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PERMIAN CORALS FROM PAHANG AND TRENGGANU, MALAYSIA

by

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(with 2 text-figures and 7 plates)

Abstract

Corals belonging to genera *Michelinia*, *Waagenophyllum*, *Ipciphyllum*, *Aridophyllum*, *Wentzelloides* and *Yatsengia* are described from Kampong Awah Quarry, Pahang. A *Yatsengia* is described from Bukit Biwah, Trengganu. The former occurrence denotes *Yabeina* Zone, while the latter *Neoschwagerina* Zone. All corals indicate Tethyan elements.

Introduction

Marine Permian has been known to develop extensively in the Malaysian Peninsula, and records of the occurrence of Permian fossils from there were summarized by Jones, Gobbett and Kobayashi (1966), Gobbett (1968), Gobbett and Hutchison (1973) and Toriyama et al. (1975).

Although a number of coralline species have been listed from various parts of Malaysia, there are still few descriptions available on them. Newton (1926) was the first to describe and figure three corals from the Permian of Perlis. But, two of them are bryozoa (*Chaetetes* (sic) sp. -pl. II, fig. 3A; *Stenopora* sp. -pl. III, figs. 6, 7) and the third is an external mould of calicular portion of an unidentifiable coral (Cyathophylloid coral -pl. III, fig. 2B). Igo's paper (1964) is thus the only article which actually describes true Permian corals from Malaysia, in which *Wentzelella malayensis* Igo and *Sinopora* cfr. *dendroidea* (Yoh) are figured from northern Pahang, together with such fusulinids as *Yabeina*, *Verbeekina* and *Sumatrana*. Minato and Kato (1965), however, felt that the former coral was probably a *Parawentzelella* because canal like structure is seen at the corners of polygonal corallites of *Wentzelella malayensis* (Igo, 1964, text-fig. 3).

Kato, as a member of the 5th Expedition to southeast Asia sent by the Osaka City University, did some field work in Malaysia in the winter of 1966, jointly with Professors K. Ishii and Y. Nogami, with the generous and able assistance given to them by the University of Malaysia and the Geological Survey of Malaysia. Amongst the corals collected, those from the Government quarry at Kampong Awah in Pahang, only are herein described. Some specimens were given to Kato by Professors K. Ichikawa and K. Ishii, and Dr. D. Gobbett, for study. Also a fragmentary coral from Bukit Biwah, Trengganu, stored at the Department of Geology, University of Malaysia was entrusted to Kato by Dr. Gobbett for identification.

The following is a list of identified corals from both localities (Text-fig. 1).

1) Kampong Awah, Pahang.

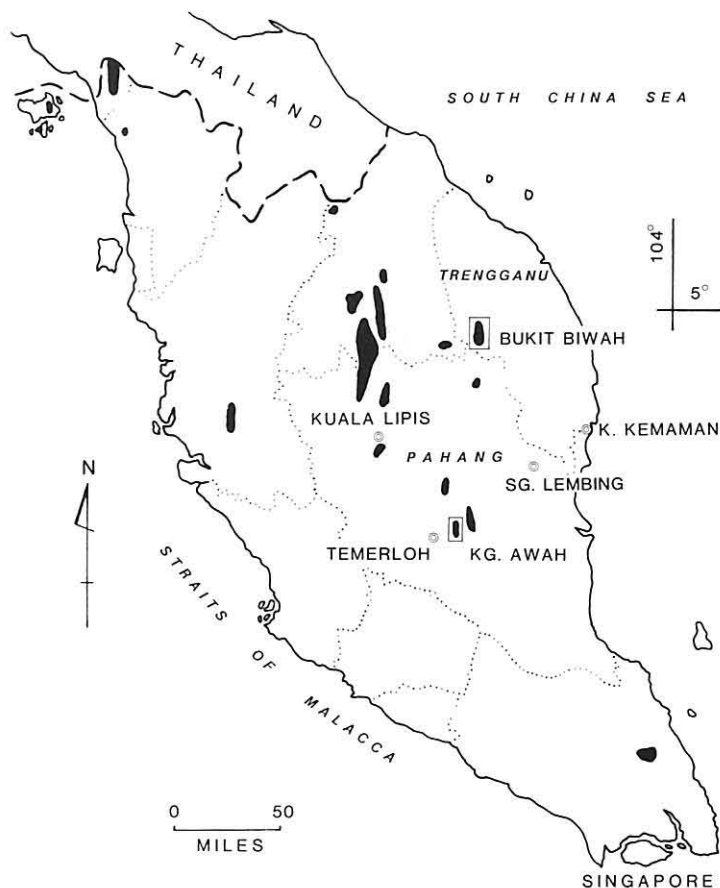
Government quarry of altered andesite, and andesite breccia which carries numerous limestone fragments. In turn these limestones also contain fragments of volcanics.*

<i>Michelinia</i> cfr. <i>indica</i> Waagen & Wentzel	 1 colony
with <i>Verbeekina</i> , <i>Kahlerina</i> , <i>Pseudofusulina</i> , <i>Yabeina</i> etc.	
<i>Waagenophyllum</i> (<i>W.</i>) <i>virgalense</i> (Waagen & Wentzel)	 3 colonies
with <i>Yabeina</i> , <i>Sumatrana</i> , <i>Mizzia</i> etc.	
<i>Wentzeloides fontainei</i> Kato & Ezaki, sp. nov.	 3 colonies
<i>Aridophyllum fluegeli</i> Kato & Ezaki, sp. nov.	 1 colony
<i>Ipciphyllum subelegans</i> Minato & Kato	 2 colonies
<i>Yatsengia</i> sp. A	 1 colony

Even though these corals occur separately in different limestone blocks, they are probably of the same age denoting the *Yabeina* Zone in fusulinid zonation.

2) Bukit Biwah, Trengganu

<i>Yatsengia</i> sp. B	 1 colony
with <i>Pseudofusulina</i> , <i>Pseudodoliolina</i> and <i>Yangchienia</i> ?	



Text-fig. 1 Index map showing the fossil localities and distribution of Permian outcrops (after Gobbett, 1968).

* According to Jones, Gobbett and Kobayashi (1966) *Waagenophyllum* aff. *indicum* (Waagen & Wentzel) and *Ipciphyllum elegans* (Huang) were previously identified by Prof. D. Hill from Kampong Awah.

The age of the coral is the *Neoschwagerina* Zone in fusulinid zonation.*
All these corals listed above definitely represent Tethyan elements.

Systematic Description**

Class Anthozoa Ehrenberg, 1834
Subclass Tabulata Milne-Edwards & Haime, 1850
Order Favositida Wedekind, 1937
Family Michelinidae Waagen & Wentzel, 1886
Genus *Michelinia* de Koninck, 1841

Type species (subsequent designation by Edwards & Haime, 1850): *Calamopora tenuisepta* Phillips, 1836

Michelinia cfr. *indica* Waagen & Wentzel

(Pl. 2, fig. 1.)

