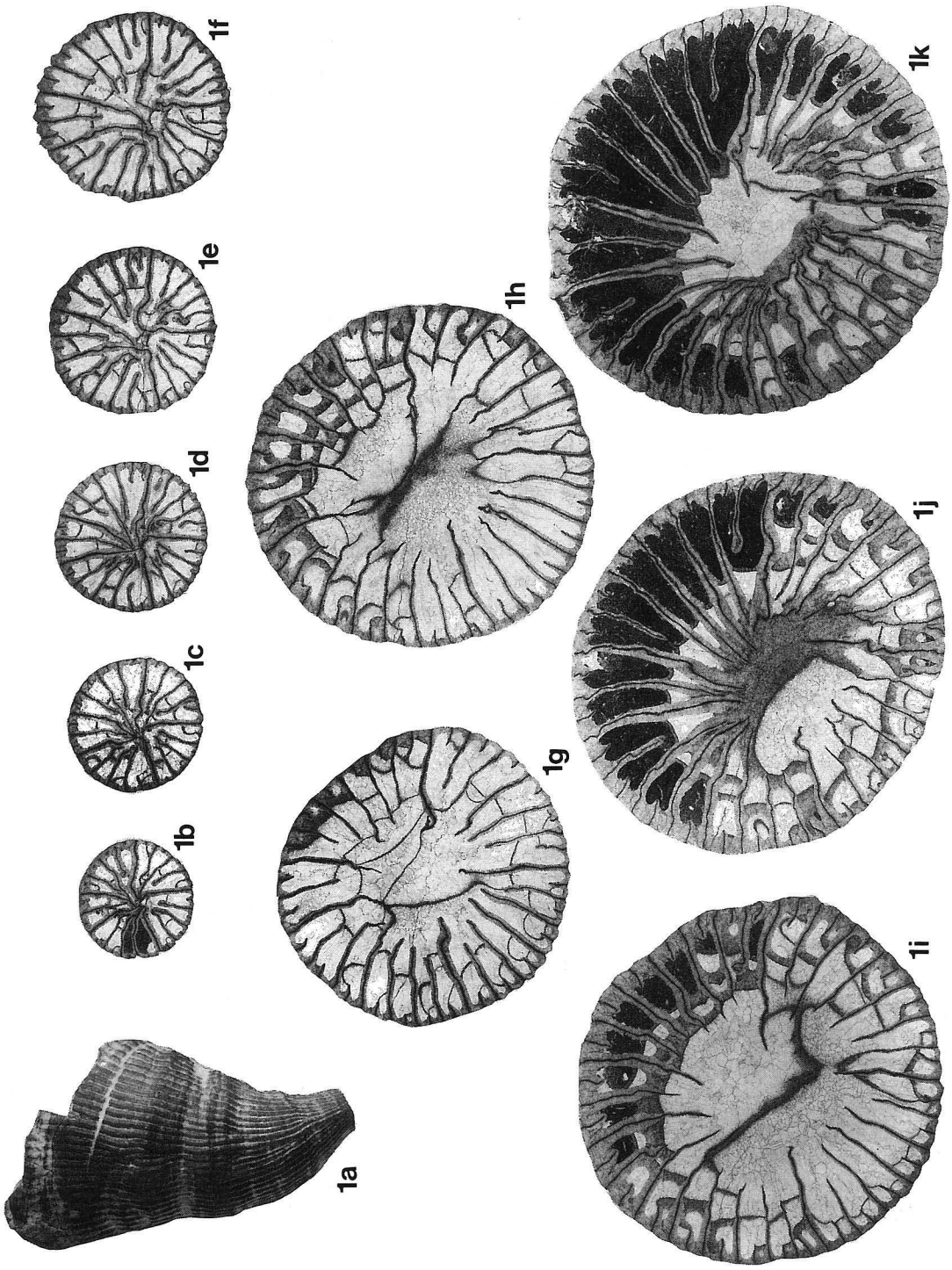
Explanation of Plate 1

Fig. 1 *Pentaphyllum excentricum* (Iljina). UHR 30676, middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa. a, side view showing distinct septal grooves, ×2. b-k, serial transverse sections showing numerous and irregularly flexuose major septa, ×4.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Wentzelella subtimorica Huang, which Zhao (1981) ascribed to his new species *Ipciphyllum spumidum* Zhao in having well developed lonsdaleoid dissepiments. Iljina's specimens is, however, conspecific with *"Wentzellophyllum" persicum* (Douglas). The present specimen is identical with the forms described by Iljina (1965a) under the name of *Wentzelella flexuosa* Huang, which Minato and Kato (1966) treated as *Ipciphyllum flexuosum* (Huang). The original Chinese specimen, however, has rather larger corallites having numerous major septa and a densely constructed axial column. The Iranian species resembles *Ipciphyllum kwangsiense* Wu from the Upper Permian of Yishan District, Kiangsi, but the former possesses slightly larger corallites having numerous major septa.

Ipciphyllum huangi Minato and Kato, 1965
(Pl. 15, fig. 2a-c)

1963 *Ipciphyllum irregulare* Wu, p. 497, pl. 2, figs. 7-10. (*non Wentzelella irregularis* Fontaine, 1961).
1965 *Ipciphyllum huangi* Minato and Kato, p. 157.
1978 *Atopophyllum irregulare* (Wu); Wang, p. 180, pl. 58, fig. 1a, b.
non 1981 *Ipciphyllum huangi* Minato and Kato; Zhao, p. 257, pl. 9, figs. 10a, b, 11a, b.

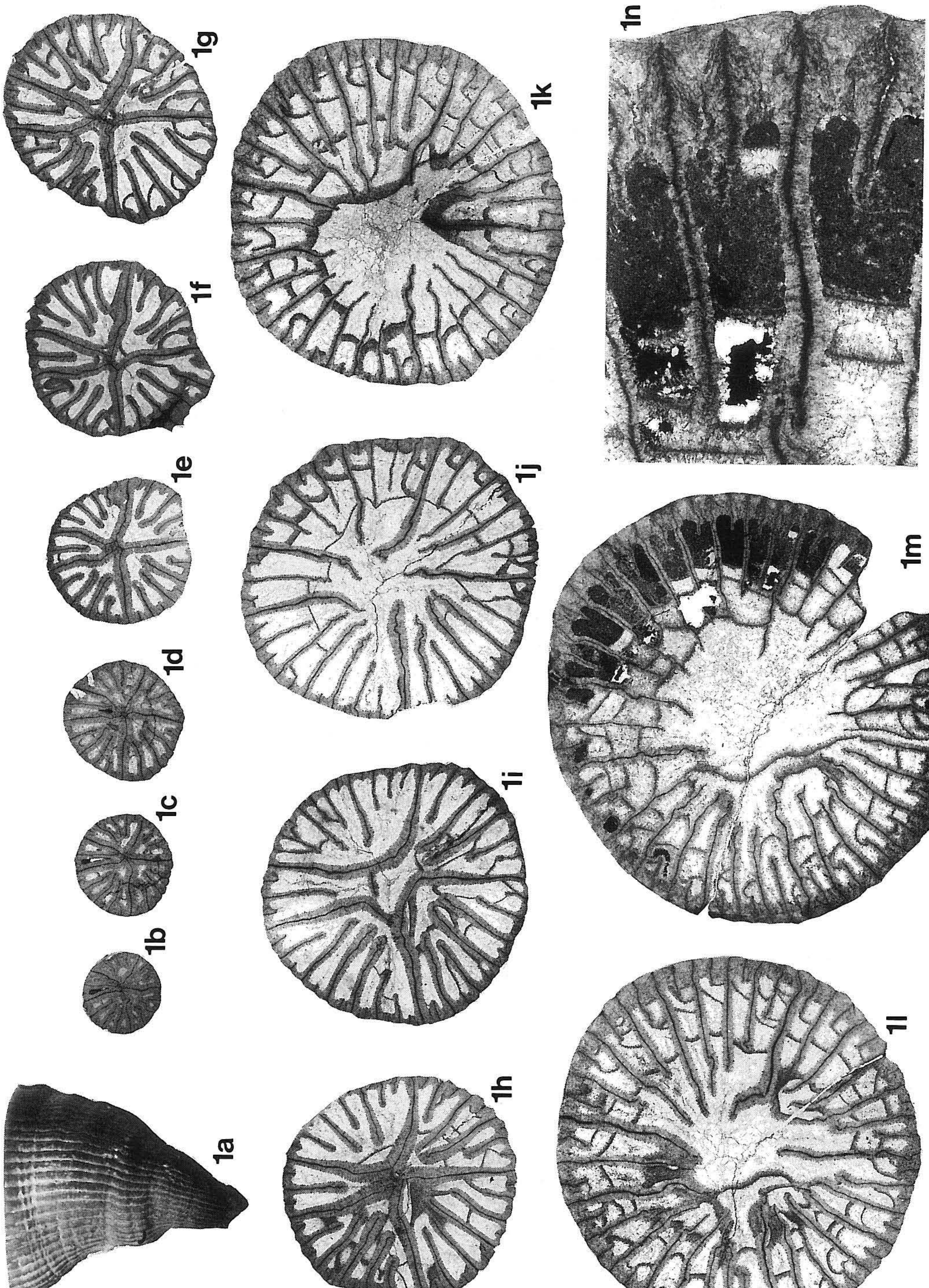
Holotype: Cat. Nos. 14043, 14044, Inst. Geol. and Palaeont., Acad. Sinica; Ziyun District, Kueichow; Maokou suite.

Material studied: A single fragmentary specimen (OCU 6245); lower part of Unit 3 of the Surmaq Formation, Kuh-e-Hambast, Abadeh. The specimen is silicified and shows numerous veins of calcite. A holotheca is missing.

Description: The corallum is compound, massive and cerioid. In transverse section, the five to six sided corallites, ranging from 6.3 to 7.8 mm in diameter, are separated by thin, more or less sinuous walls. Septa are almost radially arranged and are slightly undulating. As many as 17 major septa are present at a diameter of 7.2 mm. Major septa extend almost to the axial column and some septa touch it or unite with septal lamellae of the column. The minors generally attain two-thirds to four-fifths of the length of the majors. The fine septal structure is obliterated. The axial column is characteristically small, circular to somewhat elliptical, and measures 0.4 to 1.1 mm, occupying about one-eighth to one-fifth of the corallite diameter. It is composed of irregularly disposed septal lamellae and a few rows of axial tabellae. A medial plate is mostly discernible. Dissepiments are rather irregularly arranged. Small and irregularly shaped lonsdaleoid dissepiments may occupy the corallite periphery.

Explanation of Plate 2

Fig. 1 *Pentaphyllum excentricum* (Iljina). OCU 6000, middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa. a, side view showing distinct septal grooves, ×2. b-m, serial transverse sections showing numerous major septa and a comparatively thin wall, ×3.5. n, fine structure of septa. Septa are wedged in the wall, ×15.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In longitudinal section in a distal part of corallite, there are three to five rows of globose to somewhat elongate dissepiments which are variable in size. The axial column is narrow and consists of steeply ascending axial tabellae, septal lamellae, and a medial plate.

Remarks: Minato and Kato (1965) established a new species *Ipciphyllum huangi* based on specimens described by Wu (1963) as *I. irregulare*. Wu's species is characterised by such features as a small axial column and thin major septa, and is not conspecific with *Wentzelella timorica* (Gerth) of Huang (1932) and *W. laosensis* Patte var. *tenuis* Fontaine, although Minato and Kato (1965) considered them to be synonymous.

This specimen is similar to *Ipciphyllum simplex* Wu, but it is distinguished from the latter in having longer minor septa and a small but well constructed axial column. The species resembles *Ipciphyllum elegans* (Huang), but it is clearly separated in having a smaller axial column and longer minor septa.

Ipciphyllum heritschi Minato and Kato, 1965
(Pl. 18, fig. 1a, b)

1939 *Stylidophyllum gnomeiense* Huang; Heritsch, p. 6, pl. 1, figs. 4, 5; pl. 2, figs. 11, 12.
1965 *Ipciphyllum heritschi* Minato and Kato, p. 151.

Type: The specimen shown by Heritsch (1939, pl. 1, figs. 4, 5) was designated as the "lectotype" (Minato and Kato, 1965, p. 151); Permian of Ala Dagh, Kilikischer Taurus, Turkey.

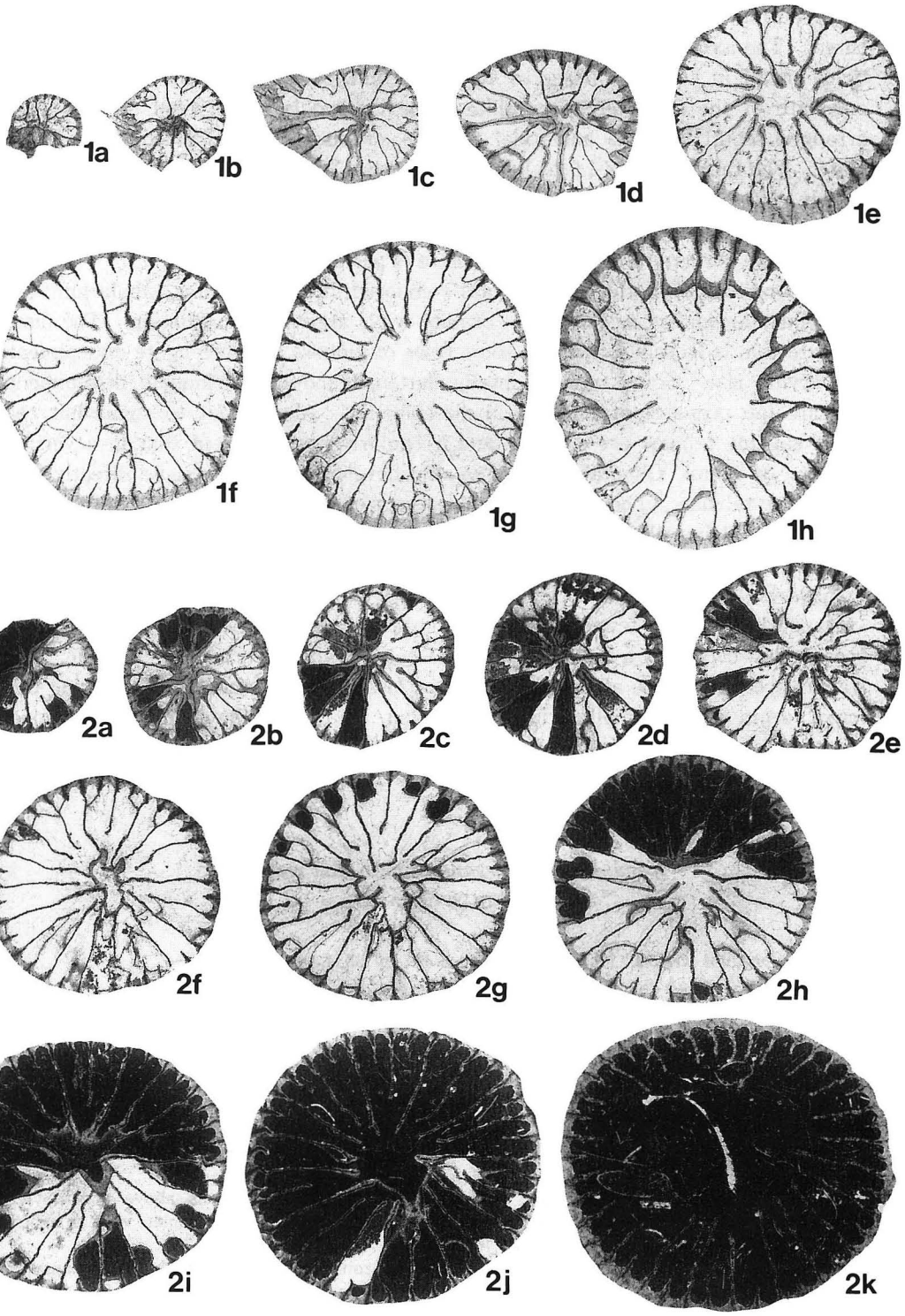
Material studied: Three specimens (OCU 6246-6248); lower part of Unit 3 of the Surmaq Formation, Kuh-e-Hambast, Abadeh. They are rather poorly preserved.

Description: The corallum is compound, massive and cerioid, normally four to seven sided. In transverse section, corallites are moderate-sized, measuring never more than 11 mm in diameter and have an average diameter of 8.2 mm. Corallite walls are thin and slightly sinuous. Septa are in two orders, showing a radial arrangement. Major septa are more or less dilated in the tabularium, around which an inner wall may be formed. As many as 18 major septa are present in the mature corallite. The majors nearly reach the axial column, but do not unite directly with septal lamellae of the column. Minor septa are slightly short and thin compared to the majors. They may be axially sinuous and contratingent on the

Explanation of Plate 3

Fig. 1 *Pentaphyllum antractum* (Iljina). OCU 6003, middle part of Unit 6 of the Hambast Formation (*Araxoceras tectum* Subzone), Kuh-e-Hambast, Abadeh. a-h, successive transverse sections showing thin major septa with a rhopaloid shape, ×4.

Fig. 2 *Pentaphyllum antractum* (Iljina). OCU 6004, middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa. a-k, serial transverse sections showing weakly differentiated major septa in length. Major septa are more or less flexuose and rhopaloid, ×4.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neighbouring major septa. The fine skeletal structure of septa is completely obscured. The axial column is circular to somewhat elliptical in outline and comparatively small in size. It measures 1.2 to 1.6 mm, occupying about one-seventh to one-sixth of the diameter of corallite. The column is constructed of irregularly arranged septal lamellae and axial tabellae, ordinarily accompanied by a medial plate. The tabularium is 1.0 to 1.6 mm in width. The dissepimentarium is comparatively wide, 3.0 to 4.5 mm, filled with sparsely arranged dissepiments in several rows. Small and irregularly formed lonsdaleoid dissepiments are present, especially at the corners of corallites. Increase is peripheral.

In longitudinal section, three zones composed of axial column, tabularium, and dissepimentarium are detectable. Corallite walls are rather undulating. The dissepimentarium is loosely formed by some rows of globose to subelongate dissepiments of varying size. Some subhorizontally flattened and quite elongate dissepiments indicate the presence of lonsdaleoid dissepiments. Almost flat to somewhat centrally sagging tabulae are sparsely and irregularly spaced, about four in a vertical distance of 2 mm. Clinotabulae are weakly developed and may unite directly with transverse tabulae. The axial column consists of steeply ascending axial tabellae, sinuous septal lamellae, and a medial plate. The medial plate is slightly undulating.

Remarks: The present species is closely similar to *Ipciphyllum gnomeiense* (Huang) in showing fewer and widely spaced major septa. The latter Chinese species, however, has a quite simple axial column and no transverse tabulae. The Iranian species may be allied to *Ipciphyllum huangi* Minato and Kato in having long minor septa and a small axial column, but the latter shows highly developed clinotabulae. This species resembles *Ipciphyllum simplex* Wu from the Upper Permian of Yishan District, Kiangsi, but the Chinese species has smaller corallites with well developed clinotabulae.

Ipciphyllum subelegans Minato and Kato, 1965
(Pl. 19, fig. 1a, b)

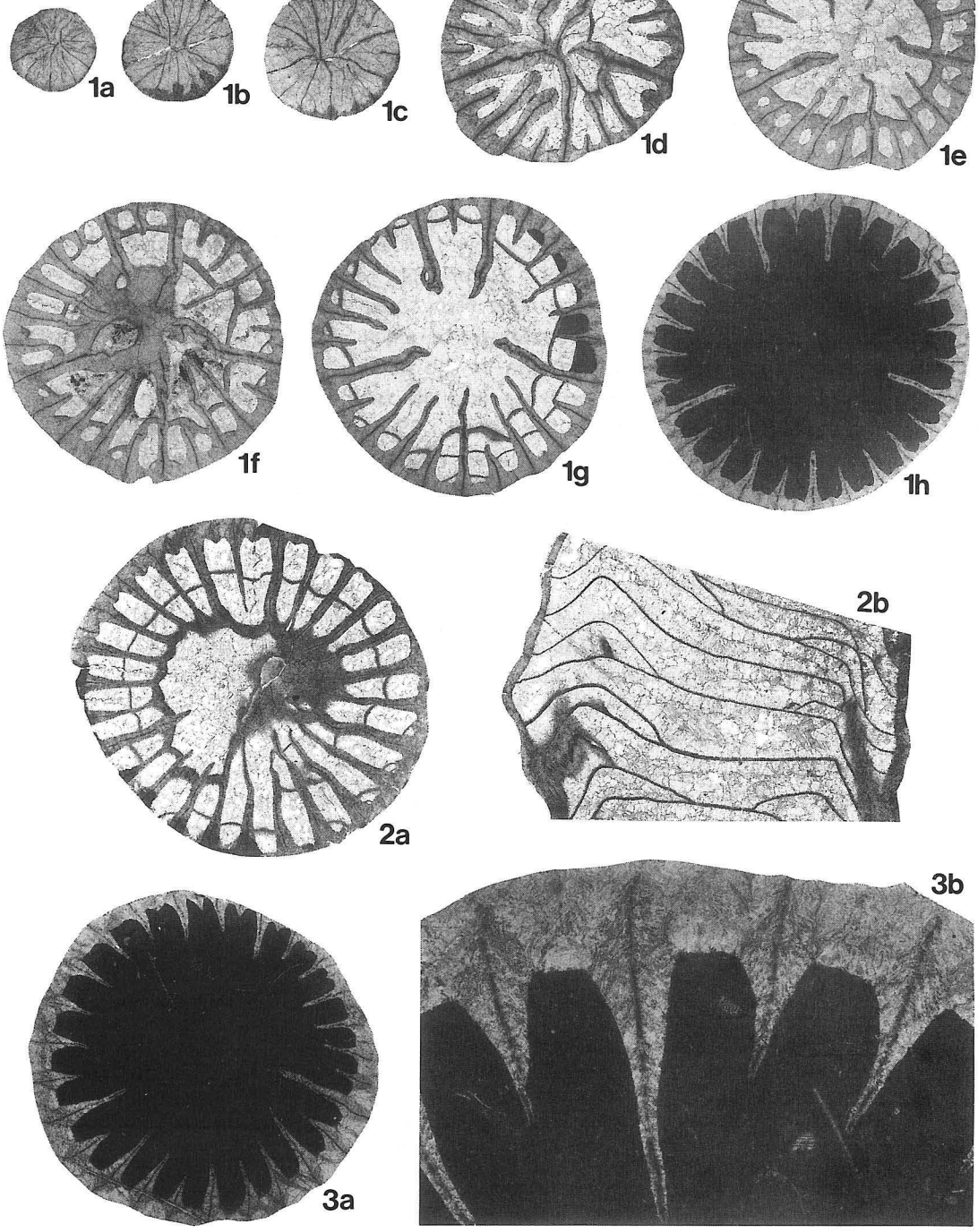
1958 *Ipciphyllum elegans* (Huang); Hudson, p. 181, pl. 33, fig. 6; text-fig. 1a-d.
1965 *Ipciphyllum subelegans* Minato and Kato, p. 155.
1983 *Ipciphyllum subelegans* Minato and Kato; Fontaine, p. 6, pl. 3, figs. 1-4.

Explanation of Plate 4

Fig. 1 *Pentaphyllum cuneatum* (Iljina). OCU 6007, middle part of Unit 6 of the Hambast Formation (*Araxoceras tectum* Subzone), Kuh-e-Hambast, Abadeh. a-h, serial transverse sections. Major septa are much thickened in the earlier stages and taper in the later stages, ×4.

Fig. 2 *Pentaphyllum cuneatum* (Iljina). OCU 6008, horizon and locality as above. a, transverse section, ×4. b, longitudinal section showing roughly trapezoidal tabulae with a central depression and peripheral troughs, ×4.

Fig. 3 *Pentaphyllum cuneatum* (Iljina). OCU 6009, horizon and locality as above. a, transverse section, ×4. b, fine structure of septa. Septa become wedge-shaped in the wall, ×15.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1986a *Ipciphyllum subelegans* Minato and Kato ; Kato and Ezaki, p. 647, pl. 1, fig. 1a, b ; pl. 2, fig. 2a-c.
1986 *Ipciphyllum subelegans* Minato and Kato ; Wang, p. 234, pl. 56, figs. 4a, b, 7a, b.

Holotype : R 42001 (two pieces) and sections (Hudson, 1958, pl. 33, fig. 6 ; text-fig. 1) ; Geli Khana section, Ora, northern Iraq ; *Wentzelella* Limestones.

Material studied : Two coralla (OCU 6249, 6250) ; Unit 1 of the Surmaq Formation (*Neoschwagerina cheni* and *N. margaritae* Zones), Kuh-e-Hambast, Abadeh. The specimens are much silicified.

Description : The corallum is compound, massive and cerioid. In transverse section, each corallite is four to six sided in the mature stage. The average corallite diameter is 7.9 mm. Corallite walls are very thin and straight. Septa are in two orders, showing a radial arrangement. Major septa number 16 to 20 at a diameter of 6.0 to 8.5 mm. The majors may be a little thickened centrally, tapering both axially and peripherally to an elongate spindle shape. They are slightly sinuous and extend almost to the outer margin of the axial column, scarcely protruding into it. Minor septa generally protrude into the tabularium and are about two-thirds to four-fifths of the length of the majors. The fine skeletal structure of septa is obliterated. The axial column is almost round to elliptical in outline and is rather loosely constructed, mostly free from the axial ends of major septa. The column measures 1.2 to 1.8 mm in diameter in the mature corallite, occupying about one-sixth of the diameter of corallite. It is composed of some irregularly arranged septal lamellae and axial tabellae. A prominent medial plate is ordinarily present. The dissepimentarium is about 1.6 mm wide, consisting of concentric to angulo-concentric dissepiments and small lonsdaleoid dissepiments. The innermost surface of the dissepimentarium is slightly dilated by stereoplasm to form an inner wall.

In longitudinal section, corallites are clearly trizonal. Corallite walls are thin and more or less undulating. The dissepimentarium is made up of several rows of small dissepiments. The tabularium consists of slightly inclined tabulae and periaxial tabellae. They may be moderately to greatly concave upwards. About five tabulae occur in a vertical distance of 2 mm. The axial column is comparatively well differentiated from the tabularium, composed of rather steeply domed axial tabellae, septal lamellae, and an irregularly sinuous medial plate.

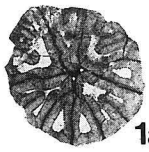
Explanation of Plate 5

Fig. 1 *Pentaphyllum cuneatum* (Iljina). OCU 6010, middle part of Unit 6 of the Hambast Formation (*Araxoceras tectum* Subzone), Kuh-e-Hambast, Abadeh. a, b, serial transverse sections, ×4.

Fig. 2 *Pentaphyllum cuneatum* (Iljina). OCU 6011, horizon and locality as above. a, b, serial transverse sections. The wall is thick and minor septa (catasepta) are absent or rudimentary, ×4.

Fig. 3 *Pentaphyllum leptoconicum* (Abich). OCU 6030, middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa. a-g, successive transverse sections, ×4.

Fig. 4 *Pentaphyllum leptoconicum* (Abich). UHR 30679, horizon and locality as above. a-i, serial transverse sections. Major septa temporarily show an apparent radial symmetry, ×4.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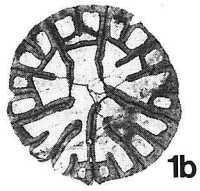
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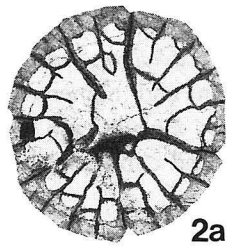
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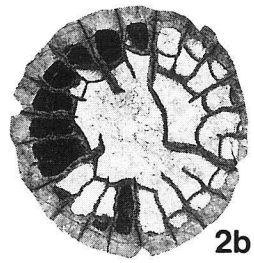
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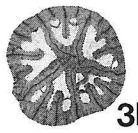
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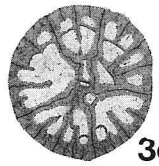
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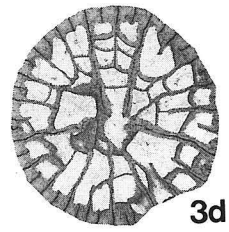
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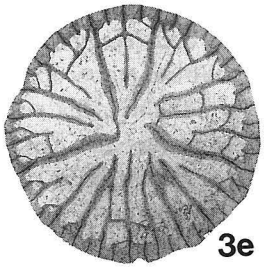
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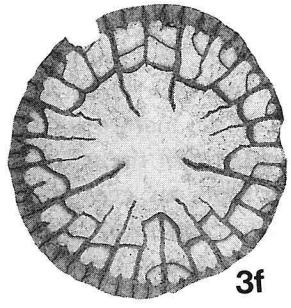
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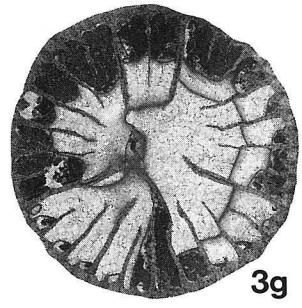
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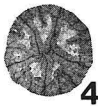
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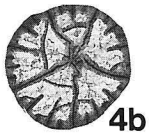
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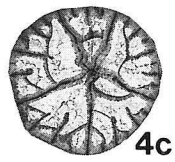
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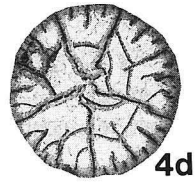
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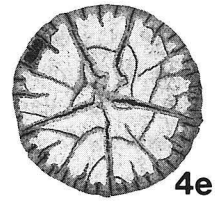
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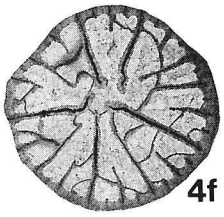
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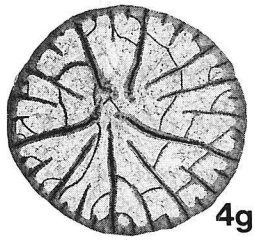
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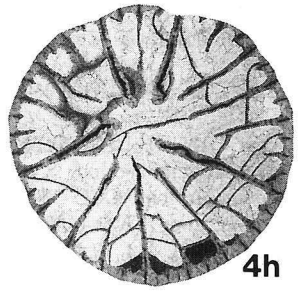
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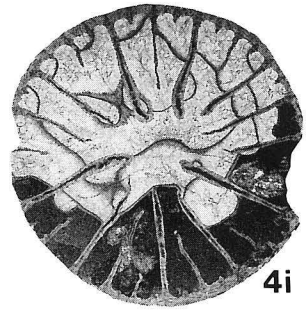
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Remarks: The present species resembles *Ipciphyllum simplex* Wu in having a similarly formed axial column, but *I. simplex* has well developed clinotabulae. The species is closely allied to *Ipciphyllum bijishanense* Fan, but the latter differs in having a large axial column and numerous rows of small dissepiments. This species is akin to *Ipciphyllum kwangsiense* Wu, but it is distinguishable from the latter in having poorly developed clinotabulae and much dilated major septa.

Ipciphyllum guangdongense Xu, 1977
(Pl. 19, fig. 2a, b)

1977 *Ipciphyllum guangdongense* Xu, p. 233, pl. 91, fig. 2a, b.

Holotype: IV 38594, Hubei Inst. Geol. Sci.; Guangdong, South China; Middle Permian, Maokou Formation.

Material studied: Two fragmentary coralla (OCU 6251, 6252); middle part of the Surmaq Formation (Unit 2), Kuh-e-Hambast, Abadeh.

Description: The corallum is compound, massive and cerioid. In transverse section, corallites are generally polygonal, having four to six sides. The mature corallite attains about 10.5 mm in diameter. Corallite walls are thin and irregularly undulating. Septa are in two orders and their fine structure is of diffuso-trabecular type. Major septa number 15 to 17 in the mature stage. They are slightly dilated in the tabularium and their axial ends touch the axial column, sometimes not continuous with septal lamellae. Minor septa are generally three-fifths to five-sixths of the length of the majors. Both major and minor septa may not be directly connected to the wall, especially at the corners of corallites, owing to the presence of small lonsdaleoid dissepiments. The axial column is circular to elliptical in outline, consisting of irregularly disposed septal lamellae and axial tabellae. A medial plate may be present and more or less sinuous. The column ranges from 1.4 to 2.0 mm in diameter, occupying about one-sixth to one-fourth of the diameter of corallite. The tabularium is annular, 0.7 to 1.2 mm in width. Tabulae are transversely intercepted in an almost concentric arrangement in a few rows. The disse-

Explanation of Plate 6

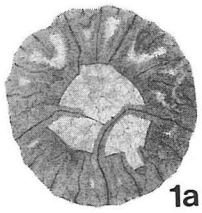
Fig. 1 *Pentaphyllum leptoconicum* (Abich). OCU 6032, middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa. a, b, transverse sections, ×4.

Fig. 2 *Pentaphyllum leptoconicum* (Abich). UHR 30689, horizon and locality as above. Transverse section, ×4.

Fig. 3 *Pentaphyllum leptoconicum* (Abich). UHR 30690, horizon and locality as above. a, b, transverse sections, ×4. c, longitudinal section, ×4.

Fig. 4 *Pentaphyllum leptoconicum* (Abich). OCU 6033, upper part of the Julfa Formation (*Haydenella-Pseudowellerella* Zone), Kuh-e-Ali Bashi, Julfa. a–c, transverse sections showing some rhopaloid major septa, ×4. d, fine structure of septa, showing the frontal zones and dilation by the addition of growth lamellae, ×15.

Fig. 5 *Pentaphyllum leptoconicum* (Abich). OCU 6034, horizon and locality as above. Fine structure of septa, showing successive growth lamellae, ×15.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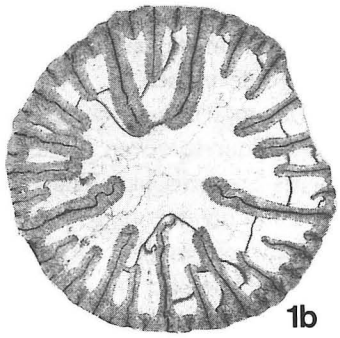
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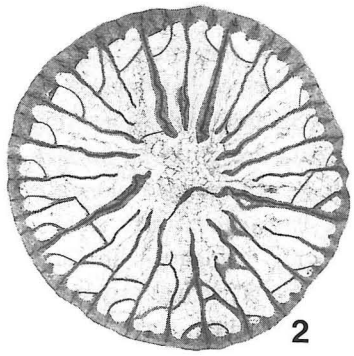
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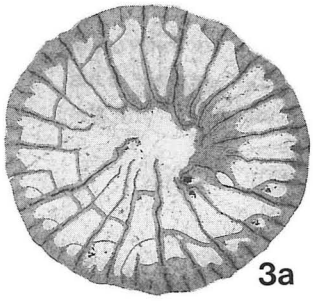
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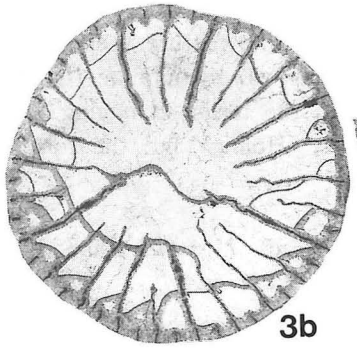
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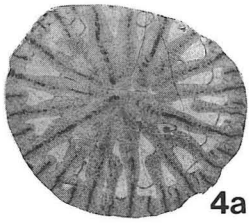
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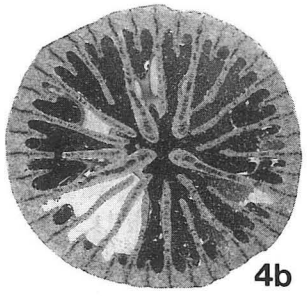
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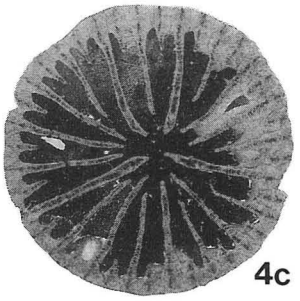
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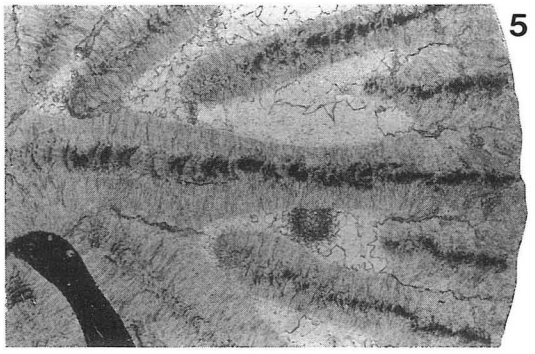
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pimentarium is 1.5 to 3.1 mm in width, provided with several rows of dissepiments showing concentric, angulo-concentric and lateral arrangement. Small and irregularly shaped lonsdaleoid dissepiments are developed.

In longitudinal section, the dissepimentarium is comparatively wide. Dissepiments are irregular in size and shape. Four to seven rows of globose and steeply to gently inclined elongate dissepiments are present. The tabularium is composed of flat to centrally sagging tabulae, counting six in a vertical distance of 2 mm. Highly elongate clinotabulae are partly recognised. Rather steeply domed and somewhat irregularly superimposed axial tabellae and septal lamellae, including a medial plate, form the axial column. The column varies in size throughout growth.

Remarks: The Iranian species possesses comparatively small lonsdaleoid dissepiments at the corners of corallites. The feature seems to be variably developed, even in a corallite. The species is closely similar to *Ipciphyllum subtimoricum* (Huang), but it is separable from the latter in having fewer major septa. This species is like *Ipciphyllum elegans* (Huang), but the former is distinct from the latter in having long minor septa.

Ipciphyllum sp. aff. *I. stabilis* Zhao, 1981
(Pl. 17, fig. 2)

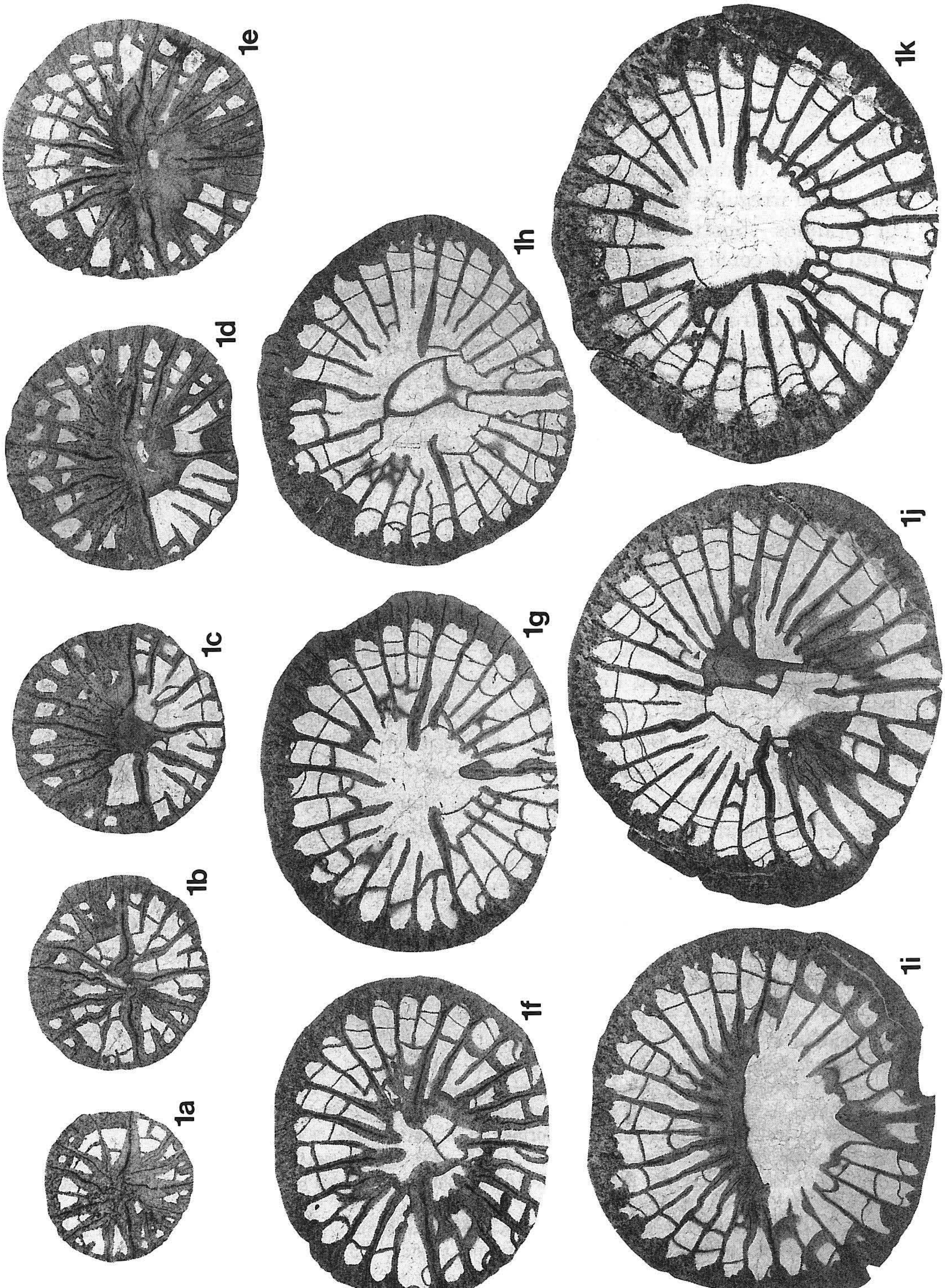
Compare:
1981 *Ipciphyllum stabilis* Zhao, p. 258, pl. 10, fig. 5a, b.