1886 *Michelinia indica* Waagen & Wentzel, p. 853, pl. 99, fig. 1.

1932 *Michelinia* cfr. *indica*, Huang, p. 98, pl. 13, fig. 2.

1964 *Michelinia indica*, Gräf, S. 415, Taf. 40, Fig. 10; Taf. 41, Fig. 12.

Material: Single fragmental corallum firmly embedded in dark gray foraminiferal limestone carrying such fusulinids as *Yabeina*, *Verbeekina*, *Kahlerina*, *Pseudofusulina*. etc. (UHR 30650)

Description: Corallum small, massive, and cerioid. Only some corallites are preserved, and an oblique section of the corallum is available.

Corallite is prismatic. The longest diagonal length in the largest corallite attains 6mm. Corallite wall is thin, 0.5mm in total thickness in two neighbouring corallites, with a dark, somewhat wavy line in between. Inside of the corallite is smooth or weakly undulated with occasional projections indicating the presence of septal spines. Mural pore is 0.3mm in diameter, situated at the corner and on the middle of prismatic corallite surface. Tabulae are incomplete, domed and large with vesicular appearance.

Remarks: The present form is almost identical with the form described by Huang (1932), which was obtained from the Chihhsia Limestone of Guizhou Province, China. Mural pores are numerous in the specimen of Waagen & Wentzel (1886) from the Middle Productus Limestone of Salt Range, Pakistan. This character is not well detected in the present Malaysian specimen.

Subclass Rugosa Milne-Edwards & Haime, 1850

Order Stauriida Verrill, 1865

Family Waagenophyllidae Wang, 1950

Genus *Ipciphyllum* Hudson, 1958

Type species (by original designation): *Ipciphyllum ipci* Hudson, 1958

Ipciphyllum subelegans Minato & Kato

(Pl. 1, figs. 1a-b; Pl. 2, figs. 2a-c.)

* From Bukit Biwah the late Dr. H.D. Thomas identified *Huangia* cfr. *chutsingensis* (Yoh). Limestone at Bukit Biwah was generally considered as correlatable with the Chinese Chihhsian or Lower Permian (Gobbett, 1968; Toriyama et al., 1975). However as the above datum implies it should contain, at least in parts, deposits of Middle Permian.

** Suprageneric classification is mostly after Hill (1981)

1958 *Ipciphyllum elegans*, Hudson, p. 181, pl. 33, fig. 6; text-fig. 1. (non *Wentzelella elegans* Huang, 1932)

1965 *Ipciphyllum subelegans* Minato & Kato, p. 155.

1983 *Ipciphyllum subelegans*, Fontaine, p. 6, pl. 3, figs. 1-4.

Material: Two fragmental coralla (M-36 = UHR 30658, P121 = UHR 30657) from the Kampong Awah quarry, Pahang, Malaysia.

Description: Corallum compound, massive, and cerioid. Surface characters unknown. The larger specimen measures 4.3 mm $\times$ 2.8 mm in transverse section.

In transverse section, corallite is polygonal, 5 to 6 sided. Diagonal length of corallite is 6 to 7 mm. Corallite wall is thin, straight to a little sinuous, represented by a dark line and brownish fibres perpendicular to it. Thickness of the wall is only 0.05 mm. Occasionally transparent layer appears between the two neighbouring corallites, so that the wall reveals a feature quite comparable with a fibro-normal septum. Small, round and bright coloured spots are often observed in between neighbouring corallites (pl. 1, figs. 1a-b). These spots may have been caused by some parasitic organisms as they clearly cut through the fine structure of wall. Septa are in two orders. Major septa are thick, especially at their central portion, tapering towards both their axial and peripheral ends, so as to give elongated spindle form as a whole. Major septa nearly reach axial column, radially arranged with indistinct fossula. But a septum, presumably cardinal one, corresponding to the direction of median plate, is a little shorter and thinner than the other major septa. Number of major septa is 15 to 17 in a specimen (P121), while a corallite with 20 major septa is seen in another specimen (M-36). Minor septa alternate with the major, almost as long as, or a little shorter than the major. They are decidedly thinner than the major. Fine structure of septa is fibronormal. A dark line sometimes bears transparent layer within it. Dissepimentarium is wide, 1.5 mm in peripheral width, consists of concentric or anguloconcentric dissepiments which are loose in periphery but closely disposed near tabularium. Small lonsdaleoid dissepiments sometimes interrupt minor septa, and occasionally and locally even major septa. Inner wall is not prominent. Tabularium is wide, 2.5 to 3.5 mm in diameter. Axial column is elliptical in outline, with a distinct, long and thick median plate, up to 10 septal lamellae and 3 to 5 rows of outwardly convex axial tabellae on each side of the median plate. As a whole axial column is densely constructed and large. Width of axial column is 1.5 to 1.6 mm.

In longitudinal section, triareal or trizonal arrangement of skeletal elements, namely axial column, tabularium and dissepimentarium, is very clear. Corallite wall is thin, smooth and almost straight, with many small, bright spots mentioned above. These spots are also present in septa (pl. 1, fig. 1b). Dissepimentarium is wide, with gently inclined, large dissepiments up to several rows. Elongate dissepiments present. Tabularium is wide, well differentiated from the dissepimentarium, consists of clinotabulae, periaxial tabellae and transverse tabulae; 6 to 10 tabulae; are counted in a vertical distance of 2 mm. Axial column is also well differentiated from the tabularium, consists of a straight median plate, cuts edges of septal lamellae and rather closely piled up axial tabellae with steep lateral slopes.

Remarks: The present form falls in the group of *Ipciphyllum* with broad transverse

tabulae. Distinct median plate in axial column and long minor septa are said to be characteristic features of the present species (Minato & Kato, 1965). We would further add the nature of central dilation of major septa as seen in transverse section to be diagnostic. Major septa dilate, not only in tabularium but also in dissepimentarium in the present Malaysian form. And this character is found in the Iraqi specimens too. Lonsdaleoid dissepiments are absent in *Ipciphyllum subelegans* from Iraq, but are locally developed in Malaysian specimens. The specimen P121 has fewer septa than the specimen M-36. Mode of axial column in transverse section is dibunophylloid in M-36, which is somewhat like *Ipciphyllum laosense*. These two specimens are, however, conspecific with each other and with *Ipciphyllum subelegans* in having common features enumerated above. *Ipciphyllum subelegans* was formerly called as *Ipciphyllum elegans* by Hudson (1958), but actually differs from the original *Wentzelella elegans* Huang (1932) in having large, compact axial column with median plate, thick major septa and long minor septa. Compared to *Ipciphyllum subelegans*, typical *Ipciphyllum laosense* has larger corallites and smaller axial column. *Ipciphyllum subelegans* is distinguishable from *Ipciphyllum subtimoricum* and *Ipciphyllum fliegeli* in having thick septa and small corallites.