Material studied: Two fragmentary coralla (OCU 6253, 6254); upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. They are embedded in limestone matrix and slightly silicified at the periphery. A holotheca is missing.

Description: The corallum is compound, massive and cerioid. In transverse section, corallites have four to six sides and reach 11.2 mm in diameter in the mature stage. Corallite walls are prominent and slightly sinuous. Septa are in two orders. As many as 18 to 20 major septa are present at a diameter of 10.0 to 11.7 mm. Major septa ordinarily do not unite directly with septal lamellae. They are more or less thickened, especially in the tabularium. Minor septa are three-fifths to four-fifths of the length of the majors and protrude slightly into the tabularium. Some septa are interrupted by the presence of lonsdaleoid dissepiments. Septa are of diffuso-trabecular type in fine skeletal structure. The axial column is comparatively large, circular to somewhat elliptical, sometimes denticulate. It ranges from

Explanation of Plate 7

Fig. 1 *Pentaphyllum leptoconicum* (Abich). OCU 6035, middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa. a-k, serial transverse sections showing highly thickened major septa, especially in the earlier stages, and a thick wall, ×3.5.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1.5 to 2.8 mm in diameter, occupying about one-fifth to one-fourth of the diameter of corallite. The column is composed of radially disposed septal lamellae, concentrically arranged axial tabellae, and a prominent medial plate which is dilated and flexuose. Some septal lamellae are connected to the medial plate. The tabularium is annular, 1.2 to 1.8 mm in width. It is separated from the dissepimentarium by an inner wall. The dissepimentarium is 1.1 to 3.2 mm in width. Many rows of dissepiments are concentrically to angulo-concentrically arranged. Small and irregular lonsdaleoid dissepiments are present, particularly at the corners of corallites. Short septal crests may be developed on their surfaces. No longitudinal section could be prepared.

Remarks: This species is closely allied to *Ipciphyllum stabilis* Zhao, but it is distinguished from the latter in having a larger axial column and a wider tabularium. The present species resembles *Wentzelella (W.) densicolumnata,* originally described by Iljina (1965a) in having a well developed axial column and prominent dividing walls. The present species, however, reveals no tertiary septa. "*Wentzelella*" *densicolumnata multiseptata* reported by Zhang (1977) from the Upper Permian of South China resembles the present species, but it possesses numerous major septa.

Genus *Miyagiella* Minato and Kato, 1965

Type species: *Parawentzelella (Miyagiella) miyagiensis* Minato and Kato, 1965.

Remarks: Minato and Kato (1965) established the subgenus *Miyagiella* within *Parawentzelella,* distinguished by having prominent "canals" or gaps in corallite walls and well developed lonsdaleoid dissepiments. Recently, Kropatcheva (1989) proposed the subgenus *Armeniaphyllum* within *Wentzellophyllum,* and the subgenus was separable from *Miyagiella* and *Wentzellophyllum* in having definite tertiary septa and corallite walls provided with "canals" respectively.

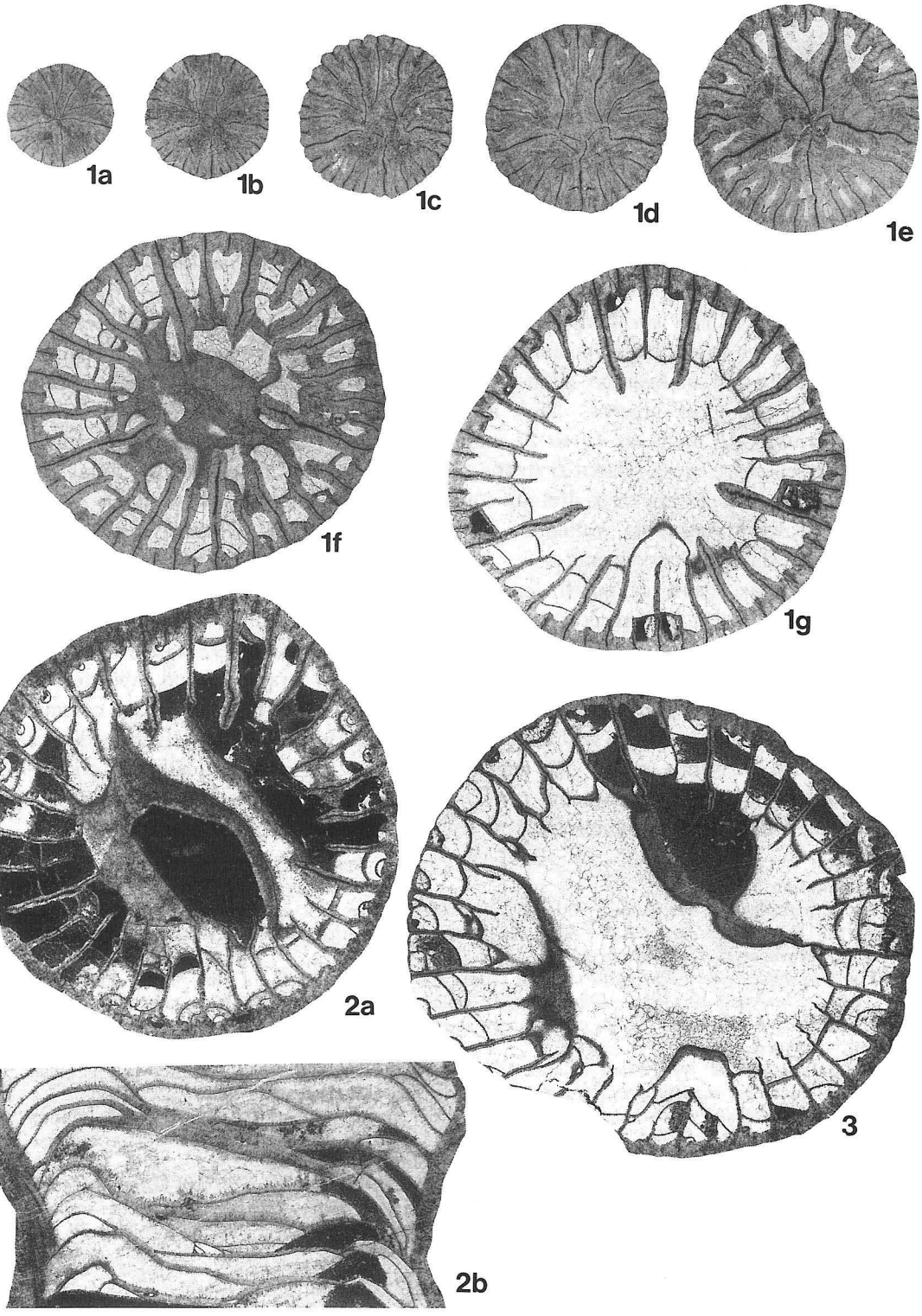
The term "canals" seems to be used commonly for an interruption of wall. The phenomenon, however, results from various factors. The "canals" may be formed as mural pores, or merely caused from the highly developed dissepiments, interrupting the wall. The connecting tube itself may be related to the pore formation. Any functional meaning of the "canal" should be considered before application of the term. In any case, *Miyagiella* can be generically separable from *Ipciphyllum* and *Parawentzelella* in having highly developed lonsdaleoid dissepiments.

Explanation of Plate 8

Fig. 1 *Pentaphyllum leptoconicum* (Abich). OCU 6036, middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa. a-g, serial transverse sections. Major septa are so much dilated in the earlier stages as to fill completely the corallite. A faint fossula is formed in the later stage, ×4.

Fig. 2 *Pentaphyllum leptoconicum* (Abich). OCU 6037, lower part of the Julfa Formation (*Araxilevis-Orthotetina* Zone), Kuh-e-Ali Bashi, Julfa. a, transverse section, ×3.5. b, longitudinal section, ×3.5.

Fig. 3 *Pentaphyllum leptoconicum* (Abich). OCU 6038, Gnishik Formation, Kuh-e-Ali Bashi, Julfa. Transverse section showing a faint cardinal fossula, ×3.5.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Miyagiella tabasensis (Minato and Kato, 1965)
(Pl. 20, fig. 1a, b)

1965 *Wentzelophyllum*? [*sic*] *tabasense* Minato and Kato, p. 213, pl. 20, figs. 1-3.

Holotype: UHR 18152; south flank of Kuh-e-Jamal, southeast of Tabas, East Iran; "*Parafusulina*" Zone.

Material studied: A single massive corallum (OCU 6255), 88.1×91.2×35.0 mm in size; lower part of the Julfa Formation (*Araxilevis-Orthotetina* Zone), Kuh-e-Ali Bashi, Julfa.

Description: The corallum is compound, massive and cerioid. Corallites are ordinarily five to six sided, bounded by thin but locally thickened walls. Corallites measure 9.8 mm in average diameter and 12.3 mm in maximum diameter. Two orders of septa are present. They are more or less flexuose and dilated in the tabularium. As many as 19 to 21 major septa are present in the mature stage. Major septa are more dilated than the minors and extend almost to the axial column. Minor septa are three-fifths to four-fifths of the length of the majors. In the fully grown stage, septa ordinarily do not reach the wall, where comparatively small lonsdaleoid dissepiments occur in many rows. Younger corallites have only two to three rows of small lonsdaleoid dissepiments. Septa are of diffuso-trabecular type in fine structure. The axial column is circular to fusiform in outline. The column ranges from 1.3 to 2.0 mm in short diameter, occupying about one-sixth to one-fourth of that of corallite. Regularly arranged axial tabellae and radially disposed septal lamellae, including a medial plate, form the axial column. The medial plate is dilated and distinct. The tabularium is comparatively wide, 1.2 to 1.8 mm in width, where cut edges of tabulae are concentrically to angulo-concentrically arranged in some rows. The dissepimentarium is wide, 1.1 to 2.9 mm in width, almost completely covered with globose to fan-shaped lonsdaleoid

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Explanation of Plate 9

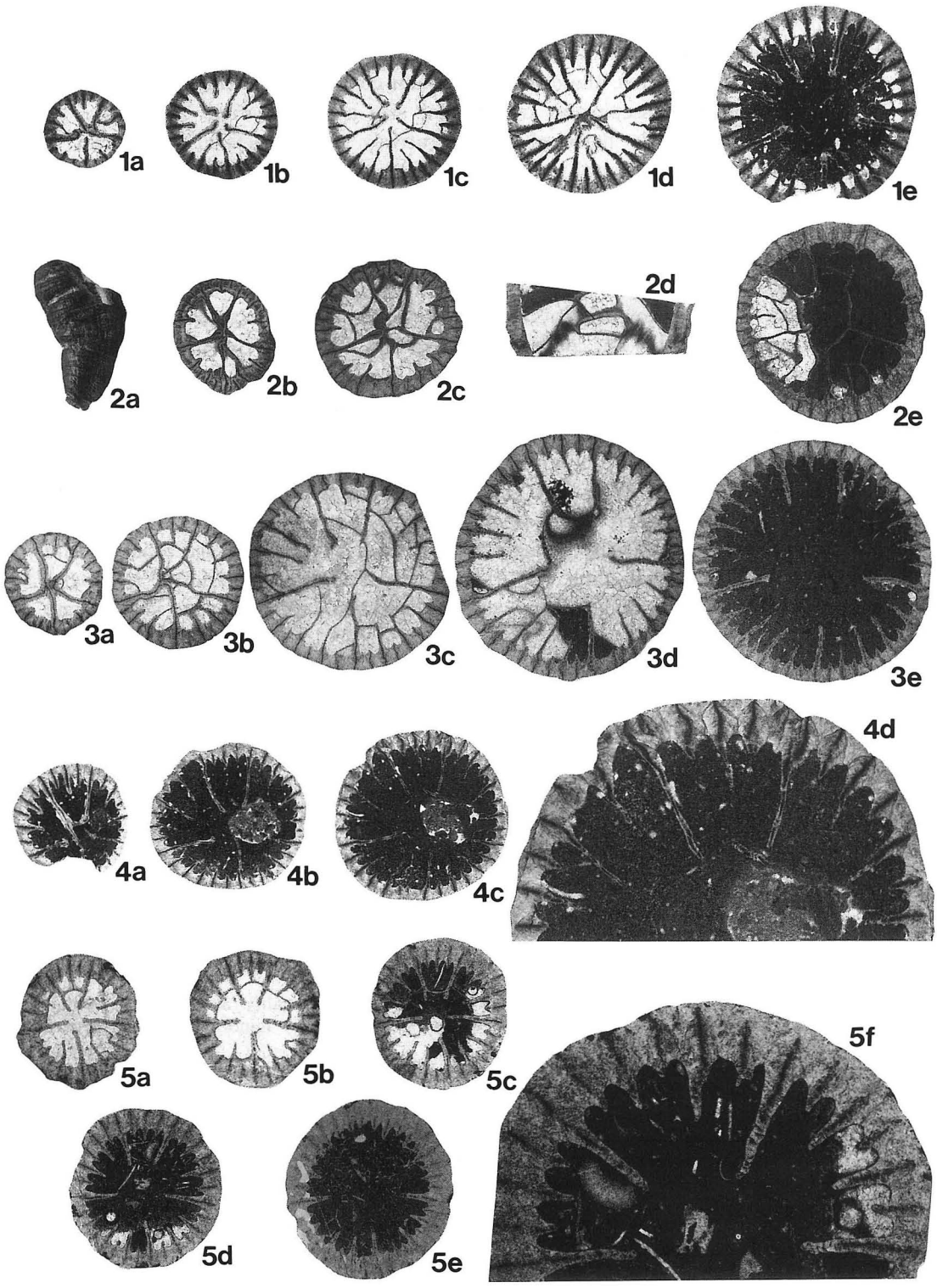
Fig. 1 *Pentaphyllum breviseptum* (Iljina). UHR 30688, upper part of the Ali Bashi Formation (*Paratirolites* Zone), Kuh-e-Ali Bashi, Julfa. a-e, serial transverse sections showing distinct minor septa (catasepta), ×5.

Fig. 2 *Pentaphyllum breviseptum* (Iljina). UHR 30686, middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa. a, side view of the trochoid corallite, ×2. b, c, e, transverse sections showing a thick wall, ×5. d, longitudinal section, ×5.

Fig. 3 *Pentaphyllum breviseptum* (Iljina). UHR 30682, horizon and locality as above. a-e, serial transverse sections showing restricted major septa in length and a thick wall, ×5.

Fig. 4 *Pentaphyllum breviseptum* (Iljina). UHR 30687, upper part of the Ali Bashi Formation (*Paratirolites* Zone), Kuh-e-Ali Bashi, Julfa. a-c, transverse sections, ×5. d, transverse section showing septal dislocation on the counter-lateral septa, ×12.

Fig. 5 *Pentaphyllum subcylindricum* Schindewolf. OCU 6099, upper part of the Julfa Formation (*Haydenella-Pseudowellerella* Zone), Kuh-e-Ali Bashi, Julfa. a-e, transverse sections showing a small corallite and a thick wall, ×5. f, transverse section showing a thick wall and the frontal zones of septa, ×15.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dissepiments. They may become rather irregular in size and shape, especially at the periphery. Septal crests are rarely developed.

In longitudinal section, the dissepimentarium consists of several rows of small, globose to elongate dissepiments of different size and inclination. Some dissepiments are conspicuously flattened. Comparatively clearly defined tabularium is composed of almost horizontal transverse tabulae, sometimes bent centrally. They may be supplemented by periaxial tabellae and clinotabellae. Six to eight transverse tabulae occur in a vertical distance of 2 mm. The axial column is very stout, constructed of septal lamellae and closely superimposed steep axial tabellae. A medial plate is mostly distinct.

Remarks: As Minato and Kato (1965) previously noted, this species shows no trace of tertiary septa. The author places the species within the genus *Miyagiella,* instead of *Wentzellophyllum.*

The Iranian specimen is akin to Miyagiella miyagiensis (Minato and Kato), but it is distinct from the latter in having larger corallites and a regularly constructed axial column showing a prominent medial plate. The specimen bears a close resemblance to *" Wentzellophyllum " jenningsi* (Douglas), but the former differs in having a well constructed large axial column. The present form is similar to *" Wentzellophyllum " orientale* (Douglas) in showing a stoutly formed axial column having a distinct medial plate, but it is distinguished from the latter in having thicker corallite walls and rather variable lonsdaleoid dissepiments in size and shape.

Genus *Wentzelella* Grabau in Huang, 1932

Type species: *Lonsdaleia salinaria* Waagen and Wentzel, 1886.

Wentzelella (Wentzelella) densicolumnata Iljina, 1965

(Pl. 21, figs. 1, 2a, b)

Explanation of Plate 10

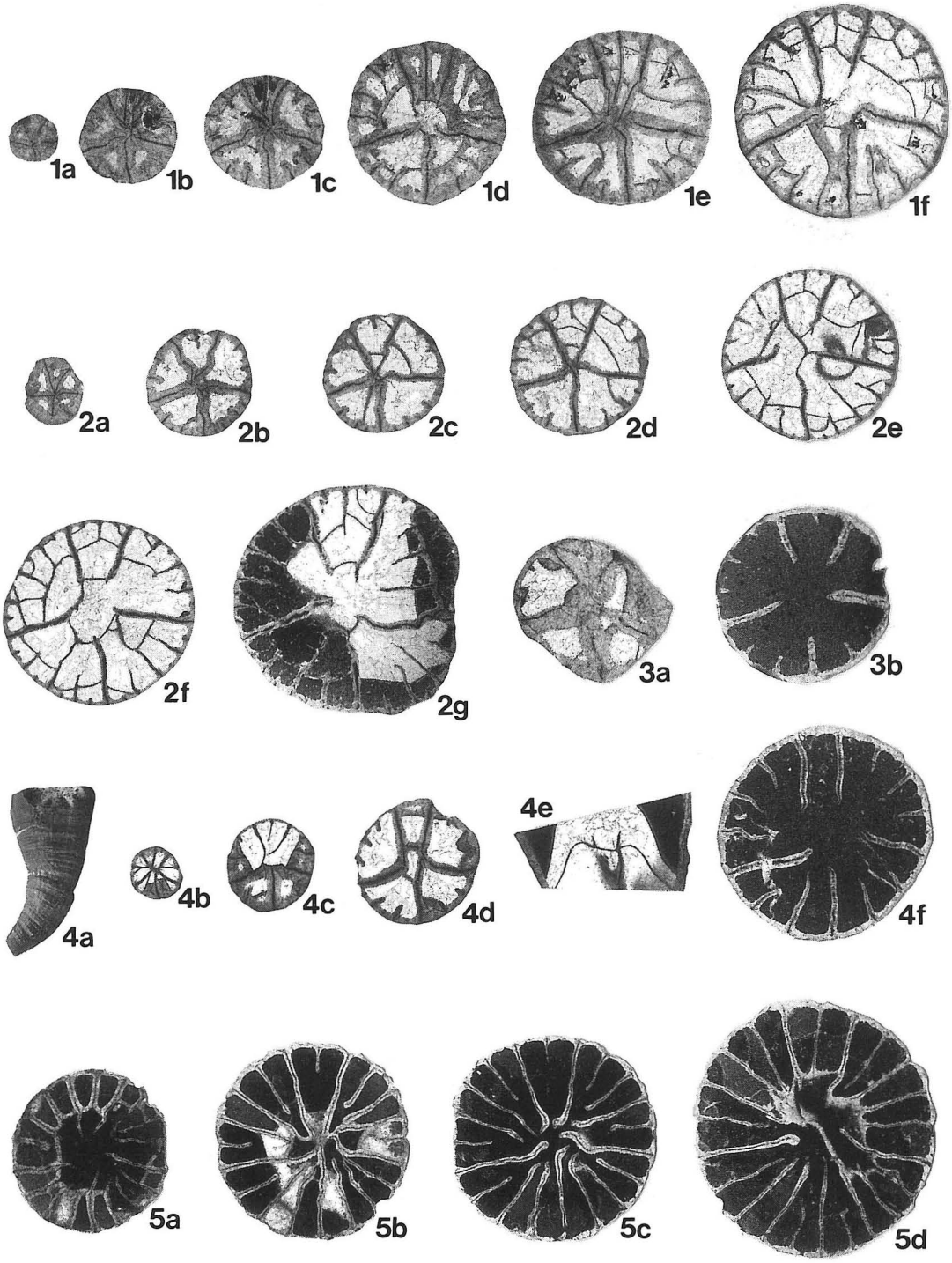
Fig. 1 *Pentaphyllum minimum* (Iljina). UHR 30677, middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa. a-f, serial transverse sections showing slightly dilated major septa and rudimentary minor septa (catasepta), ×5.

Fig. 2 *Pentaphyllum minimum* (Iljina). UHR 30681, horizon and locality as above. a-g, serial transverse sections showing thin major septa and rudimentary minor septa (catasepta), ×5.

Fig. 3 *Pentaphyllum minimum* (Iljina). OCU 6100, middle part of Unit 6 of the Hambast Formation (*Araxoceras tectum* Subzone), Kuh-e-Hambast, Abadeh. a, b, transverse sections showing a small corallite, ×7.

Fig. 4 *Pentaphyllum minimum* (Iljina). UHR 30683, middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa. a, side view of the ceratoid corallite, ×2. b-d, f, serial transverse sections, ×5. e, longitudinal section, ×5.

Fig. 5 *Pentaphyllum* sp. OCU 6117, uppermost part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. a-d, transverse sections showing slender major septa and rudimentary minor septa (catasepta), ×5.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1965a *Wentzelella densicolumnata* Iljina, p. 88, pl. 20, fig. 3a-d.
1989 *Wentzelophyllum* [*sic*] (*Armeniaphyllum*) *densicolumnatum* (Iljina); Kropatcheva, p. 114, pl. 13, fig. 6.

Holotype: PIN No. 1820/1209, Palaeont. Inst., USSR Acad. Sci.; southwestern slope of the Mt. Baisal, Nakhichevan; Guadalupian, Gnishik horizon.

Material studied: Two fragmentary coralla (OCU 6256, 6257); lower part of Unit 3 of the Surmaq Formation, Kuh-e-Hambast, Abadeh. They are rather poorly preserved.

Description: The corallum is compound, massive and cerioid. In transverse section, corallites are irregularly polygonal, ordinarily five to six sided, measuring 6.9 to 10.2 mm in diameter. Corallite walls are somewhat sinuous and partly interrupted. Septa are in three orders and wavy or zigzag, especially at the periphery. Major septa extend almost to the outer margin of the axial column, but ordinarily do not unite directly with septal lamellae. Major septa number 17 at a diameter of 8.0 mm and are more or less dilated in the tabularium, tapering towards both axial and peripheral ends. Minor septa are slightly shorter than the majors and they ordinarily project into the tabularium. Tertiary septa attain about one-fourth to three-fifths of the length of the majors. The fine septal structure is completely obscured. The compactly constructed axial column is circular to somewhat elliptical, ranging from 1.1 to 1.8 mm in short diameter, occupying about one-sixth to one-fourth of the diameter of corallite. It is composed of irregularly radiating septal lamellae and several rows of concentric axial tabellae. A medial plate is mostly detectable, which is well dilated. The tabularium is narrow, 0.7 to 1.2 mm in width. Interseptal spaces are filled with many rows of dissepiments which are quite irregular in shape. Dissepiments are aligned in concentric to angulo-concentric pattern. Small lonsdaleoid and lateral dissepiments are sporadically present. An inner wall is formed by dilation of the innermost series of dissepiments.

In longitudinal section, corallite walls are more or less undulating. The dissepimentarium is rather wide, composed of several rows of dissepiments. They are ordinarily globose, sometimes rather elongate, and variously inclined. The tabular-

Explanation of Plate 11

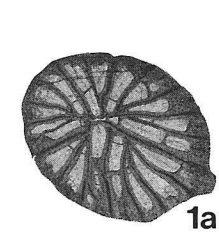
Fig. 1 *Ufimia carbonaria* Stuckenberg. OCU 6118, basal part of the Abadeh Formation (Unit 4), Kuh-e-Hambast, Abadeh. a-g, serial transverse sections showing short or rudimentary minor septa (catasepta), ×5.

Fig. 2 *Ufimia carbonaria* Stuckenberg. OCU 6119, horizon and locality as above. a-f, serial transverse sections showing the four definite majors and a thick wall, ×5.

Fig. 3 *Ufimia carbonaria* Stuckenberg. OCU 6120, horizon and locality as above. a, b, transverse sections, ×5.

Fig. 4 *Ufimia carbonaria* Stuckenberg. OCU 6121, horizon and locality as above. a, transverse section of the more or less abraded corallite, ×5. b, longitudinal section, ×5.

Fig. 5 *Ufimia carbonaria* Stuckenberg. OCU 6122, horizon and locality as above. Transverse section showing a thick wall, ×5.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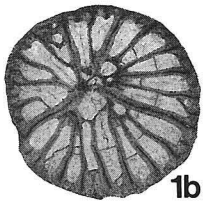
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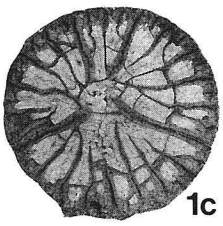
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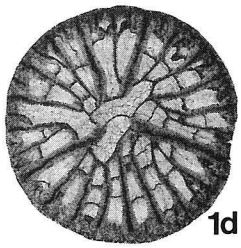
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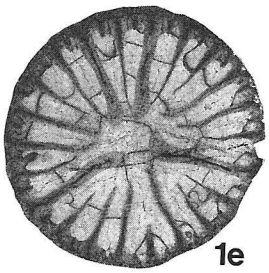
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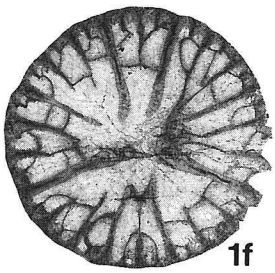
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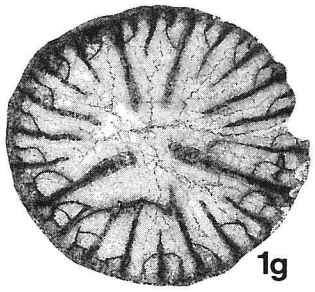
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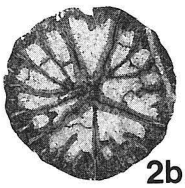
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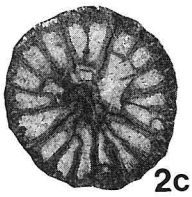
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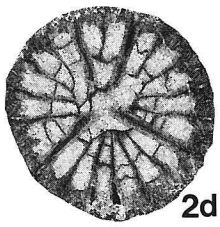
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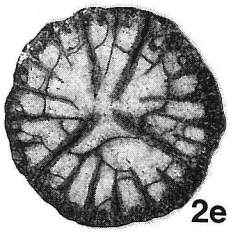
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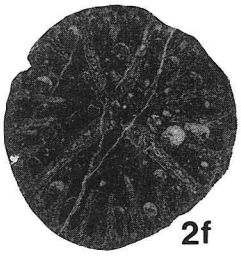
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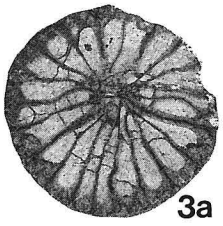
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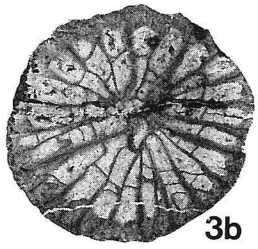
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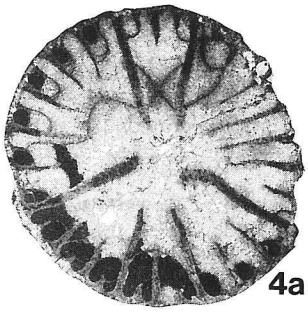
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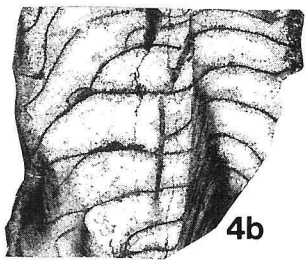
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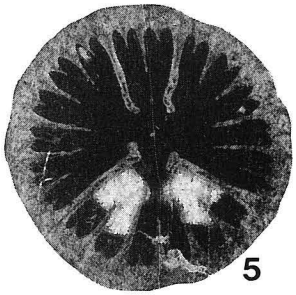
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ium is composed of sparsely distributed transverse tabulae, averaging four to six in a vertical distance of 2 mm. Clinotabulae are sporadically present. The axial zone is clearly separated from the tabularium and consists of successively superimposed and steeply up-arched axial tabellae as well as some septal lamellae. A medial plate is sometimes present.

Remarks: The species is identical with *Wentzelella* (*W.*) *densicolumnata* Iljina in having a well developed axial column and long minor septa. Minato and Kato (1966) placed the present species within the genus *Wentzellophyllum* with a query, because it shows lonsdaleoid dissepiments and a beaded corallite wall. The species, however, shows only sporadical lonsdaleoid dissepiments. The present species is similar to *Wentzelella* (*W.*) *regularis* Fontaine, described by Fontaine (1961) as *Wentzelella szechuanensis* var. *regularis*. The former is, however, clearly separable in having longer minor septa.

Genus *Polythecalis* Yabe and Hayasaka, 1916

Type species: *Polythecalis confluens* Yabe and Hayasaka, 1916.

Polythecalis dupliformis Huang, 1932

(Pl. 22, fig. 1a-c)

1932 *Polythecalis dupliformis* Huang, p. 86, pl. 9, fig. 1a, b.
1963 *Polythecalis dupliformis* Huang; Yü *et al.*, p. 179, pl. 52, fig. 4a, b.

Holotype: Cat. No. 3886, Geol. Surv. China; between Chiuts'aitung and Singch'ang, Hsishuihsien, Kueichow; Chihsia Limestone.

Material studied: A single corallum (OCU 6258); a rolled cobble at Kuh-e-Ali Bashi, Julfa. The specimen is more or less silicified. The corallum attains 87.4×

Explanation of Plate 12

Fig. 1 *Ufimia differentiata* (Iljina). OCU 6163, middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa. a-e, serial transverse sections showing highly differentiated major septa in length and the short cardinal septum in the mature stage, ×4. f, longitudinal section, ×4.

Fig. 2 *Ufimia elongata* (Grabau). OCU 6166, upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. Transverse section, ×4.

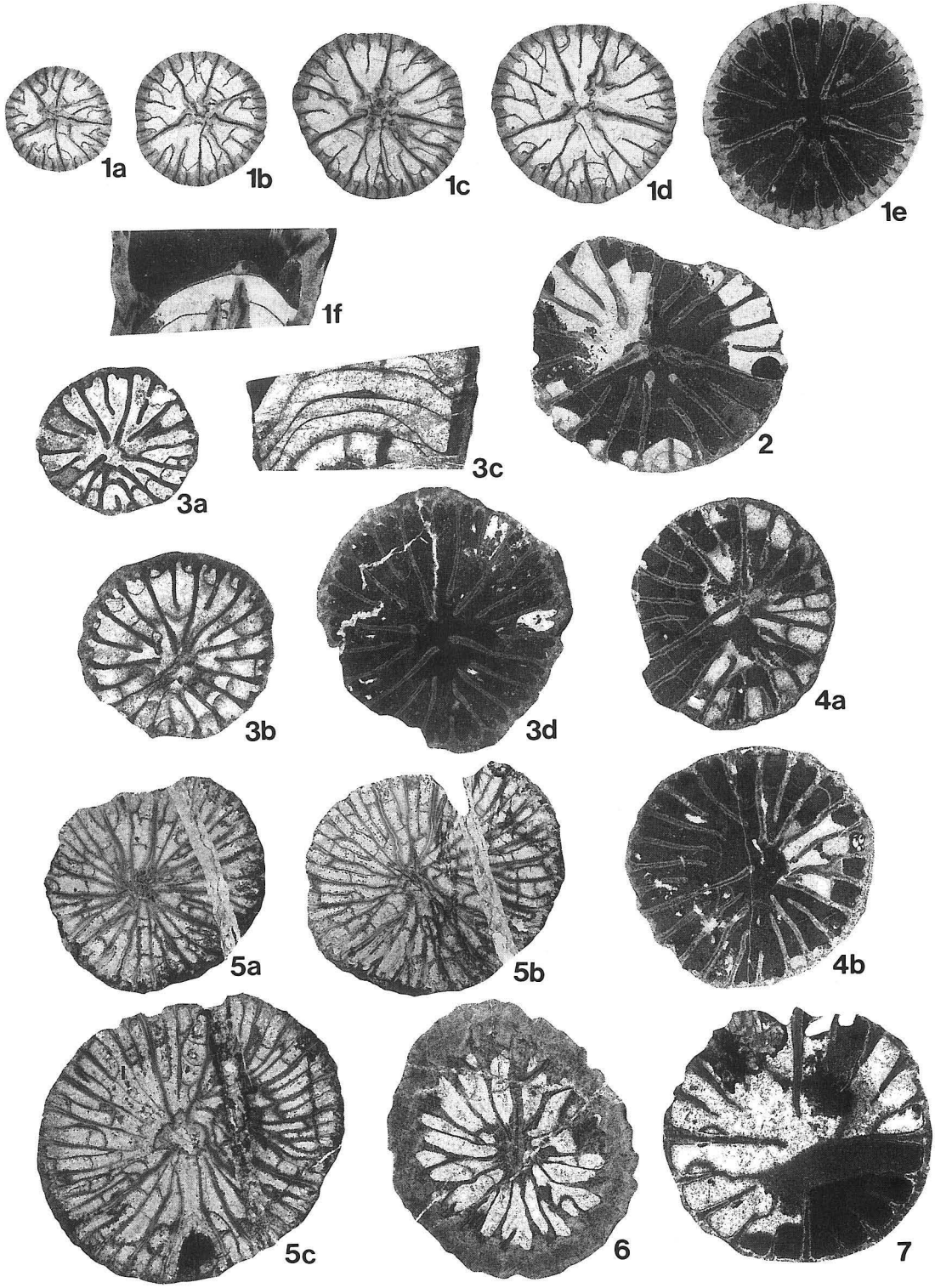
Fig. 3 *Ufimia elongata* (Grabau). OCU 6167, horizon and locality as above. a, b, d, transverse sections showing thin major septa and the very short cardinal septum, ×4. c, longitudinal section, ×4.

Fig. 4 *Ufimia elongata* (Grabau). OCU 6168, horizon and locality as above. a, b, transverse sections, ×4.

Fig. 5 *Praetachylasma alternatum* (Huang). OCU 6216, upper part of the Surmaq Formation (Unit 3), Kuh-e-Hambast, Abadeh. a-c, transverse sections showing bilaterally arranged major septa and very long minor septa (catasepta), ×4.

Fig. 6 *Asserculinia* sp. OCU 6237, upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. Transverse section showing a well provided wall and a kind of columella formed by the axial elongation of the counter septum, ×7.

Fig. 7 *Calophyllum* sp. OCU 6238, horizon and locality as above. Transverse section, ×6.


1a
1b
1c
1d
1e
1f
2
3a
3c
3b
3d
4a
5a
5b
4b
5c
6
7

71.8 mm and 32.0 mm in height.

Description: The corallum is compound, massive and cerioid to partly aphroid. The weathered surface of the corallum shows some calicular pits. A holotheca is not preserved.

In transverse section, corallites are ordinarily polygonal, five to six sided, measuring 8.5 to 12.0 mm in diameter. Corallite walls are generally denticulate or comb-like. A septal wall is formed by lateral fusion of septa at the periphery and is variable in thickness. Corallite walls may be discontinuous at the corners of corallites, where small globose to somewhat circular dissepiments are present. Lonsdaleoid dissepiments are fairly well developed and ordinarily small in size. They are irregular to fan-shaped or subglobose. Faint septal crests may be present on their upper surfaces. Septa are in three orders, almost radially arranged. Major septa average 17 in the mature corallite. They nearly reach the axial column, but ordinarily do not unite directly with septal lamellae of the column, although some major septa are connected to the lamellae. Minor septa are slightly shorter than the majors. Both major and minor septa protrude into the tabularium, where they are more or less dilated. Tertiary septa are observed as crests on corallite walls and lonsdaleoid dissepiments. The fine skeletal structure is obscured. The axial column is well constructed, circular to somewhat elliptical in outline. The column averages 1.3 mm in diameter and occupies one-seventh to one-fifth of that of corallite. It consists of irregularly disposed septal lamellae, sometimes having a medial plate, and axial tabellae. The medial plate may be slightly dilated and the axial tabellae are mostly concentrically arranged. In a relatively younger corallite, the axial column is composed of a single circular axial tabula having a medial plate. The tabularium is annular and is about 1 mm in width. It is composed of cut edges of tabellae which are arranged in concentric to subconcentric pattern. An inner wall may be formed by dilation of the innermost surface of the dissepimentarium. Increase is peripheral. The offset arises in the dissepimentarium of the mother corallite.

In longitudinal section, corallite walls are slightly undulating. The dissepimentarium is comparatively wide, where many rows of globose to somewhat elongate dissepiments are distributed, gently to steeply inclined axially. Dissepiments are rather variable in size. Steeply inclined tabulae may be connected to transverse tabulae, which sometimes arch slightly to the column. Four to seven tabulae occur in a vertical distance of 2 mm. The axial column is composed of successive-

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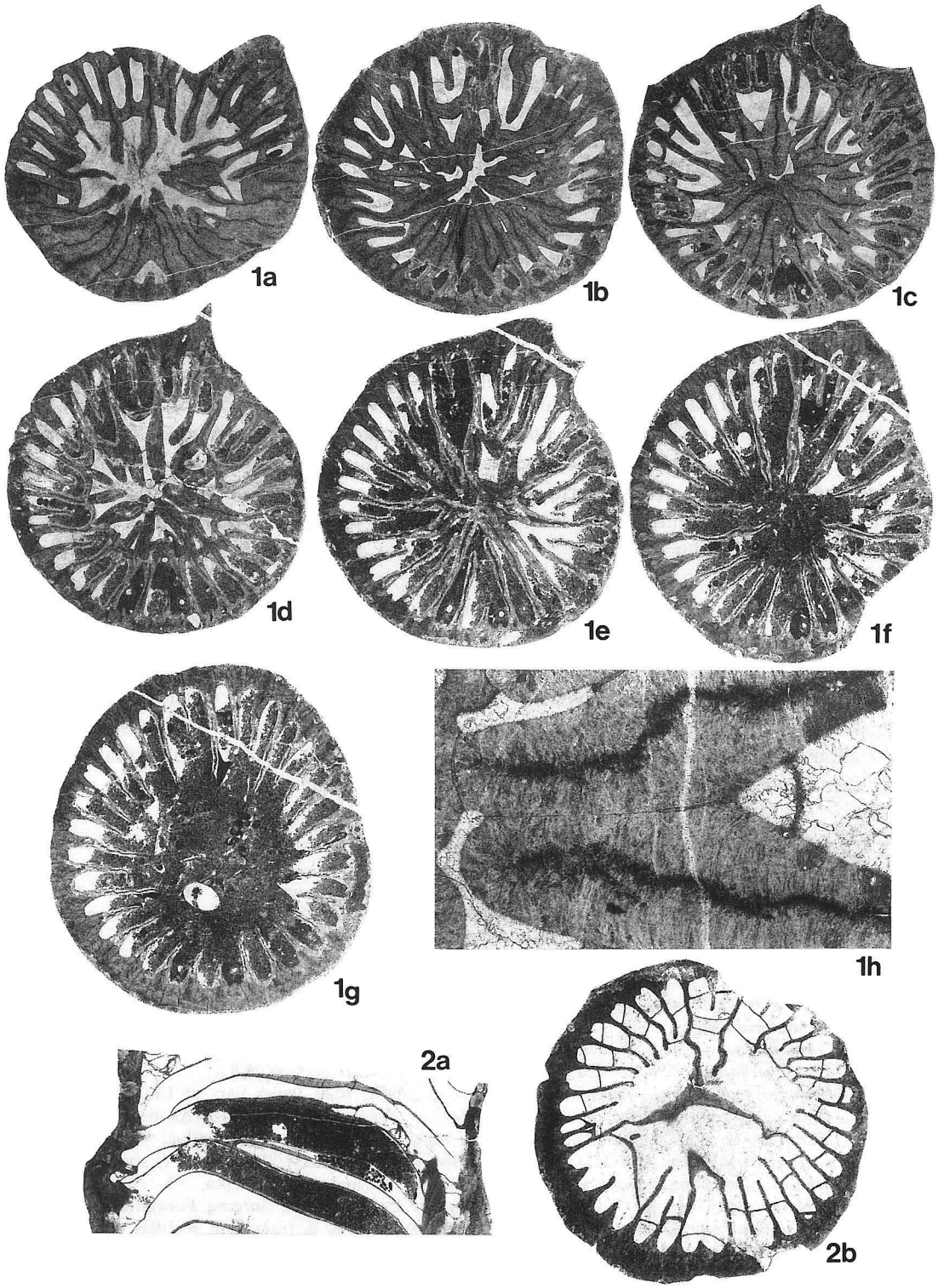
Explanation of Plate 13

Fig. 1 *Ufimia* sp. aff. *U. vanganensis* (Fomichev). OCU 6209, upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. a-g, serial transverse sections. Major septa are curved convex to the cardinal septum and are axially thickened, showing a rhopaloid shape. Minor septa (catasepta) are quite rudimentary when present, ×2.5. h, fine structure of septa, ×15.

Fig. 2 *Ufimia* sp. aff. *U. vanganensis* (Fomichev). OCU 6210, horizon and locality as above. a, longitudinal section, ×2.5. b, transverse section, ×2.5.


1a
1b
1c
1d
1e
1f
1g
1h
2a
2b

ly piled up axial tabellae, steeply descending towards the periphery, and septal lamellae. A medial plate may be discernible, but not persistent.