Geological age of *Ipciphyllum subelegans* in Iraq is probably *Neoschwagerina* Zone. Fontaine (1983) described the same species from the Middle Permian of the Highland of Padang, Sumatra. We presume that it may correspond to the horizon of *Sumatrina annae* Volz and *Yabeina tobleri* (Lange), both of which were formerly described from the same region.

Genus *Aridophyllum* Zhao, 1976

Type species (by original designation): *Aridophyllum anshunense* Zhao, 1976

Remarks: *Aridophyllum* closely resembles *Ipciphyllum*, from which it only differs in having thick septal wall. Validity of *Aridophyllum* is therefore questionable. Hill (1981) synonymized it with *Ipciphyllum* with query, whereas Yü et al. (1983) considered it as an independent genus. The following forms may be listed as forming a group which conforms to the category of *Aridophyllum*.

Lonsdaleia timorica Gerth, 1921

Ipciphyllum timoricum var. *regulare* Wu, 1963

Aridophyllum anshunense Zhao, 1976

Although the exact geological age of the first species from Timor is unknown, the second form comes from the Maokou Limestone, and the third one from the Wuchiaping Limestone, both of Guizhou Province, China. It thus ranges from the Middle to the early Late Permian.

Zhao (1976) considered that *Aridophyllum* was derived from *Ipciphyllum* which in China was normally confined within the Maokou Limestone of *Neoschwagerina-Yabeina* Zone.

Aridophyllum fluegeli Kato & Ezaki, sp. nov.

(Pl. 1, fig. 2; Pl. 3, figs. 1a-c)

Derivation of the specific name: After Prof. Helmut Flügel, who greatly contributed to the Palaeozoic coral research.

Material: A single corallum (Holotype-UHR 30659) from the Kampong Awah quarry, Pahang, Malaysia, collected by M. Kato. The coral is embedded in black limestone breccia carrying fragments of *Yabeina*.

Diagnosis: *Aridophyllum* having wide tabularium with gently inclined clinotabulae.

Description: Corallum composed, massive, and cerioid. Although exact external characters are unknown, corallum outline appeared in three thin sections suggesting that it must have had an inverted tetrahedron-like form. The widest part of the corallum attains 33.5 mm and the height 14.3 mm.

In transverse section corallite is polygonal, 5 to 7 mm in diameter in mature corallites, which consist internally of wall, dissepimentarium and axial column. Septal wall is thick. Combination of external wall in most peripherally situated corallites makes up holotheca. This outermost part of the corallite wall consists of a very thin dark line and thin layers of bright coloured fibres inwardly perpendicular to the dark line. Still inside dark coloured septal wall is present. Dissepimentarium is narrow, consists of several rows of concentric dissepiments. Lonsdaleoid dissepiments absent. Inner wall is usually distinct. Tabularium is round in outline, wide, and 3.5 to 4.0 mm in diameter. Septa are in two orders, major and minor respectively. They are pinnately arranged, but fossula is indistinct. Major septa nearly reach axial column, and comparatively thick. Number of major septa is 10 to 16. Minor septa are thin, long, almost two thirds the length of the major with which they alternate. Septal fine structure is diffusotrabecular. Axial column is almost free from the axial ends of major septa, varies in size. It is a simple rod like columella to begin with in a young offshoot. In mature corallites the axial column is of typical waagenophyllid with elliptical outline, consisting of a median plate, a few septal lamellae and several outwardly convex axial tabellae. Median plate is sometimes obscure, however. The largest one attains 1.7 mm in short diameter. Increase is lateral. One small corallite with thick wall, without dissepiments, and with a simple columella is seen connected with a large mother corallite by a tube like or canal like passage.

In longitudinal section corallites are divergent towards upward. Wall is thick. Dissepimentarium is narrow with a few series of dissepiments. Elongate dissepiments develop. Differentiation between the dissepimentarium and tabularium is not sharp. Tabularium is wide, and is occupied by gently inclined clinotabulae and some transverse tabulae. Axial column is well differentiated from the tabularium, stout, consists of piled up steeply inclined axial tabellae and a median plate which may be thin or thick, straight or sinuous.

Remarks: At a glance the present form appeared to the authors as representing a form of *Yokoyamaella* with very thick wall. But the wall structure in *Yokoyamaella* is so unique that it is distinguishable from the one with a dark line or a transparent layer dividing two neighbouring corallites in *Ipciphyllum*. The present form is, however, dif-

ferent from ordinary species of *Ipciphyllum* in having thick wall, and is thus placed under *Aridophyllum*. All other species of *Aridophyllum* enumerated above have very steep clinotabulae which give the impression of extremely narrow tabularium in longitudinal sections whereas clinotabulae are gently inclined in the present form.

On the other hand, the present form may have some similarity with *Parawentzelella* which shows numerous canal structures. Tube like connection between a large corallite and its offshoot is similar to this canal in *Parawentzelella*, but in fact it is more precisely compared with lateral budding in fasciculate *Waagenophyllum*.

Genus *Waagenophyllum* Hayasaka, 1924

Type species (subsequent designation by Grabau, 1931):

Lonsdaleia indica Waagen & Wentzel, 1886.

Waagenophyllum (Waagenophyllum) virgalense (Waagen & Wentzel)

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

1886 *Lonsdaleia virgalense* Waagen & Wentzel, p. 900, pl. 101, fig. 4; pl. 116, fig. 2.

1965 *Waagenophyllum (Waagenophyllum) virgalense*, Minato & Kato, p. 109, pl. 7, fig. 2; text-figs. 38-41, 48v. (for further synonymy)

1970 *Waagenophyllum (Waagenophyllum) virgalense*, Oekentorp & Kaever, S. 279, Taf. 1, Fig. 1; Abb. 2.

1971 *Waagenophyllum (Waagenophyllum) virgalense*, Ozaki & Yamagiwa, p. 299, pl. 1, figs. 1, 2.

Material: Three colonies in three black limestone clasts in breccia, collected at the Kampong Awah quarry, Pahang, Malaysia. M-36 = UHR 30662, collected by K. Ichikawa and K. Ishii, is with a fragment of *Ipciphyllum*. Kpg. Awah 7 = UHR 30660, collected by M. Kato, is with *Yabeina*, *Verbeekina*, *Mizzia*, and *Sinopora*?. Kpg. Awah 9 = UHR 30661, collected by M. Kato, is with *Yabeina*, and *Sumatrana*. The geological age of these corals is therefore *Yabeina* Zone in fusulinid zonation.

Description: Corallum compound, fasciculate and dendritic. Surface characters unknown. Interspace between corallites is variable. Corallites may be closely situated or sparsely separated.

In transverse section corallite is round in outline, consists internally of wall, dissepimentarium, tabularium and axial column. Stereowall is very thick especially in young corallites. But it becomes thin in larger corallites in mature stage. Dissepimentarium is not clearly differentiated from tabularium; consists of concentric dissepiments. Tabularium is narrow, where straight cut edges of tabulae are seen. Septa are in two orders, major and minor respectively. Major septa are moderately thick at their base, but gradually taper towards axis, 20 or 21 in number, reach the periphery of axial column. Minor septa are a little thinner than and alternate with the major. Length of the minor septa is a half to two thirds of the major. Septal fine structure is diffusotrabecular. Axial column is large and roughly elliptical in outline. Larger ones attain 2 mm in short diameter. The axial column is loosely constructed by a short median plate and only a few septal lamellae and axial tabellae. Increase is lateral. At first the side of a corallite is swollen, then the part is semidetached from the mother corallite in a form of raindrop, inside of which is filled with stereoplasmic deposits with a central open space. Septa are introduced within this mass of stereoplasmic deposits. Finally a

new offshoot is separated from mother corallite as a small round corallite with simple axial structure and thick stereowall.

In longitudinal section, corallites are sinuous. Wall is wavy and thick. Dissepiments are large, flattened, steeply inclined and less numerous. Large elongate dissepiments are developed. Also steeply inclined clinotabulae occupy most of the space of tabularium. Narrow transverse tabulae are developed by the axial column, which is clearly differentiated from the tabularium. Axial column consists of sinuous median plate and steeply ascending axial tabellae, which perhaps appear as a series of gentle domes in a tangential section. Calice is deep. Lateral offshoot almost horizontally projects on the side of corallite.

Remarks: Specimens of *Waagenophyllum* from Salt Range, Pakistan, are currently being investigated by the authors. Preliminary result suggests that they are in fact representing a series of variation of one species, containing forms similar to *Waagenophyllum* (*Waagenophyllum*) *indicum* and forms resembling *Waagenophyllum* (*Waagenophyllum*) *virgalense*. Waagen & Wentzel (1886) expressed clear hesitation in separating the two above mentioned species. However, uniting various forms into one single species and reclassification of all species of the genus *Waagenophyllum* requires further study. For the time being the authors would like to follow Minato & Kato (1965), thus retaining *Waagenophyllum* (*Waagenophyllum*) *virgalense*. The present Malaysian specimens are attributed to this Pakistani "species" on account of their possession of thick stereowall, loosely constructed axial column and well developed elongate dissepiments and clinotabulae. Narrow transverse tabulae are also present.

Subfamily Wentzelellinae Hudson, 1958

Genus *Wentzeloides* Yabe & Minato, 1944

- 1944 *Wentzeloides* Yabe & Minato, p. 141.
- 1955 *Wentzeloides*, Minato, p. 113.
- 1956 *Wentzelella* (*Wentzeloides*), Hill, F. 309.
- 1964 *Wentzeloides*, Yoh & Wu, p. 172.
- 1965 *Wentzeloides*, Minato & Kato, p. 197.
- 1967 *Wentzeloides* (*Multimurinus*) Fontaine, p. 52.
- 1967 *Wentzeloides* (*Battambangina*) Fontaine, p. 56.
- 1969 *Wentzeloides* (*Multimurinus*), Fontaine, p. 45.
- 1972 *Wentzeloides* (*Multimurinus*), Flügel, p. 90.
- 1977 *Wentzeloides*, Xu, p. 235.
- 1979 *Wentzeloides* (*Multimurinus*), Wu & Zhang, p. 33.
- 1981 *Wentzeloides* (*Wentzeloides*), Hill, F. 420.
- 1981 *Wentzeloides* (*Battambangia*), Hill, F. 420.
- 1981 *Wentzeloides* (*Multimurinus*), Hill, F. 420.
- 1983 *Wentzeloides*, Fontaine, p. 7.
- 1983 *Wentzeloides*, Yü et al., p. 233.
- 1983 *Multimurinus*, Yü et al., p. 234.

Type species (by monotypy): *Wentzelella* (sic) *maiyaensis* Yabe & Minato, 1944

Generic diagnosis: Plocoid Wentzelellinae typically with meandrine corallum. Thick septal wall strongly developed. Small lonsdaleoid dissepiments may be present. Axial column usually small and compact. Tabularium wide with clinotabulae and transverse

tabulae.

Remarks: Theoretically *Wentzeloides* may have been introduced from cerioid *Wentzelella* by partial suppression of wall. Besides the genus was thought to be characteristic in having small corallites with thick septal wall, simple axial structure, less numerous major septa, and no lonsdaleoid dissepiments (Minato & Kato, 1965), when it embraced the type species only. Since then some 20 forms have been ascribed or attributed to *Wentzeloides*, as listed below. These contain forms with lonsdaleoid dissepiments developed, though not very extensively. Categorically this phenomenon would lead *Wentzeloides* close to *Polythecalis*. Therefore such criteria as the nature of wall, axial column, septal numbers, other than lonsdaleoid dissepiments are important in recognizing true systematic relationship among species within the genus, and among related genera.

Some forms described by Fontaine (1961) from Indochina seemed to Minato & Kato (1965) atypical for *Polythecalis*, under which genus these forms were placed. Instead, these forms seemed to be rather related to *Wentzeloides*. Later, in 1967 Fontaine proposed two new subgenera of *Wentzeloides*; *Multimurinus* and *Battambangina*, to cater to these "*Polythecalis*" species, thus extending generic contention of *Wentzeloides*. *Multimurinus* shows more cerioid tendency with small lonsdaleoid dissepiments, while *Battambangina* reveals sometimes cylindrical corallites. In fact, it seems rather difficult to distinguish all these three subgenera within the genus *Wentzeloides* redefined by Fontaine (1967). Diphymorph to loose axial structure was noticed by Fontaine (1967) in *Wentzeloides (Multimurinus) comensis*.

The authors would merge all these subgenera in the synonymy of *Wentzeloides*. Yü et al. (1983) also synonymized *Battambangina* with *Wentzeloides*. In the following a check list of species referred to *Wentzeloides* and forms referable to the genus is provided. Some are better removed from the genus, but others are better transferred to the genus *Wentzeloides*.

A list of species of the genus *Wentzeloides*

Lonsdaleia frechi Volz, 1904 — *Polythecalis* (Minato & Kato, 1965) — *Wentzeloides (Battambangina)* (Fontaine, 1983)

Wentzeloides maiyaensis Yabe et Minato, 1944

Polythecalis khmerianus Fontaine, 1961 — *Wentzeloides (Multimurinus)* (Fontaine, 1967)

Polythecalis khmerianus var. *regularis* Fontaine, 1961 — *Wentzeloides (Multimurinus)* (Fontaine, 1967)

Polythecalis khmerianus var. *biformis* Fontaine, 1961 — *Wentzeloides (Battambangina)* (Fontaine, 1967)

Wentzeloides (Multimurinus) comensis Fontaine, 1967

Wentzeloides (Multimurinus) homantrungi Fontaine, 1969

Wentzeloides (Multimurinus) homantrungi var. *crassicolumnis* Fontaine, 1969

Wentzeloides (Multimurinus) lunatus Flügel, 1972

Wentzeloides zhongguoensis Xu, 1977 — *Lonsdaleiastraea*

Wentzeloides (Szechuanophyllum) szechuanensis orientale of Kropatcheva, 1978,

non Ivanovsky, 1964 — *Wentzeloides*?