Remarks: Each corallite is morphologically variable in transverse section. Corallites are irregular in shape, polygonal, sometimes subovate to almost circular. Corallite walls are rather variable in thickness and partly vanish to show an aphroid appearance. Comparatively small lonsdaleoid dissepiments show a marked variation in shape, irregular to fan-shaped. The axial column is variable in size, though generally well constructed. Thus this compound corallum exhibits a wide range of morphological variation, which more or less depends on the corallite growth.

Huang (1932) described two types of corallites within a corallum, caused by the different inclination of tabulae. Huang considered the occurrence to be taxonomically important. However, the feature can be commonly observed in the other species. It is only a matter of degree and of no taxonomical use. The species is similar to *Polythecalis yangtzeensis* Huang, but it is separated from the latter in showing a weak aphroid tendency and irregular lonsdaleoid dissepiments in size and shape. The present form resembles *Polythecalis lata* Zhao from the Lower Permian of South China, but it is distinct from the latter in having smaller corallites with fewer major septa.

Genus *Lonsdaleiastraea* Gerth, 1921

Type species: *Lonsdaleiastraea vinassai* Gerth, 1921.

Remarks: Wang (1986) established the genus *Wentzelastraea* based on materials from the Lower Permian of Bianping of Houchang, Ziyun County, Guizhou. Wang separated his new genus from *Lonsdaleiastraea* by its completely thamnasterioid corallum without aphroid tendency. At present the author holds the view that the feature is not adequate for generic separation, because the type species of the new

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Explanation of Plate 14

Fig. 1 *Lophocarinophyllum lophophyllidum* Liao and Xu. OCU 6217, upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. a, b, transverse sections showing carinated major septa, ×6.

Fig. 2 *Lophocarinophyllum lophophyllidum* Liao and Xu. OCU 6218, horizon and locality as above. Transverse section showing a large axial structure and distinct carinae, ×7.

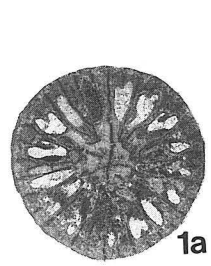
Fig. 3 *Lophocarinophyllum lophophyllidum* Liao and Xu. OCU 6219, horizon and locality as above. Transverse section, ×6.

Fig. 4 *Lophocarinophyllum lophophyllidum* Liao and Xu. OCU 6229, upper part of Unit 3 of the Surmaq Formation, Kuh-e-Hambast, Abadeh. Transverse section, ×6.

Fig. 5 *Lophocarinophyllum lophophyllidum* Liao and Xu. OCU 6220, upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. a, b, d, transverse sections showing carinated major septa, ×7. c, longitudinal section, ×7.

Fig. 6 *Lophocarinophyllum* sp. OCU 6231, Dzhulfian, Kuh-e-Hambast, Abadeh. a-f, successive transverse sections showing a simple columella and carinated major septa, ×7.

Fig. 7 *Lophocarinophyllum* sp. OCU 6232, upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. a, b, transverse sections showing much carinated major septa, ×7.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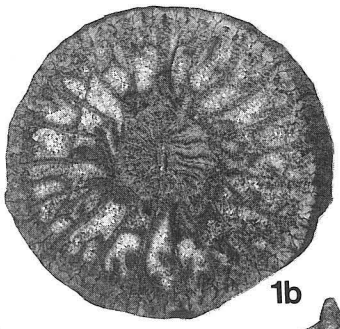
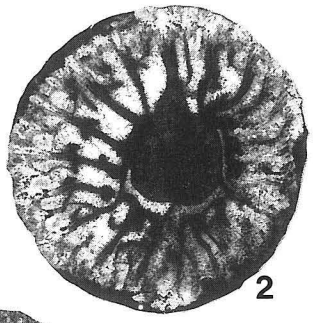

1b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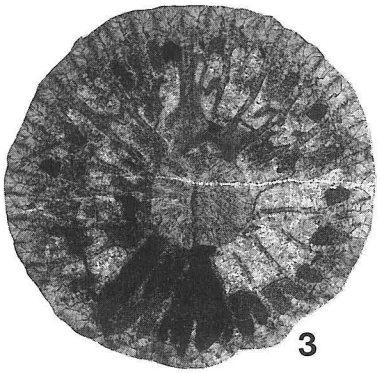
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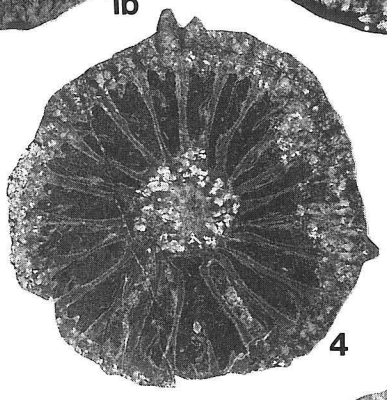
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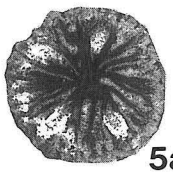
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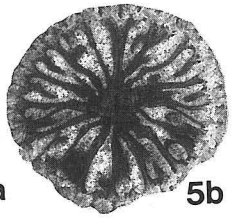
5b


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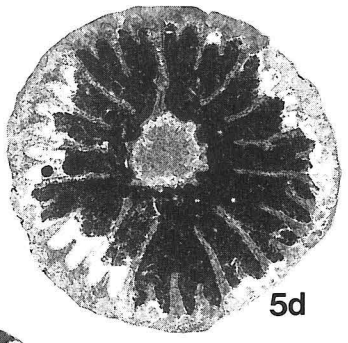
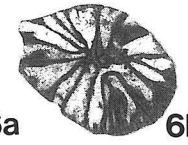
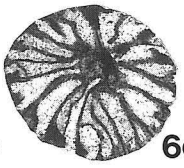

5d


6a


6b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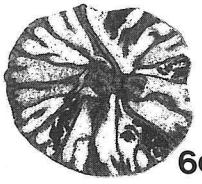
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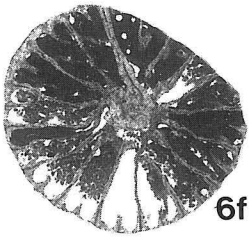
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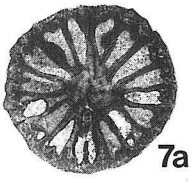
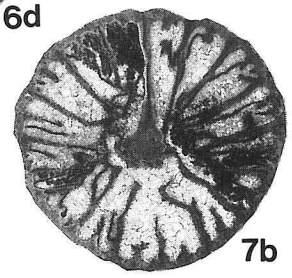

7a


7b

genus, *Wentzelastraea stellata* has partly discontinuous septa. Also, some species of *Lonsdaleiastraea* and *Wentzelastraea* illustrated by Wang (1986) (*e. g., L. guizhouensis* and *W. ziyunensis*) show periodic growth bands. The formation of lonsdaleoid dissepiments and the aphroid tendency seem to be closely related to the growth banding.

Lonsdaleiastraea iranica n. sp.
(Pl. 23, fig. 1a, b)

Derivation of name: The specific name is derived from Iran.

Holotype: OCU 6259; lower part of Unit 3 of the Surmaq Formation (*Orientoschwagerina abichi* Zone), Kuh-e-Hambast, Abadeh, Central Iran.

Material studied: A single specimen (OCU 6259); horizon and locality as above. The specimen is affected by silicification.

Diagnosis: *Lonsdaleiastraea* having a well developed axial column and numerous major septa, highly curved at the periphery.

Description: The corallum is compound, thamnasterioid and partly aphroid. Adjacent corallites are connected by confluent and irregularly sinuous septa. Septa are more or less curved in the peripheral parts, occasionally showing a spiral pattern. They may be irregularly zigzag and occasionally disrupted by the presence of small dissepiments, showing a slight aphroid tendency. About 18 major septa with the same number of minor septa are present in the mature corallite. The majors nearly reach the axial column. Minor septa are slightly shorter and thinner than the majors. They are slightly dilated in the tabularium, tapering axially. Tertiary septa are quite variable in length. Quaternary septa are sporadically present. The fine structure of septa is of diffuso-trabecular type. The axial column is elliptical to circular, constructed of densely arranged axial tabellae and radially disposed septal lamellae. No definite medial plate is present. Short diameter of the column measures 1.7 to 2.3 mm in the mature corallites. The tabularium is comparatively narrow, 1.5 to 2.8 mm in width. Some tabular intercepts are concentrically arranged in the interseptal spaces. An inner wall may be formed by dilation of the innermost part of the dissepimentarium. Dissepiments are arranged in concentric, angulo-concentric and lateral pattern.

In longitudinal section, the dissepimentarium is wide, composed of small globose to somewhat elongate dissepiments. They are almost horizontal to steeply and inclined axially. The tabularium is relatively narrow. Tabulae are complete

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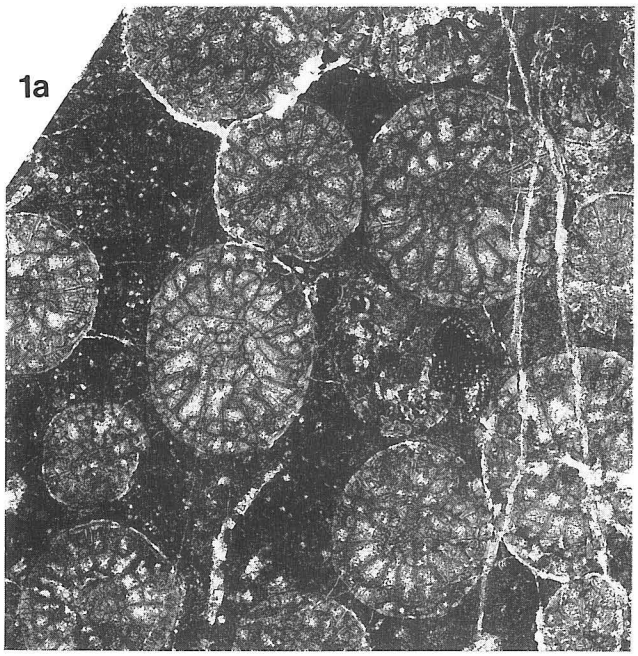
Explanation of Plate 15

Fig. 1 *Yatsengia hangchowensis* (Huang). OCU 6239, upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. a, transverse section, ×4. b, longitudinal section showing lateral increase, ×4.

Fig. 2 *Ipciphyllum huangi* Minato and Kato. OCU 6245, lower part of Unit 3 of the Surmaq Formation, Kuh-e-Hambast, Abadeh. a, b, transverse sections showing a small axial column, ×4. c, longitudinal section, ×4.


1a


1b


2a


2b


2c

or incomplete and concave upwards. They sag steeply from the innermost surface of the dissepimentarium and are sometimes turned up at the axial column. Some transverse tabulae are present. Seven to ten tabulae occur in a vertical distance of 2 mm. The axial column is stoutly constructed of closely superimposed, steep axial tabellae and some septal lamellae.

Remarks: The present species from the upper part of the Surmaq Formation at Abadeh is similar to *Lonsdaleiastraea vinassai* Gerth. However, the former shows a highly developed axial column and more numerous major septa which are strongly curved in the peripheral parts. In addition, this form shows poorly developed aphroid tendency compared to the latter species. The Iranian specimen resembles *Lonsdaleiastraea stellata* (Wang) from the Lower Permian of South China, but it is distinguishable from the latter in having a more complex axial column and curved major septa.

Subclass Tabulata Milne-Edwards and Haime, 1850
Order Favositida Wedekind, 1937

Family Micheliniidae Waagen and Wentzel, 1886
Genus *Protomichelinia* Yabe and Hayasaka, 1915

Type species: *Michelinia (Protomichelinia) microstoma* Yabe and Hayasaka, 1915.

Protomichelinia microstoma (Yabe and Hayasaka, 1915)
(Pl. 24, fig. 1a, b)

1915 *Michelinia (Protomichelinia) microstoma* Yabe and Hayasaka, p. 61.
1920 *Michelinia (Protomichelinia) microstoma* Yabe and Hayasaka; Yabe and Hayasaka, pl. 9, fig. 8a, b.
1925 *Michelinia mansuyi* Reed, p. 12, pl. 1, figs. 16-21.
1932 *Michelinia microstoma* Yabe and Hayasaka; Huang, p. 92, pl. 11, fig. 3a, b.
1962 *Protomichelinia microstoma* (Yabe and Hayasaka); Lin, p. 222, pl. 3, figs. 1a, b, 3a, b.
1963 *Protomichelinia microstoma* (Yabe and Hayasaka); Yü *et al.*, p. 241, pl. 78, figs. 1a, b, 2a, b.
?1977 *Protomichelinia microstoma* (Yabe and Hayasaka); Jia *et al.*, p. 249, pl. 108, fig. 6a, b.
1978 *Protomichelinia microstoma* (Yabe and Hayasaka); Yang, p. 193, pl. 64, fig. 5a, b.
1978 *Protomichelinia microstoma* (Yabe and Hayasaka); Kim, p. 141, pl. 46, fig. 5a, b.
1982 *Protomichelinia microstoma* (Yabe and Hayasaka); Zhu *et al.*, p. 172, pl. 65, fig. 6a, b.
?1984 *Protomichelinia microstoma* (Yabe and Hayasaka); Liu, p. 107, pl. 50, fig. 1a, b.

Type: The specimen described by Yabe and Hayasaka (1915, p. 61); Mei-tse-

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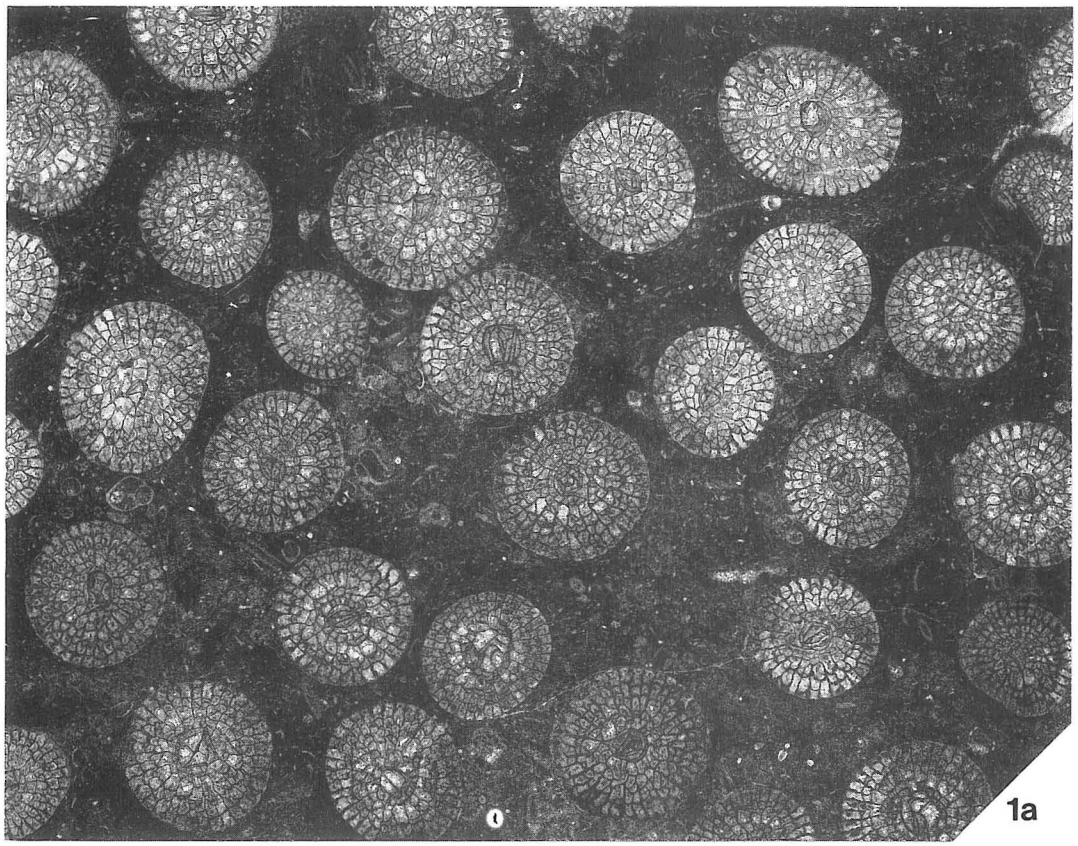
Explanation of Plate 16

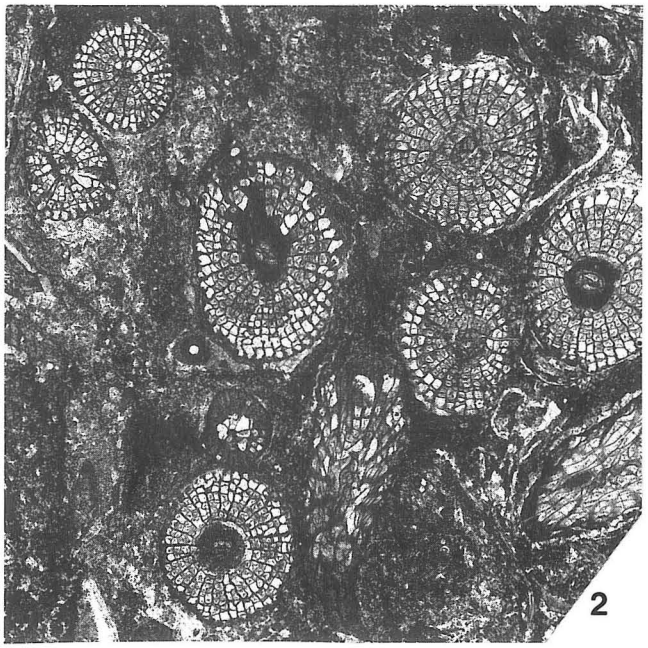
Fig. 1 *Waagenophyllum (Waagenophyllum) kueichowense* Huang. OCU 6241, upper part of the Khachik Formation (*Codonofusiella-Reichelina* Zone), Kuh-e-Ali Bashi, Julfa. a, transverse section showing thin corallite walls and a comparatively small axial column, ×4. b, longitudinal section, ×4.

Fig. 2 *Waagenophyllum (Waagenophyllum) kueichowense* Huang. OCU 6242, horizon and locality as above. Transverse section showing a small axial column, ×3.



1a

1b



2

Material studied: A single specimen (OCU 6260); Gnishik Formation, Kuh-e-Ali Bashi, Julfa. The sample is embedded in limestone matrix.

Description: In transverse section, corallites are triangular to quadrangular in the earlier stages, pentagonal to hexagonal in the later stages. Mean corallite diameter ranges from 2.1 to 2.8 mm, averaging 2.5 mm. Corallite walls are irregularly undulating, owing to numerous projections and swellings and show occasional gaps at mural pores. The walls are about 0.2 mm in thickness. The wall microstructure shows laterally directed fibres and a dark line which is rather sinuous and zigzag. Mural pores are numerous. Tabular traces show various patterns, sometimes circular, completely free from corallite walls.

In longitudinal section, tabulae are mostly complete and flat to convex upwards, sometimes incomplete to show a vesicular pattern. They are sparsely spaced, seven to ten in a vertical distance of 5 mm. Numerous vertical cuts of the projections are directed from the wall horizontally to upwards.

Remarks: The present form is specifically marked by numerous mural pores and septal projections. Domed and complete tabulae occur sparsely. The Iranian species is similar to *Protomichelinia favositoides* (Girty), but it is separable from the latter in having sparse, domed tabulae and thinner walls. The present species bears a closer resemblance to *Protomichelinia multisepta* (Huang), but it is distinguishable from the latter in having thinner walls.

Protomichelinia favositoides (Girty, 1907)
(Pl. 25, figs. 1, 2a, b)

1907 *Michelinia favositoides* Girty, p. 38.
1913 *Michelinia favositoides* Girty; Girty, p. 312, pl. 29, figs. 1, 2.
1958 *Michelinia favositoides* Girty; Hudson, p. 188, pl. 32, figs. 5, 6.
1964 *Protomichelinia favositoides* (Girty); Flügel, p. 428, pl. 34, figs. 1, 2.

Type: The specimen described by Girty (1907, p. 38); Ta-ning-hsien, east Sichuan, China; Wu-shan Limestone.