Wentzelella (*Wentzelella*) *ussurica* Kropatcheva, 1978 — *Wentzeloides*?

Wentzeloides (*Wentzeloides*) *primoricum* Kropatcheva, 1978

Wentzeloides (*Wentzeloides*) *grandicolumellatus* Kropatcheva, 1978

Wentzeloides (*Wentzeloides*) *maiyaensis* of Kropatcheva, 1978

Wentzeloides (*Multimurinus*) *irregularis* Wu et Zhang, 1979 — *Wentzeloides*

Wentzeloides (*Multimurinus*?) *minor* Wu et Zhao, 1982 — *Wentzeloides*?

Wentzeloides xizangensis Lin, 1983 — *Wentzelellites*

Wentzeloides (*Multimurinus*) sp. (Fontaine, 1983)

Wentzeloides (*Multimurinus*) *khmerianus* of Fontaine, 1983 — *Polythecalis*?

Geographic distribution: Iran, Malaysia (present record), Indonesia, Cambodia, Vietnam, China (Szechuan Province), USSR (Primoria), and Japan (Southern Kitakami Mts. & Northern Abukuma Mts.).

Stratigraphic distribution: In Chinese standard Chihhsian (Upper?) to Maokouan. In fusulinid zonation, *Parafusulina* Zone to *Yabeina-Lepidolina* Zone.

Wentzeloides fontainei Kato & Ezaki, sp. nov.

Pl. 1, figs. 3a-b; Pl. 5, figs. 1-8; Pl. 6, figs. 1-3.

Derivation of the specific name: After Dr. Henri Fontaine who greatly contributed to the knowledge on the Asiatic Palaeozoic corals.

Material: Three broken coralla embedded separately in black limestone breccias, which also yield such fusulinid genera as *Yabeina*, *Sumatrana*, *Verbeekina*, *Pseudofusulina*, and *Kahlerina* etc. Corals are considered of the same age as fusulinids, thus denoting *Yabeina* Zone. Locality-Kampong Awah quarry, Pahang, Malaysia. Holotype-UHR 30663, Paratype-UHR 30664, 30665. collector-M. Kato.

Specific diagnosis: *Wentzeloides* with meandrine corallum, comparatively large corallites, numerous septa and axial column variable in size and construction. Small lonsdaleoid dissepiments present.

Description: Corallum compound, massive, plocoid and partly meandroid. Surface characters unknown.

In transverse section partly preserved holotheca is of "septotheca". Corallites are polygonal to subround in outline, and up to 10 mm in diameter. Septal wall is thick

Explanation of Plate 1.

Some types of walls in massive coralla.

(All figures fifteen times natural size.)

Fig. 1 *Ipciphyllum subelegans* Minato & Kato UHR 30657

Fig. 1a Transverse feature of thin corallite wall with small bright coloured spots.

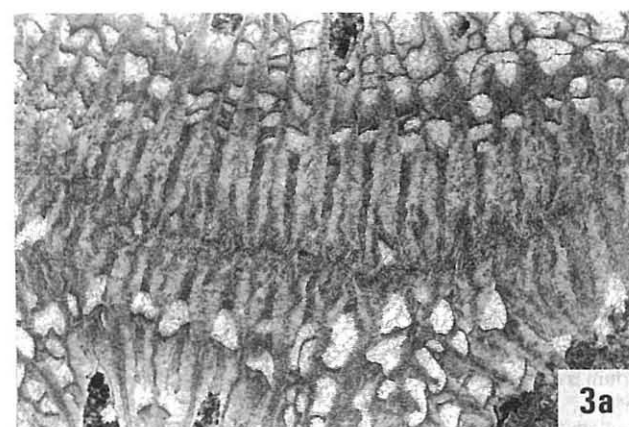
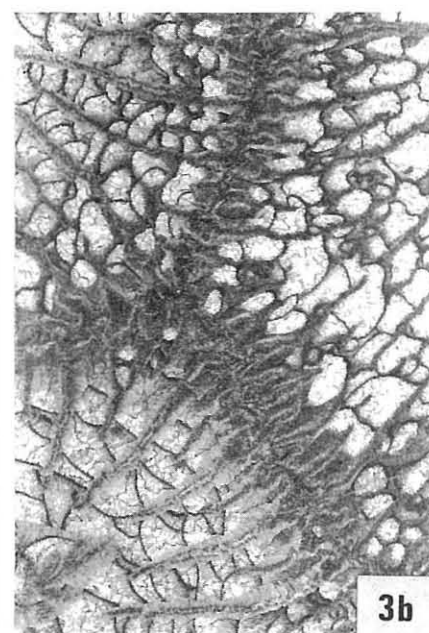
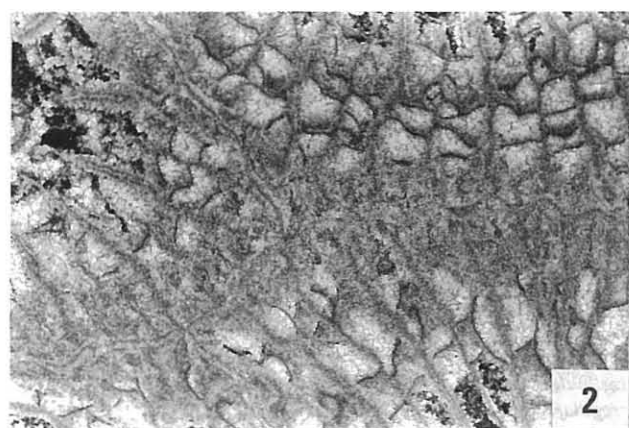
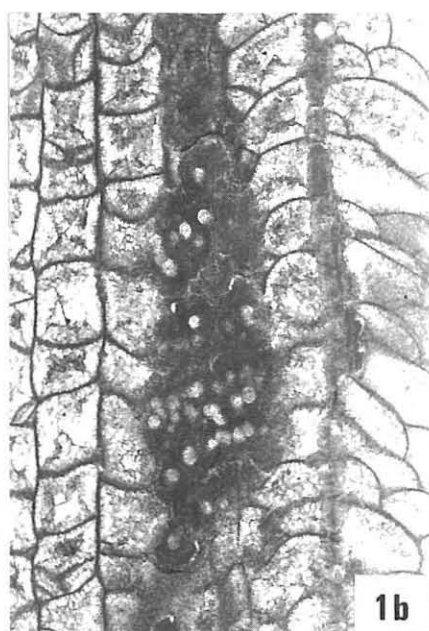
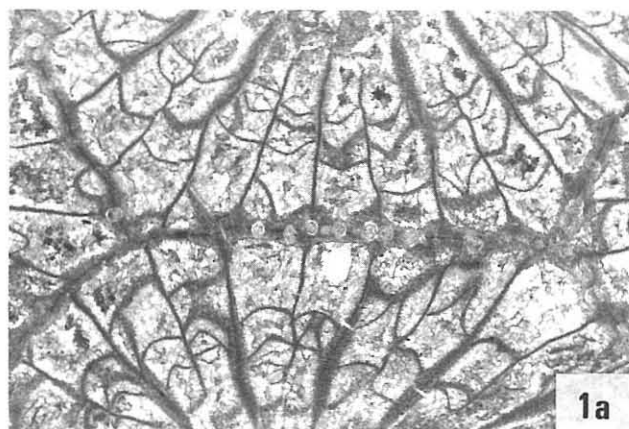
Fig. 1b Longitudinal feature of a septum with similar spots.