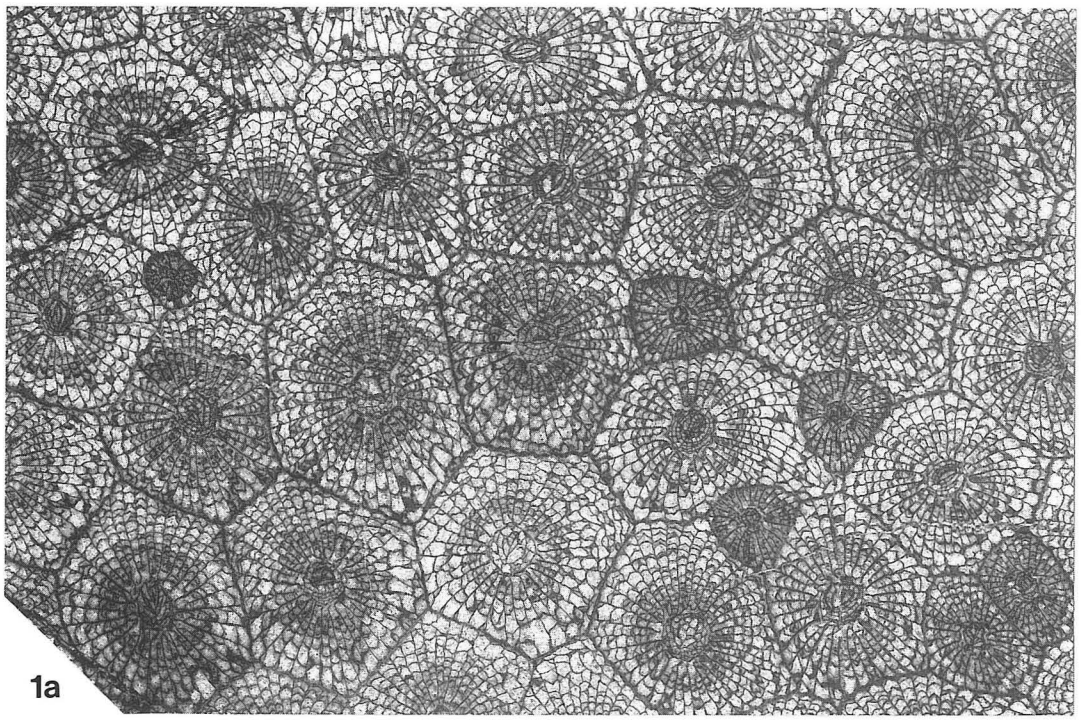
Material studied: Four fragmentary specimens (OCU 6261-6264); upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh.

Description: In transverse section, corallites are polygonal, showing five to six sides. They may be irregularly triangular to quadrangular and circular in the ear-

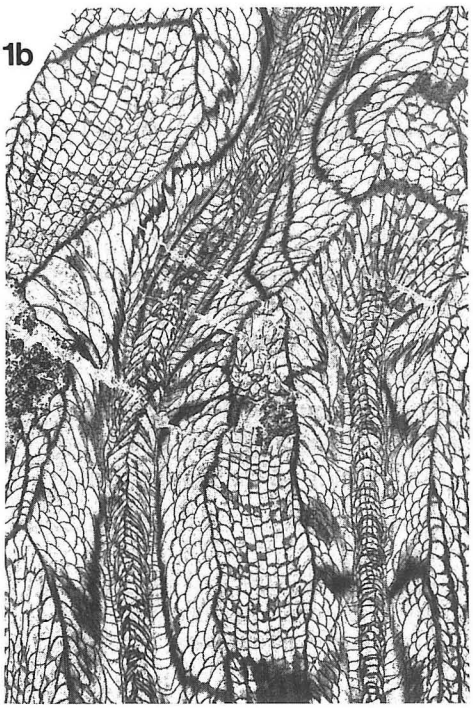
Explanation of Plate 17

Fig. 1 *Ipciphyllum subtimoricum* (Huang). OCU 6244, upper part of the Nesen Formation (Unit 2), Elikah, Alborz Mountains. a, transverse section showing a well bounded axial column with a prominent medial plate, ×3. b, longitudinal section showing a distinct trizonal arrangement, ×3.

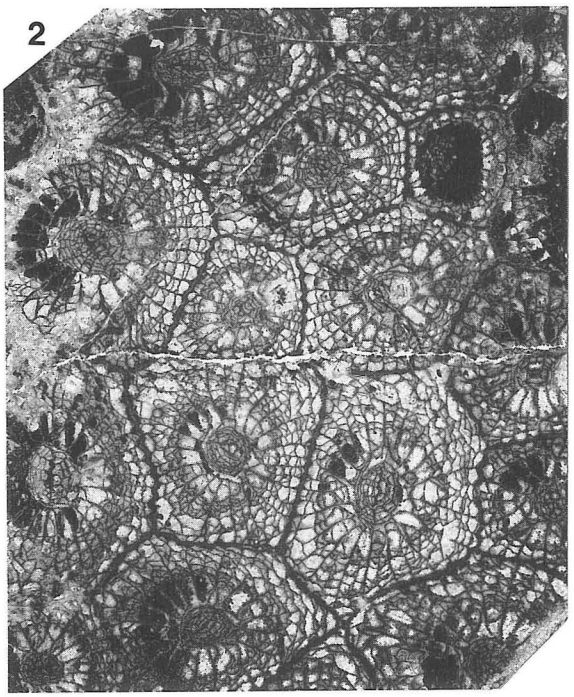
Fig. 2 *Ipciphyllum* sp. aff. *I. stabilis* Zhao. OCU 6253, upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. Transverse section showing a large axial column with a distinct medial plate, ×3.



1a



1b



2

lier stages. Corallite diameter is variable, ranging from 1.1 to 2.0 mm with an average of 1.6 mm. Corallite walls appear to vary considerably in thickness, 0.15 to 0.55 mm, but generally thick. The wall microstructure is fibrous. A dark line is ordinarily detectable in the wall. It is interrupted by sporadically formed mural pores, especially at the corallite corners. The inside of corallite walls is irregularly undulating with many spiny projections and swellings. Tabular intercepts appear, sometimes forming a vesicular arrangement.

In longitudinal section, each corallite is disposed almost parallel. Tabulae are mostly complete, flat to slightly convex upwards, 11 to 16 in a vertical distance of 5 mm. They are sometimes irregularly sinuous and inclined. Some spines are projected from the wall horizontally to upwards. They may be observed only as scattered dots.

Remarks: Although the corallites exhibit a wide range of variability in size and wall thickness, the species is characteristic in showing the comparatively small corallites with numerous spiny projections. Tabulae are ordinarily complete and horizontal, sometimes irregularly wavy. The present species is identical with *Protomichelinia favositoides* (Girty), although it has smaller corallites than the specimens illustrated by Girty (1913, pl. 29, figs. 1, 2)

Protomichelinia laosensis (Mansuy, 1914)
(Pl. 25, fig. 3a, b; Pl. 26, fig. 1a, b)

1914 *Favosites laosensis* Mansuy, p. 29. pl. 2, fig. 7a-c.
1955 *Pleurodictyum (Michelinia) laosensis* (Mansuy); Fontaine, p. 75, pl. 4, figs. 1, 2.
1986 *Protomichelinia laosensis* (Mansuy); Fontaine, p. 186, pl. 1, figs. 3, 4; pl. 2, figs. 1-3.

Type: The specimen figured by Mansuy (1914, p. 29, pl. 2, fig. 7); Nong-Po, Laos.

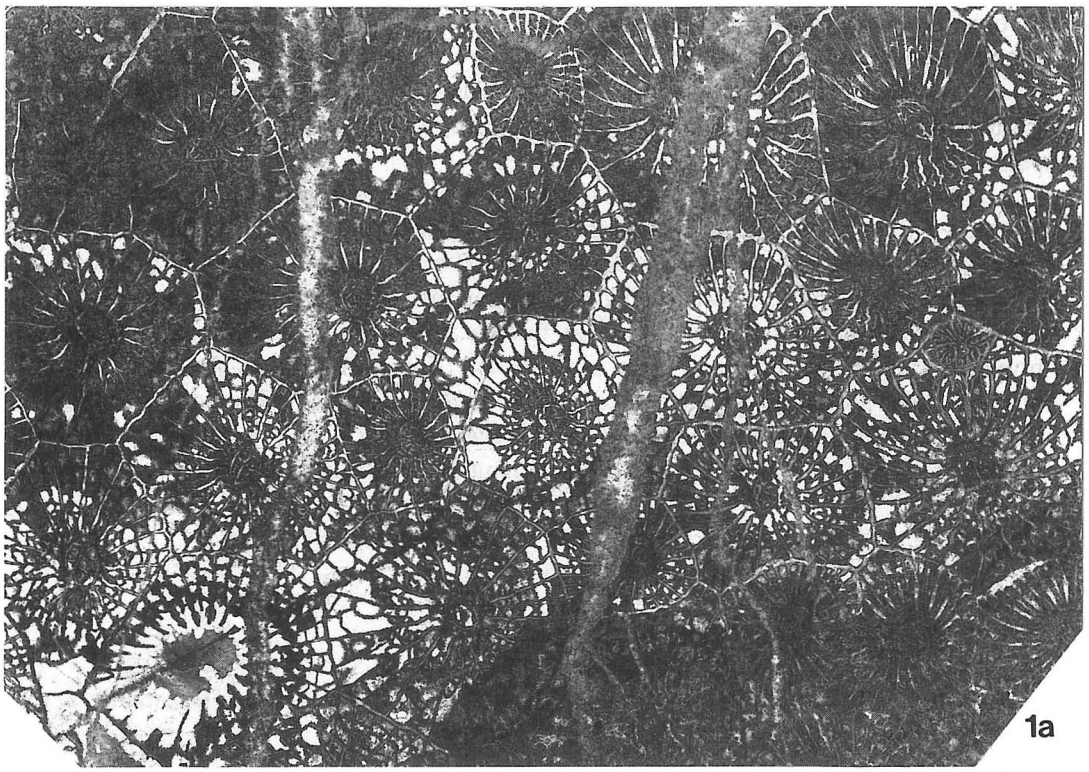
Material studied: Seventeen coral specimens (OCU 6265-6281); basal part of Unit 4 of the Abadeh Formation, Kuh-e-Hambast, Abadeh.

Description: The shape of coralla exhibits some variation, somewhat nodular to columnar, showing the maximum observed diameter and height of 49.6×37.8 mm. No proximal part of a corallum is preserved. The epitheca bears distinct transverse markings consisting of wrinkles and growth lines.

In transverse section, corallites are pentagonal to hexagonal in the later stages, whereas they are irregularly triangular to quadrangular in the earlier stages. Corallites are rather variable in size, ranging from 3.3 to 4.9 mm in diameter, with an

Explanation of Plate 18

Fig. 1 *Ipciphyllum heritschi* Minato and Kato. OCU 6246, lower part of Unit 3 of the Surmaq Formation, Kuh-e-Hambast, Abadeh. a, transverse section showing a small axial column and long minor septa. b, longitudinal section showing sparsely arranged transverse tabulae, ×3.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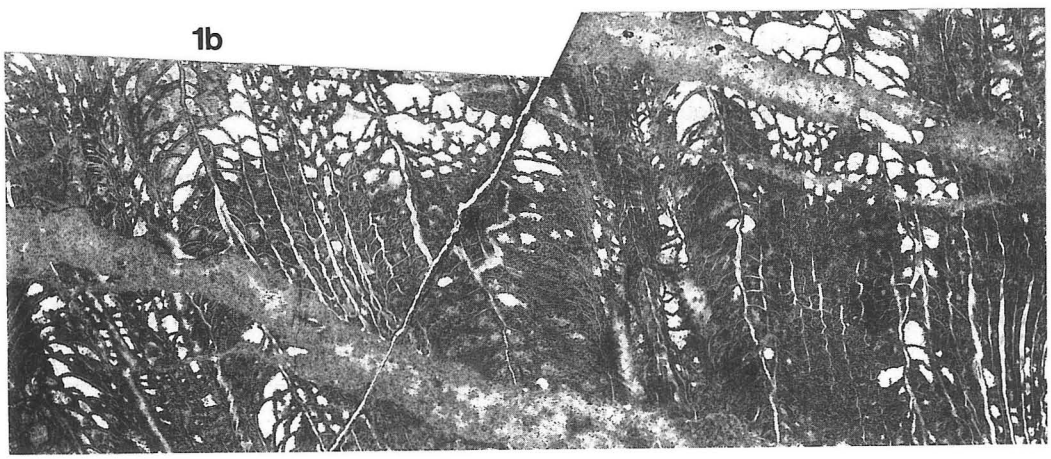
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average diameter of 4.4 mm. Corallite walls are variable in thickness, averaging 0.3 mm. It is slightly sinuous and sporadically shows irregular swellings. The wall microstructure is fibrous. The dark line is more or less curved and intermittent. Mural pores are sparsely present. Some cut edges of tabulae appear, sometimes forming a vesicular pattern. Small spots caused by the parasitic organisms may be observed in corallite walls.

In longitudinal section, corallite walls show occasional gaps by mural pores. Tabulae are mostly complete and almost flat to slightly undulating. Some are concave upwards. Four to seven tabulae are counted in a vertical distance of 5 mm.

Remarks: The most distinguishing features of the present species are moderate-sized corallites having complete and flat tabulae. Corallite walls are occasionally provided with mural pores and spiny projections. This species from the lower part of the Abadeh Formation is similar to *Protomichelinia abnormis* (Huang) in having almost complete tabulae. The latter is, however, clearly distinguishable from the former in showing much larger corallites without spiny projections.

Protomichelinia allata (Tchudinova, 1965)
(Pl. 26, figs. 2a, b, 3, 4a, b)

1965 *Michelinopora allata* Tchudinova, p. 154, pl. 10, fig. 2a, b.

Holotype: PIN, No. 2053/54, Palaeont. Inst., USSR Acad. Sci.; Dorasham 2, Dzhulfa, Nakhichevan; Upper Permian, Dzhulfa Formation.

Material studied: Eight coralla (OCU 6282-6289); middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa.

Description: The coralla exhibit a wide range of variability in size and shape, columnar forms having an average diameter and height of 14.6×26.5 mm to somewhat flattened bulbous forms, 29.7×84.0 mm. The external surface is rather undulating, marked by numerous growth lines and low wrinkles. No proximal tip is preserved.

In transverse section, corallites are irregularly quadrangular to rarely octagonal, averaging 6.6 mm in diameter. Triangular to irregularly quadrangular corallites are ordinarily observed in the earlier stages. Corallite walls are fibrous and comparatively thin, ranging from 0.15 to 0.40 mm. The dark line is partly sinuous and disrupted. Mural pores are present, but not common. Transverse tabular

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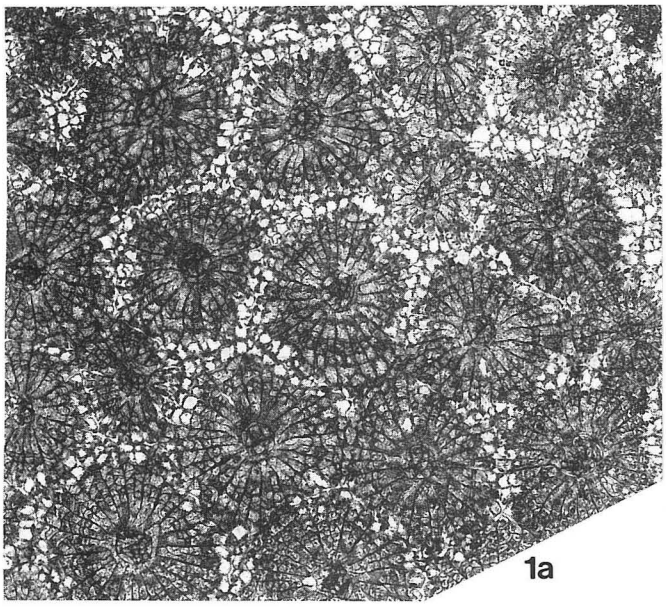
Explanation of Plate 19

Fig. 1 *Ipciphyllum subelegans* Minato and Kato. OCU 6249, upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. a, transverse section showing a loosely constructed axial column with a dilated medial plate and dilated major septa in the tabularium, ×3. b, longitudinal section, ×3.

Fig. 2 *Ipciphyllum guangdongense* Xu. OCU 6251, middle part of the Surmaq Formation (Unit 2), Kuh-e-Hambast, Abadeh. a, transverse section showing a loosely formed axial structure, ×3. b, longitudinal section, ×3.



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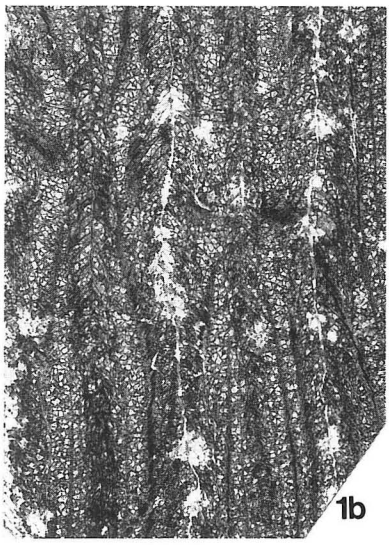

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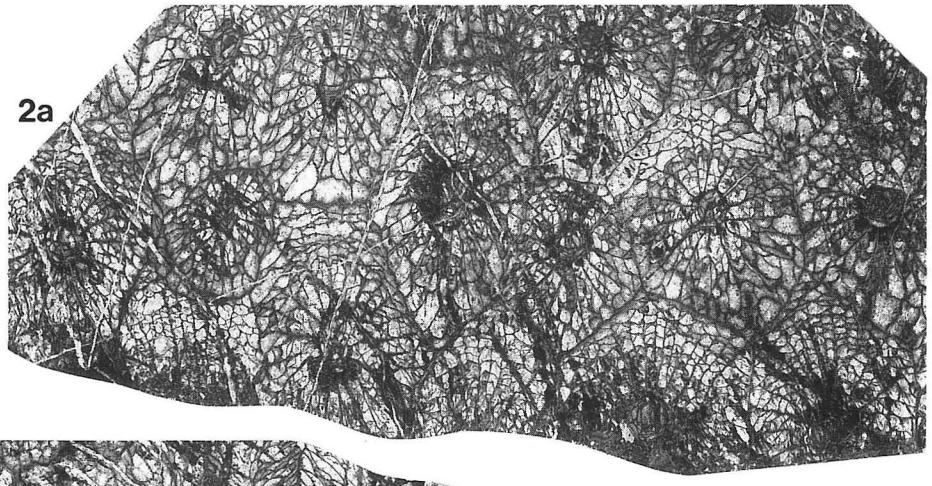


2a

2b

traces are variable in arrangement. No distinct septal spines are developed, although low swellings are sporadically distributed on corallite walls.

In longitudinal section, corallite walls are more or less sinuous. Tabulae are not so numerous and variable in arrangement. They are complete or incomplete, almost horizontal to irregularly inclined, showing a vesicular pattern. There are three to five tabulae in a vertical distance of 5 mm.

Remarks: The present species established by Tchudinova (1965) within the genus *Michelinopora* is characterised by large corallites having sparsely spaced tabulae and no septal ridges. The present author places the species within the genus *Protomichelinia,* because *Michelinopora* proposed by Yabe and Hayasaka (1915) was characterised by numerous low septal ridges.

Tchudinova (1965) proposed a new species under the name of *Michelinopora globosa* on materials from the higher horizon than that of the present species. The former was specifically discriminated from the latter in having more loosely distributed tabulae and thicker walls. Those features, however, seem to show a large variation, even within a corallum. Detailed investigation on the morphological changes combined with intraspecific variability should be needed for definite specific separation.

Protomichelinia sp.
(Pl. 27, fig. 1a, b)

Material studied: Four fragmentary coralla much affected by silicification (OCU 6290-6293); uppermost part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh.

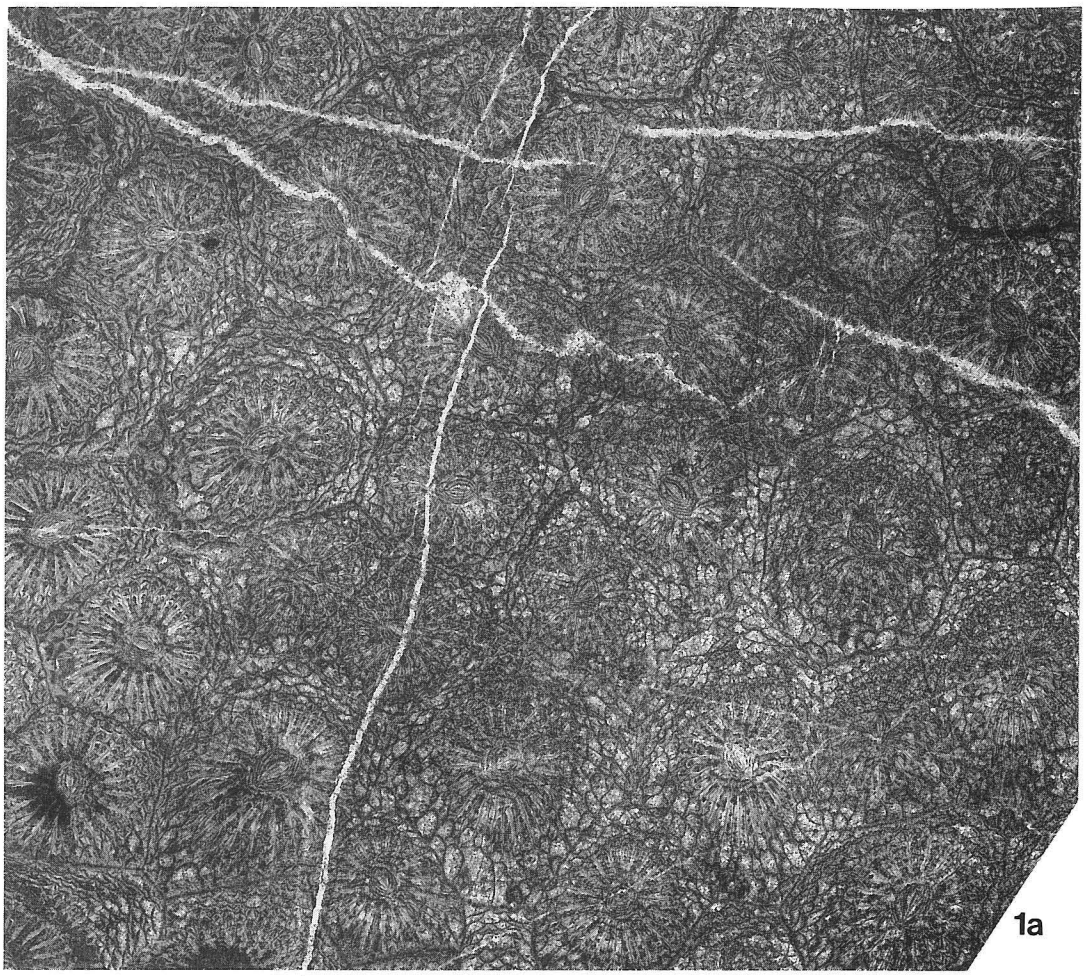
Description: Coralla of varying form, somewhat stratiform to irregular bulbous, measure at least 18.2 mm in maximum diameter and 7.3 mm in height. The epitheca is marked by fine growth lines and wrinkles.

In transverse section, corallites are regularly polygonal, showing five to six sides and range from 1.5 to 2.2 mm in diameter with an average of 1.8 mm. They show triangular to circular in the earlier stages. Corallite walls are almost straight and comparatively thick, averaging 0.3 mm in thickness. The wall microstructure appears to be fibrous with a dark line. Corallite walls are often penetrated by mural pores. The inside of corallite walls bears irregularly distributed low septal spines. Tabular intercepts are sparsely present.

In longitudinal section, tabulae are complete or incomplete, more or less convex upwards. They are variably spaced, about ten in a vertical distance of 5 mm,

Explanation of Plate 20

Fig. 1 *Miyagiella tabasensis* (Minato and Kato). OCU 6255, lower part of the Julfa Formation (*Araxilevis-Orthotetina* Zone), Kuh-e-Ali Bashi, Julfa. a, transverse section showing a well constructed axial column with a distinct medial plate. Several rows of small lonsdaleoid dissepiments occupy the corallite periphery, ×3. b, longitudinal section showing well developed transverse tabulae, ×3.



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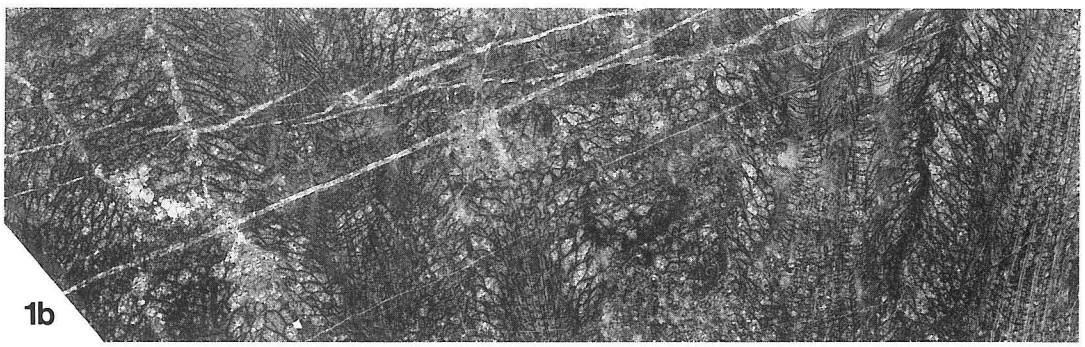

1b

sometimes showing a vesicular pattern. Some low spines are directed from the wall subhorizontally.

Remarks: The present species is marked by having comparatively small corallites, thick walls, and many mural pores. Tabulae are mostly complete and convex upwards to varying degrees. The present species can not be specifically identified due to poor preservation of the materials. This species is similar to *Protomichelinia multisepta* (Huang), but it is distinguishable from the latter in having many mural pores and less numerous septal spines. The Iranian specimens resemble *Protomichelinia laosensis* (Mansuy), but it is distinct from the latter in having smaller corallites with thick walls.

Order Auloporida Sokolov, 1947
Family Sinoporidae Sokolov, 1955
Genus *Sinopora* Sokolov, 1955
Type species: *Monilopora dendroidea* Yoh in Yoh and Huang, 1932.

Sinopora asiatica (Mansuy, 1913)
(Pl. 27, figs. 2, 3a, b)

1913 *Romingeria asiatica* Mansuy, p. 111, pl. 11, fig. 13.
1955 *Romingeria asiatica* Mansuy; Fontaine, p. 76, pl. 4, figs. 4-6; pl. 5, fig. 8.
1961 *"Romingeria" asiatica* Mansuy; Fontaine, p. 213.
1988 *Sinopora asiatica* (Mansuy); Fontaine, p. 114, pl. 10, fig. 5; pl. 11, fig. 1; pl. 13, figs. 5, 6.

Type: The specimen described by Mansuy (1913, p. 111, pl. 11, fig. 13).

Material studied: Three specimens (OCU 6294-6296); upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh; Gnishik Formation, Kuh-e-Ali Bashi, Julfa. The corallum is embedded in limestone matrix and more or less silicified.

Description: The corallum is compound and dendritic, showing branching corallites with various growth directions. The weathered surface of the corallites show slight transverse wrinkles. Some corallites are in lateral contact. No connecting processes are detected. Corallites are circular to ovate, ranging from 1.2 to 1.9 mm with an average of 1.5 mm in diameter. Corallite walls are conspicuously thick, 0.3 to 0.5 mm in thickness, occupying about two-fifths to three-fifths of the diameter of corallite. It is composed of two layers of fibrous zone, in which inner one is generally thinner, lining the corallite. The boundary zone may show a dark layer. The

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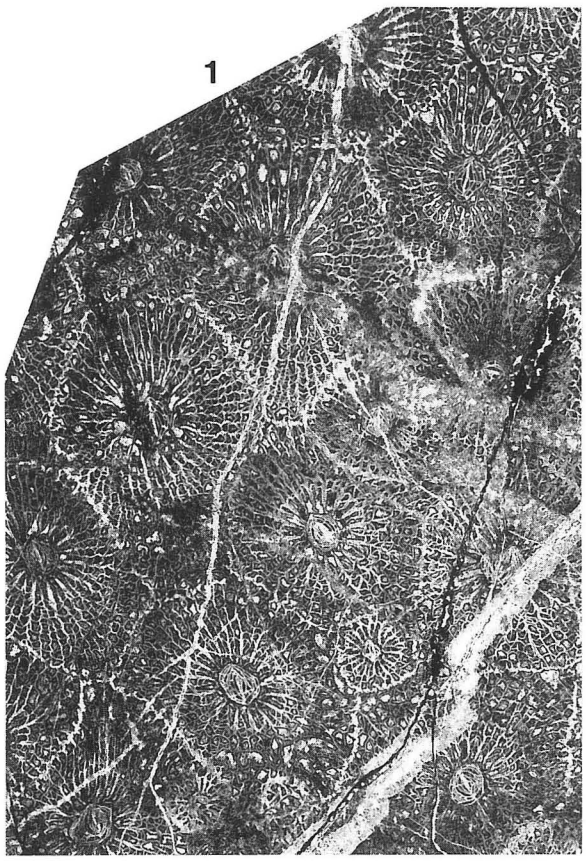
Explanation of Plate 21

Fig. 1 *Wentzelella (Wentzelella) densicolumnata* Iljina. OCU 6256, lower part of Unit 3 of the Surmaq Formation, Kuh-e-Hambast, Abadeh. Transverse section showing a compactly constructed axial column.

Fig. 2 *Wentzelella (Wentzelella) densicolumnata* Iljina. OCU 6257, horizon and locality as above. a, transverse section, ×3. b, longitudinal section showing successively piled up axial tabellae, ×3.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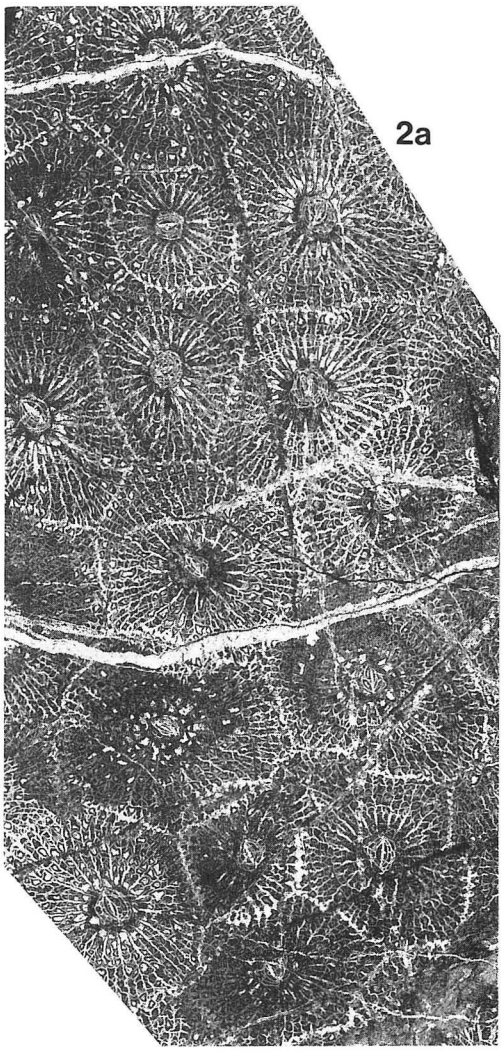
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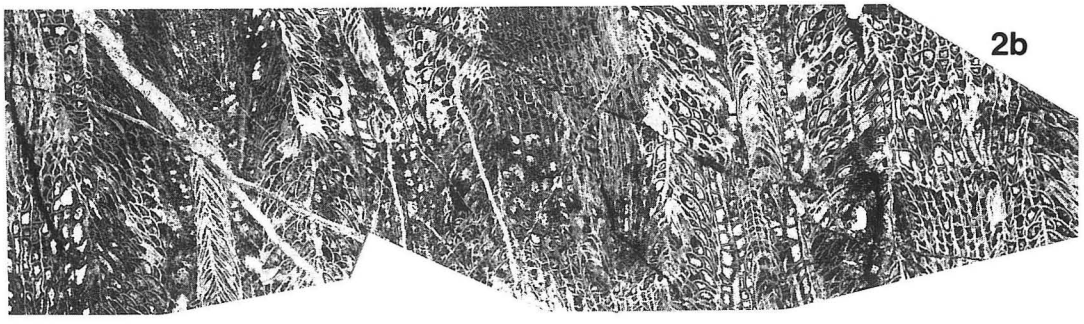
2b

inside of corallite walls is slightly undulating with some spiny projections. Tabulae are absent or rarely observed.

Remarks: This species shows a wide range of variability in corallite diameter (Fontaine, 1988). Tabulae may be sporadical, although they are generally few. The present species is characterised by dendritic corallum with some spiny projections and few tabulae. *Sinopora dendroidea* Yoh resembles the present species, but it is separable from the latter by the entire absence of septa and tabulae. This Iranian species is akin to *Sinopora minatoi* Rowett, but it differs from the latter in showing sparsely distributed corallites and few tabulae.

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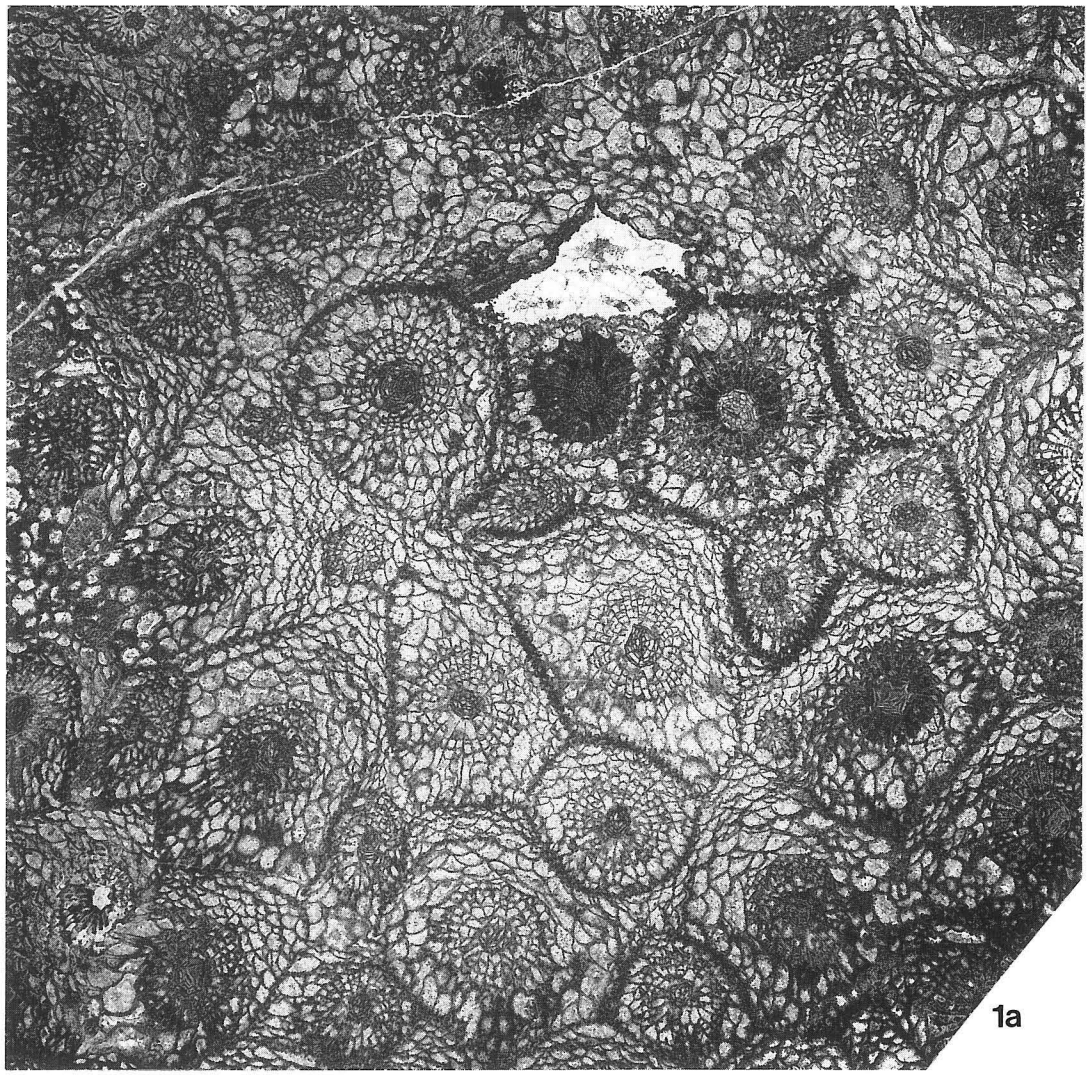
Explanation of Plate 22

Fig. 1 *Polythecalis dupliformis* Huang. OCU 6258, horizon unknown, Kuh-e-Ali Bashi, Julfa. a, transverse section. Each corallite shows a marked morphological variation. For further explanation see text, ×3. b, c, longitudinal sections, ×3.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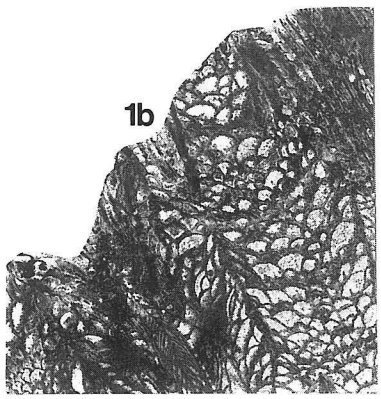
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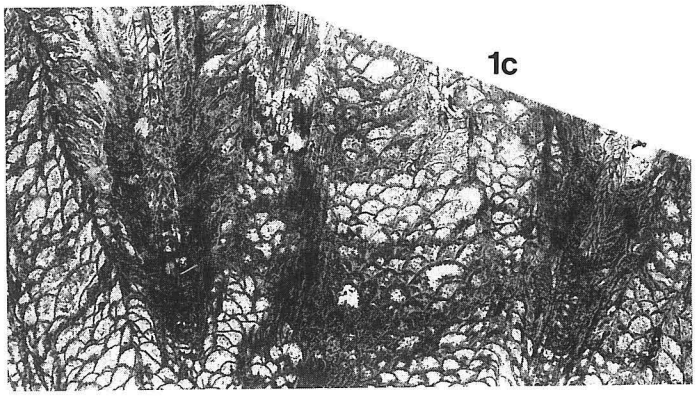
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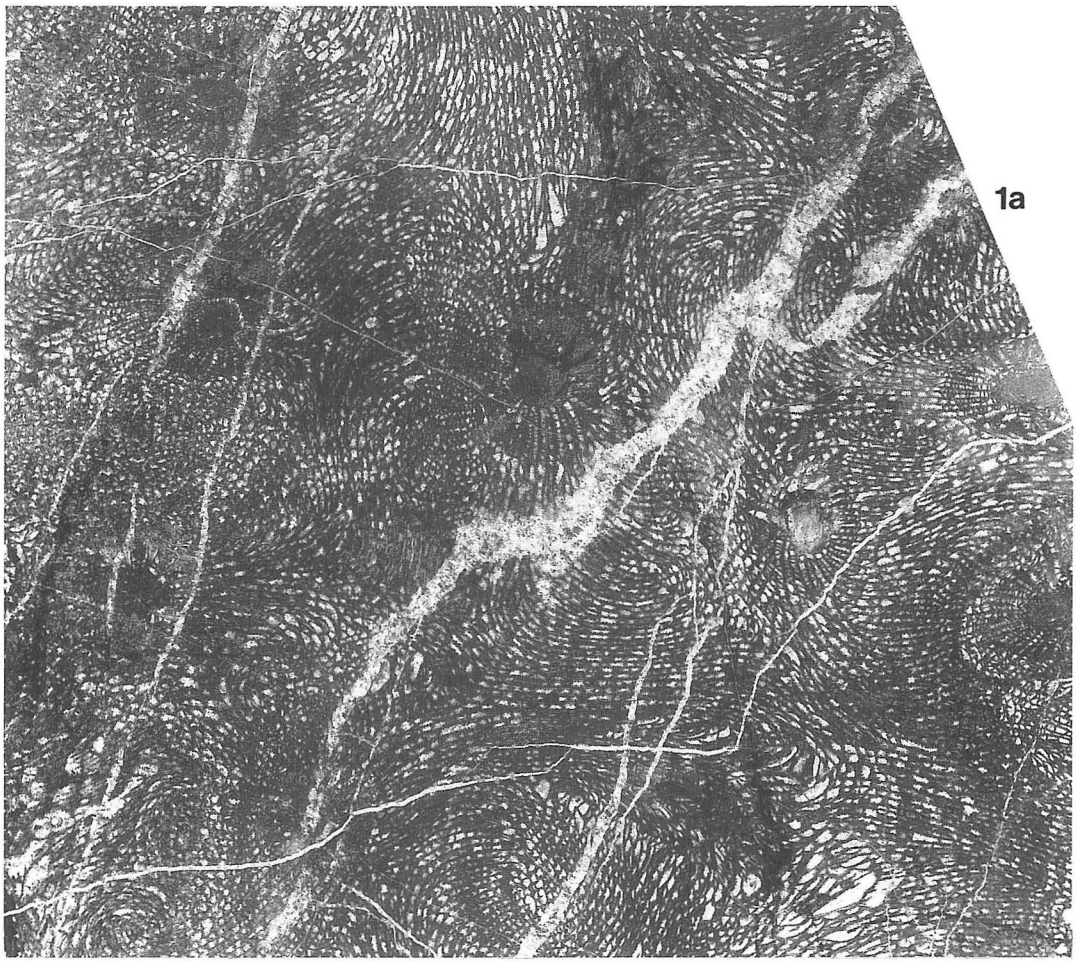
Explanation of Plate 23

Fig. 1 *Lonsdaleiastraea iranica* n. sp. OCU 6259 (Holotype), lower part of Unit 3 of the Surmaq Formation, Kuh-e-Hambast, Abadeh. a, transverse section showing a well developed axial column. Major septa are numerous and strongly curved at the periphery, ×2.5. b, longitudinal section, ×2.5.