Fig. 2 Thick septal wall by lateral fusion of peripheral ends of septa in *Aridophyllum fluegeli* sp. nov. UHR 30659 (Holotype)

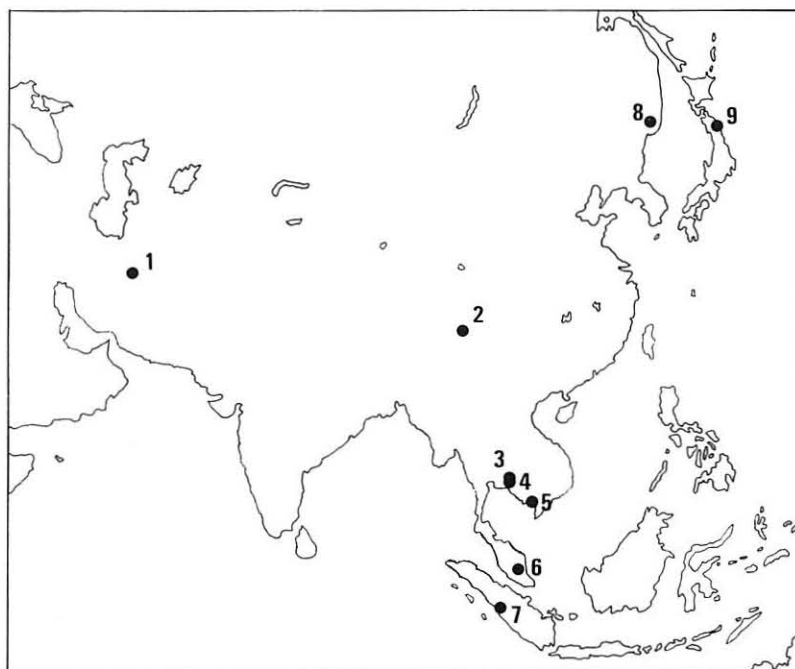
Fig. 3 Thick septal wall in *Wentzeloides fontainei* sp. nov. UHR 30663 (Holotype)

Fig. 3a Septal wall showing comb-like appearance.

Fig. 3b Septal wall showing denticulated appearance.



and worm-like, made up by lateral fusion of peripherally dilated septa. Septa in one corallite correspond to septa in neighbouring corallites through the wall. Wall thickness varies considerably, so that the wall may be denticulated in parts, or comb-like in other parts. Wall structure is partially absent where small lonsdaleoid dissepiments usually develop. As a whole meandrine or pseudomeandroid (Hill, 1981, F. 10)



Text-fig. 2 Distribution of *Wentzeloides*. 1. *Wentzeloides (Multimurinus) lunatus* Flügel 2. *W. (M.) irregularis* Wu et Zhang 3. *W. (M.) khmerianus* (Fontaine); *W. (M.) regularis* (Fontaine) 4. *W. (Battambangina) biformis* (Fontaine) 5. *W. (M.) comensis* Fontaine; *W. (M.) homantungi* var. *crassicolumnis* Fontaine 6. *W. fontainei* sp. nov. 7. *W. (B.) frechi* (Volz); *W. (M.)* sp. (Fontaine, 1983) 8. "*W. (Szechuanophyllum) szechuanensis orientale*" (Kropatcheva, 1978); *Wentzelella (Wentzelella) ussurica* Kropatcheva; *W. (W.) primoricum* Kropatcheva; *W. (W.) grandicolumellatus* Kropatcheva; "*W. (W.) maiyaensis*" (Kropatcheva, 1978) 9. *W. maiyaensis* Yabe & Minato
See a list of species of the genus *Wentzeloides* in the text.

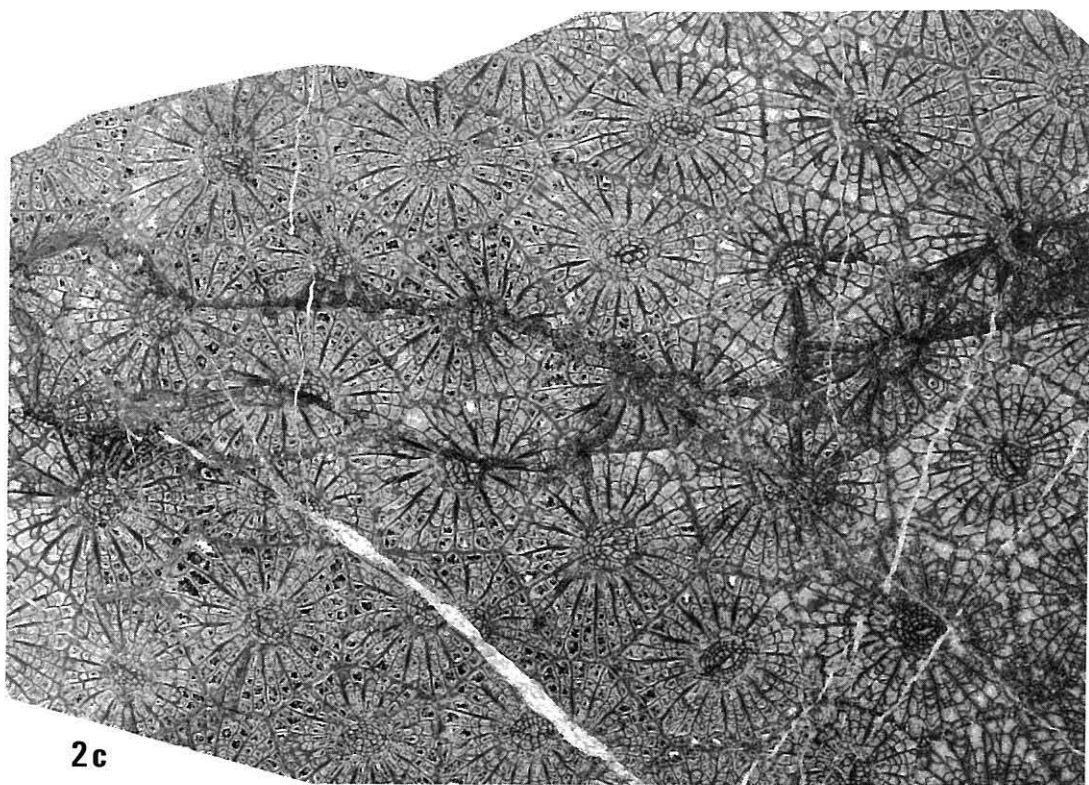
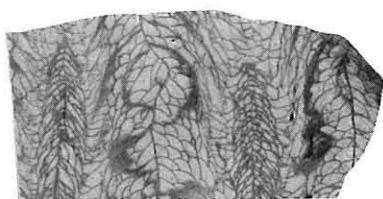
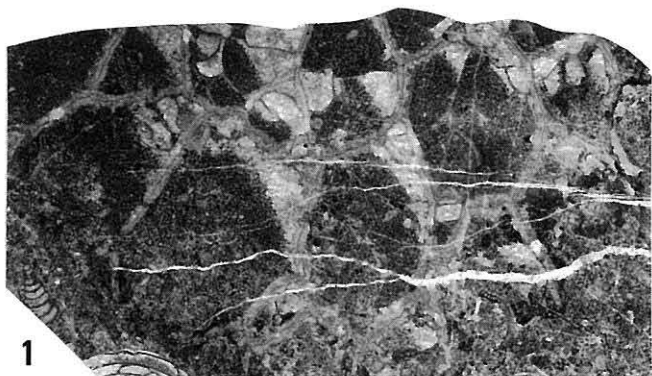
Explanation of Plate 2.