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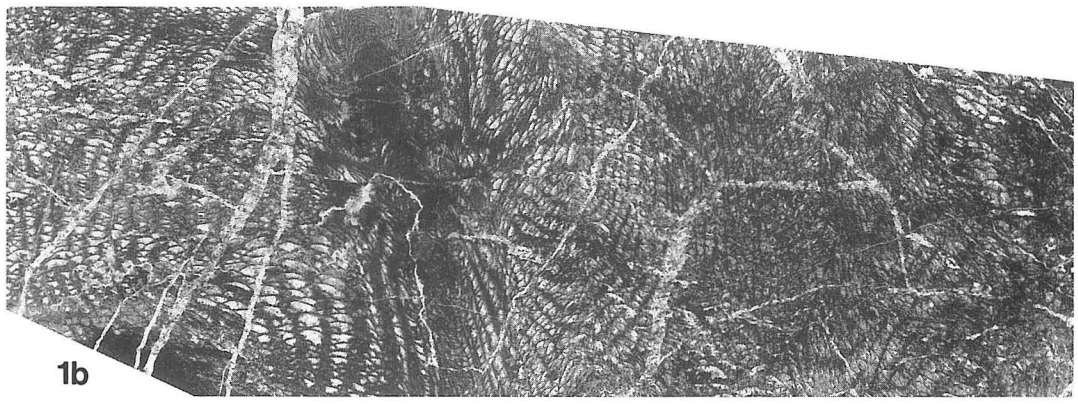

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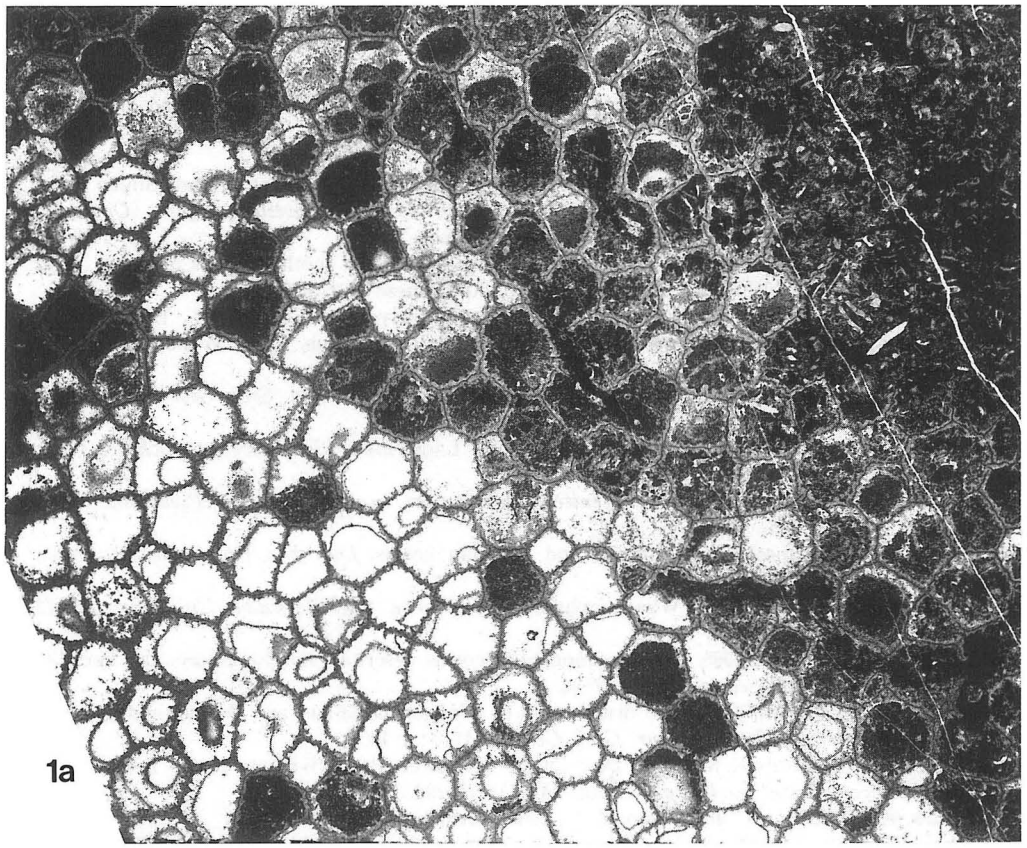
Explanation of Plate 24

Fig. 1 *Protomichelinia microstoma* (Yabe and Hayasaka). OCU 6260, Gnishik Formation, Kuh-e-Ali Bashi, Julfa. a, transverse section showing numerous septal projections, ×4. b, longitudinal section showing somewhat domed tabulae, ×4.



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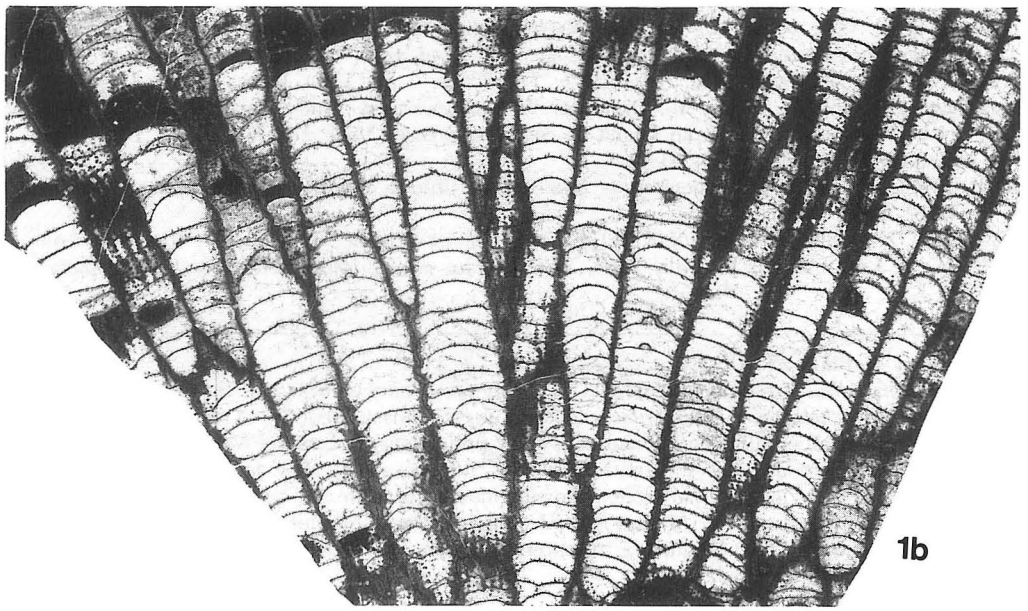

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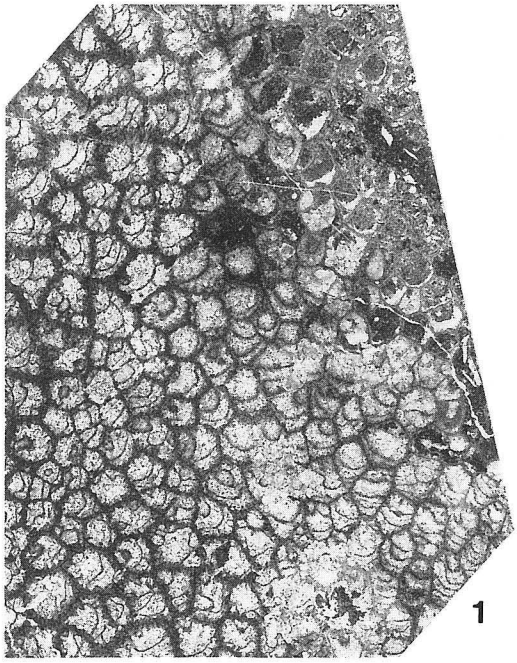
Explanation of Plate 25

Fig. 1 *Protomichelinia favositoides* (Girty). OCU 6261, upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. Transverse sections showing small corallites with numerous spiny projections on corallite walls, ×4.

Fig. 2 *Protomichelinia favositoides* (Girty). OCU 6262, horizon and locality as above. a, transverse section, ×4. b, longitudinal section showing mostly complete and horizontal tabulae, ×4.

Fig. 3 *Protomichelinia laosensis* (Mansuy). OCU 6265, basal part of Unit 4 of the Abadeh Formation, Kuh-e-Hambast, Abadeh. a, transverse section, ×3. b, longitudinal section showing complete and flat tabulae, ×3.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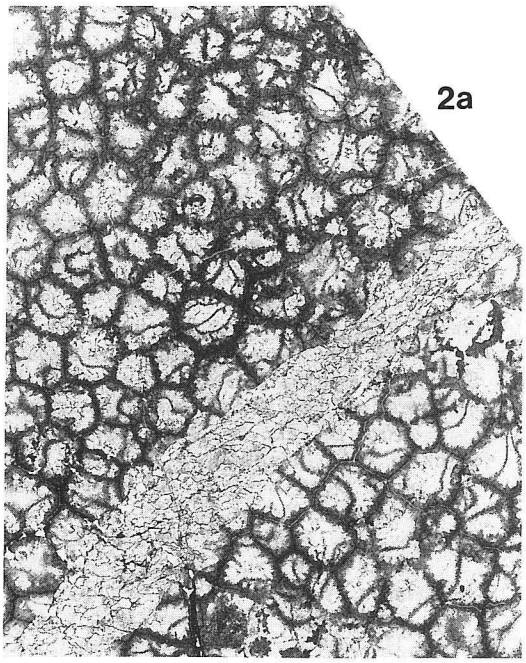
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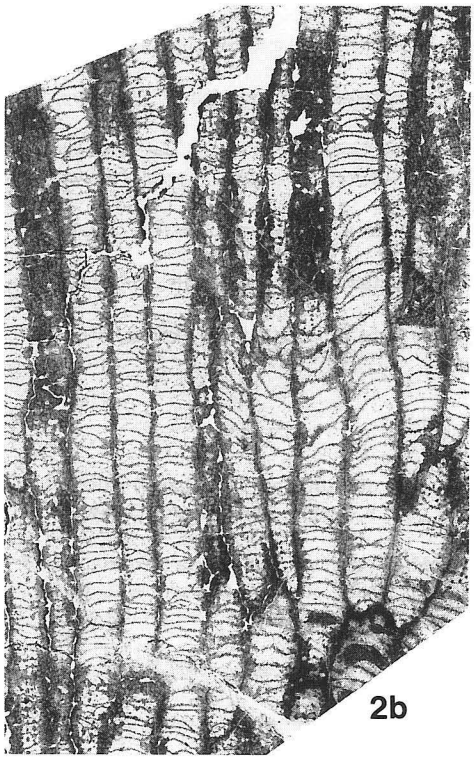
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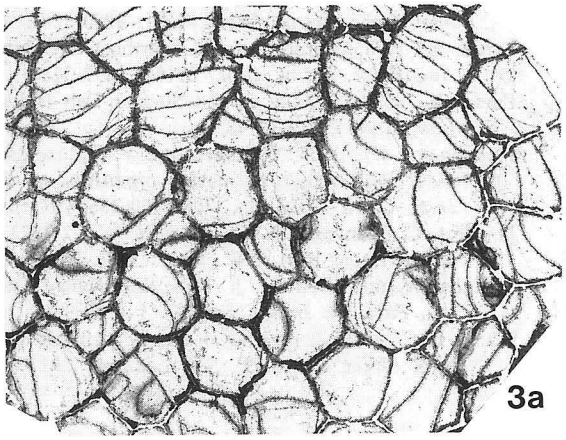
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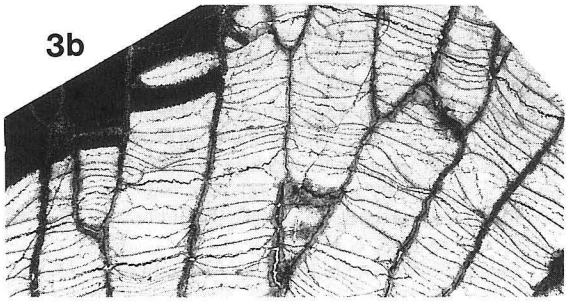
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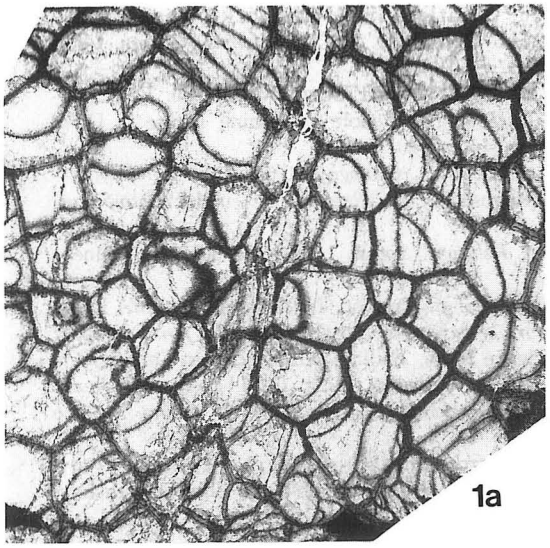
Explanation of Plate 26

Fig. 1 *Protomichelinia laosensis* (Mansuy). OCU 6266, basal part of Unit 4 of the Abadeh Formation, Kuh-e-Hambast, Abadeh. a, transverse section, ×3. b, longitudinal section showing complete tabulae, ×3.

Fig. 2 *Protomichelinia allata* (Tchudinova). OCU 6282, middle part of the Julfa Formation (*Pseudogastrioceras-Permophricodothyris* Zone), Kuh-e-Ali Bashi, Julfa. a, transverse section showing thin corallite walls and few septal spines, ×3. b, longitudinal section showing sparsely arranged tabulae, ×3.

Fig. 3 *Protomichelinia allata* (Tchudinova). OCU 6283, horizon and locality as above. Transverse section, ×3.

Fig. 4 *Protomichelinia allata* (Tchudinova). OCU 6284, horizon and locality as above. a, transverse section, ×3. b, longitudinal section, ×3.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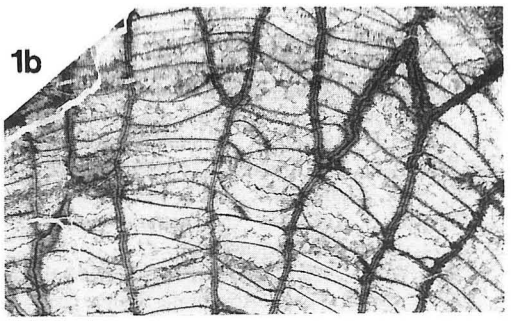
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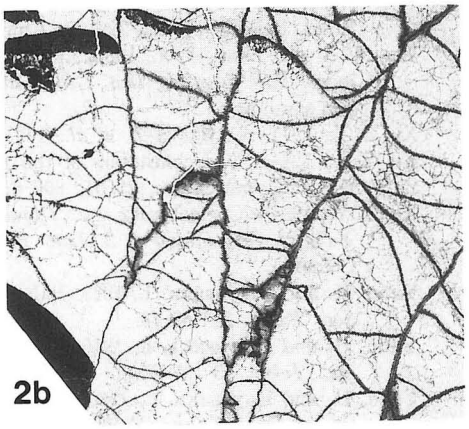
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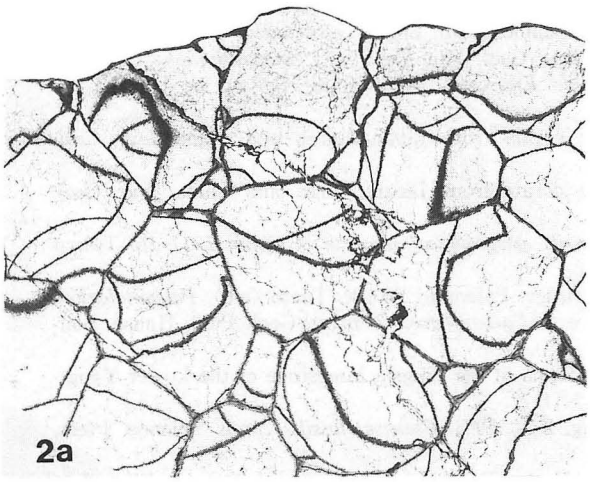
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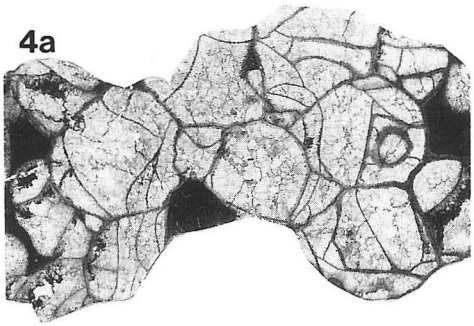
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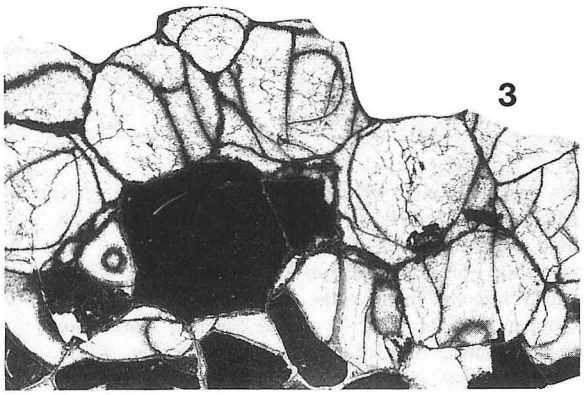
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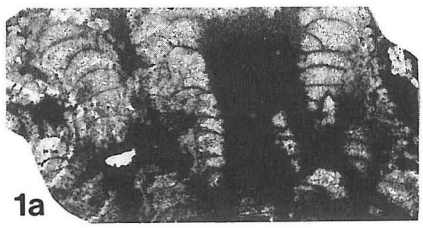
Explanation of Plate 27

Fig. 1 *Protomichelinia* sp. OCU 6290, uppermost part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. a, longitudinal section, ×6. b, transverse section showing small corallites and thick walls, ×6.

Fig. 2 *Sinopora asiatica* (Mansuy). OCU 6294, Gnishik Formation, Kuh-e-Ali Bashi, Julfa. Transverse section showing circular to ovate corallites and thick walls, ×6.

Fig. 3 *Sinopora asiatica* (Mansuy). OCU 6295, upper part of Unit 1 of the Surmaq Formation (*Neoschwagerina margaritae* Zone), Kuh-e-Hambast, Abadeh. a, transverse section, ×6. b, longitudinal section showing a few spiny projections, ×6.



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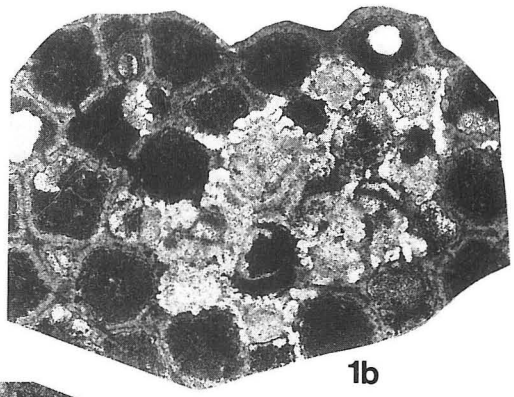

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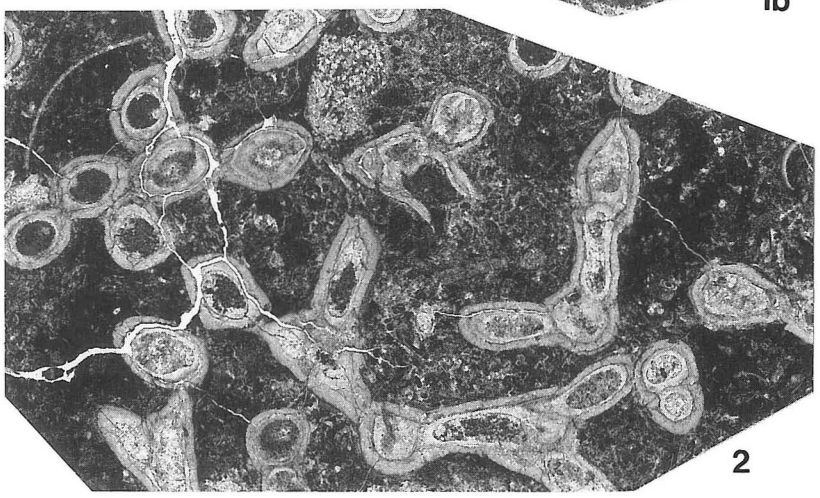

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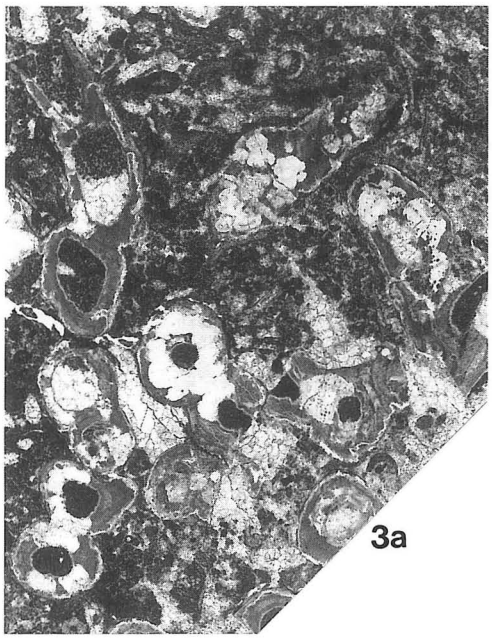

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