Fig. 1 *Michelinia* cfr. *indica* Waagen & Wentzel UHR 30656 Transverse section of a fragmental corallum, x4.

Fig. 2 *Ipciphyllum subelegans* Minato & Kato

Fig. 2a-b Longitudinal sections showing well differentiated skeletal elements; dissepimentarium, tabularium, and axial zone. Tabularium is composed of clinotabulae, periaxial tabellae, and transverse tabulae, x4. UHR 30657, 30658

Fig. 2c Transverse section showing medially thickened septa in tabularium and dissepimentarium. Note a shorter and thinner cardinal septum in each corallite and axial column with distinct median plate, x4. UHR 30657



feature is recognized where two or three corallites are arranged in a row without corallite wall bounding them. Dissepimentarium is wide with many interseptal dissepiments facing their convex sides inward. At the periphery, small, irregularly shaped lonsdaleoid dissepiments are locally developed. Also small such vesicles occur when septa become intermittent. Tabularium is wide, round in outline, 3 to 5 mm in diameter. Intrathecal dilation is clearly recognized. Septa are in three orders. But quaternary septa are also present when we count peripheral ends of septa in septal wall. Septal arrangement is somewhat pinnate, but fossulae are indistinct. Major septa are long, nearly reach the axial column. Number of major septa is 12 to 16, but the distinction between the major and minor septa is often difficult because minor septa are sometimes elongated quite as long as the major. Tertiary septa are confined within the dissepimentarium, and quaternary septa occur only near the periphery of corallite. Septal fine structure is diffuso-trabecular.

Axial column is small, but is variable in size and construction (pl. 5, figs. 3-8). It may be a simple, thickened columella with a dark median line, especially in young corallites. Then some septal lamellae and some axial tabellae become differentiated to achieve typical waagenophyllid axial column. In one case the axial column is even split into two parts. Outline of axial column is spindle form, triangular, elliptical or even irregular. Width of the largest axial column measures 1.6 mm, which lacks median plate. Increase is peripheral.

In longitudinal section corallites are slightly divergent in arrangement from bottom to top. Trizonal arrangement of skeletal elements in a corallite is clearly recognizable. Wall is moderately thick to thick, sinuous. Dissepimentarium is wide, occupies a half to one third the width of corallite, consists of small, gently to steeply inclined globose or sometimes flattened dissepiments. Elongate dissepiments develop. Tabularium is cylindrical, wide, well differentiated from the dissepimentarium. It consists of gently inclined clinotabulae and transverse tabulae. In a vertical distance of 2 mm, 6 to 7 tabulae are counted. Axial column is narrow but stout with axial tabellae, when recognizable, steeply ascending towards the median plate or columella.

Remarks: The present Malaysian form closely resembles *Wentzeloides (Multimurinus) lunatus* Flügel (1972) from Iran, but differs from the latter in having more meandrine corallum, larger corallites, and variable axial column. Number of major septa in Iranian species is described by Flügel (1972) as 18, but appears to be a little less, judging from illustration.

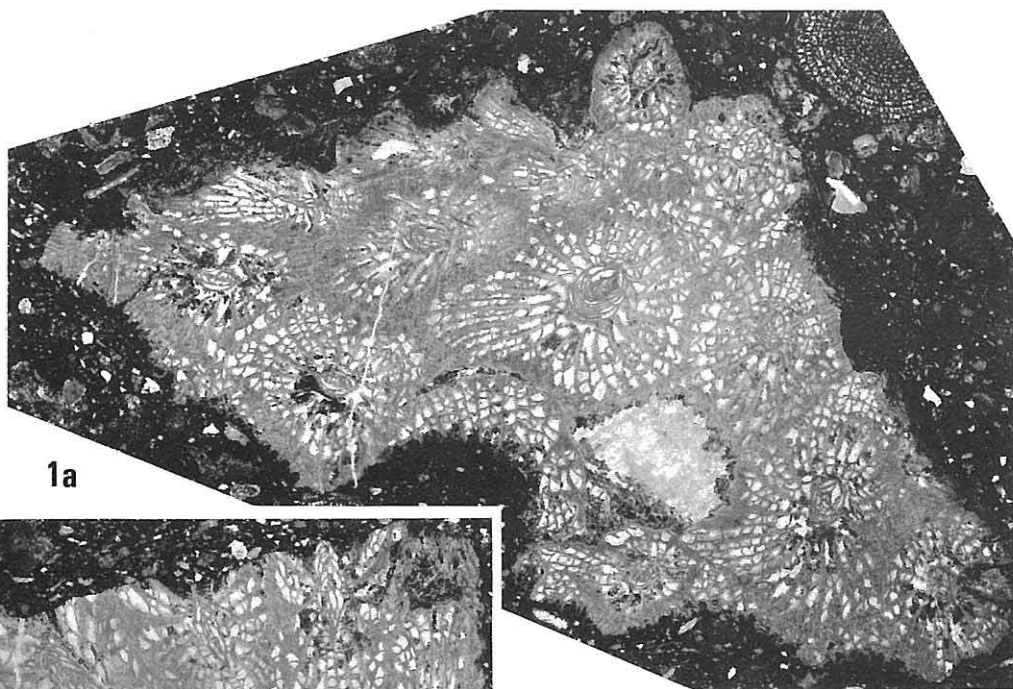
The present form also resembles *Wentzeloides (Battambangina) frechi* described by Fontaine (1983) from Indonesia, but differs from that in having thick wall, long ter-

Explanation of Plate 3.

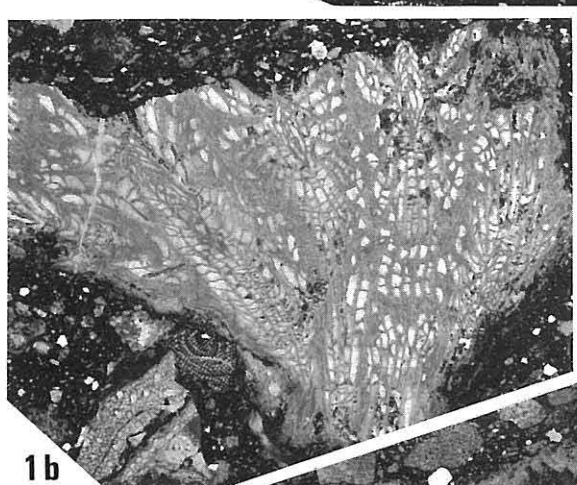
Fig. 1 *Aridophyllum fluegeli*, sp. nov., UHR 30659 (Holotype)

Fig. 1a, 1c Transverse section of holotype revealing thick septal wall and elliptical axial column of typical waagenophyllid. An arrow indicates a tube like or canal like process between the neighbouring corallites, x4.

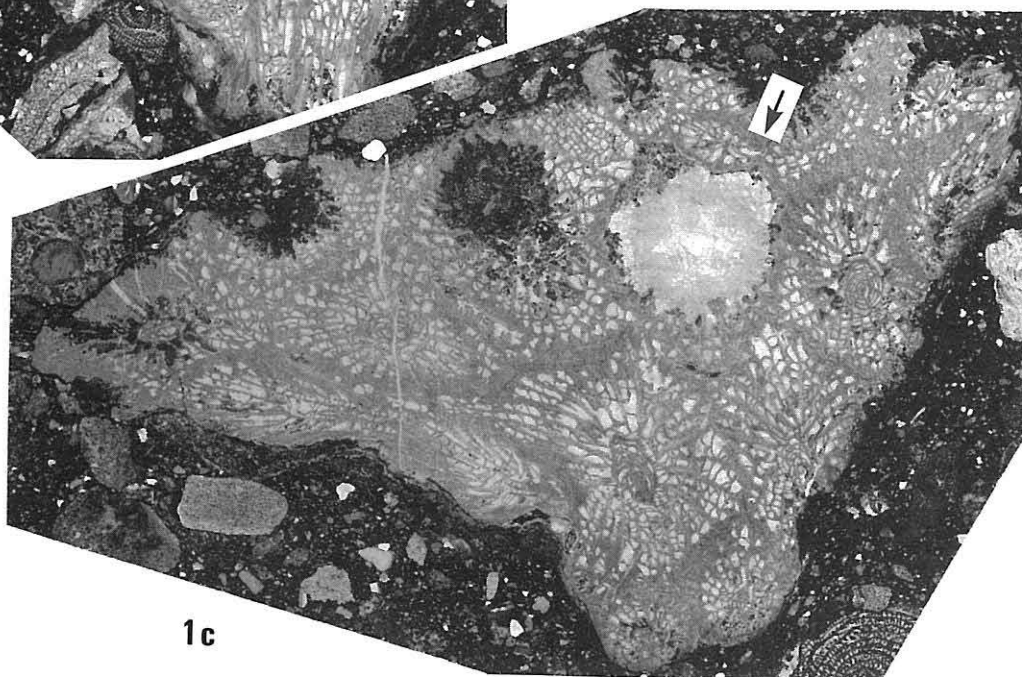
Fig. 1b Oblique section of holotype, x4.



1a



1b



1c

tiary septa and compact axial column compared to the latter.

In respect of meandrine corallum the present form is similar to *Wentzellioides maiyaensis* Yabe & Minato (1944). However the latter is provided with small corallites, less numerous septa and no lonsdaleoid dissepiments.

Family Yatsengiidae Hill, 1956

(*nom. transl.* Flügel, 1964 *ex* Yatsengiinae Hill, 1956)

Genus *Yatsengia* Huang, 1932

Type species (by original designation): *Waagenophyllum (Yatsengia) asiatica* Huang, 1932

Yatsengia sp. A

(Pl. 7, figs. 1a-d.)

Material: A large colony (P122-L536 = UHR 30666) collected from Kampong Awah quarry, and is now stored at the Department of Geology, University of Malaysia. Several fragmental corallites were presented to Kato for study.

Description: Corallum compound, large, fasciculate and phaceloid. Corallite is cylindrical, slender and tall.

In transverse section corallite is round in outline, and is 6.4 mm in diameter in the largest corallite. Internally it consists of dissepimentarium, tabularium and axial structure. Wall is thin. Dissepimentarium is narrow with one row of concentric dissepiments, but often it lacks dissepiments. Tabularium is wide, in which axial structure is not well differentiated. Septa are radially arranged and in two orders. Major septa are 14 in number, some of which are extending into the axial structure. Minor septa are short, restricted within the dissepimentarium when the latter is present. Fine structure of septa is obscured owing to recrystallization, but may have been diffuso-trabecular, judged from shadow structures left behind the recrystallization. Axial structure consists of a few, irregularly twisted septal lamellae, some of which are direct axial elongation of major septa.

In longitudinal section, wall is sinuous. Dissepiments are small, and in one row or they may be altogether absent. Tabulae are mostly complete and ascending gently to the axial structure, and are distantly spaced. They may be locally incomplete. Axial structure is in a form of not well defined axial column with domed axial tabellae and sinuous septal lamellae. But it may be reduced to simple wavy lamellae at the centre of corallite.

Explanation of Plate 4.

Fig. 1 *Waagenophyllum (Waagenophyllum) virgalense* (Waagen & Wentzel) UHR 30661

Fig. 1a Transverse section of some corallites showing the presence of stereowall. Young corallite which is in contact with their mother corallites is observable, x4.

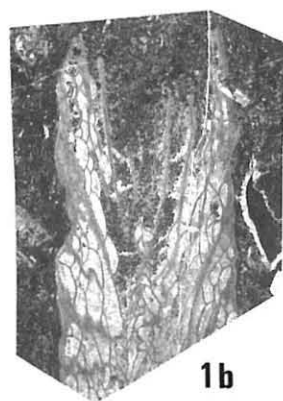
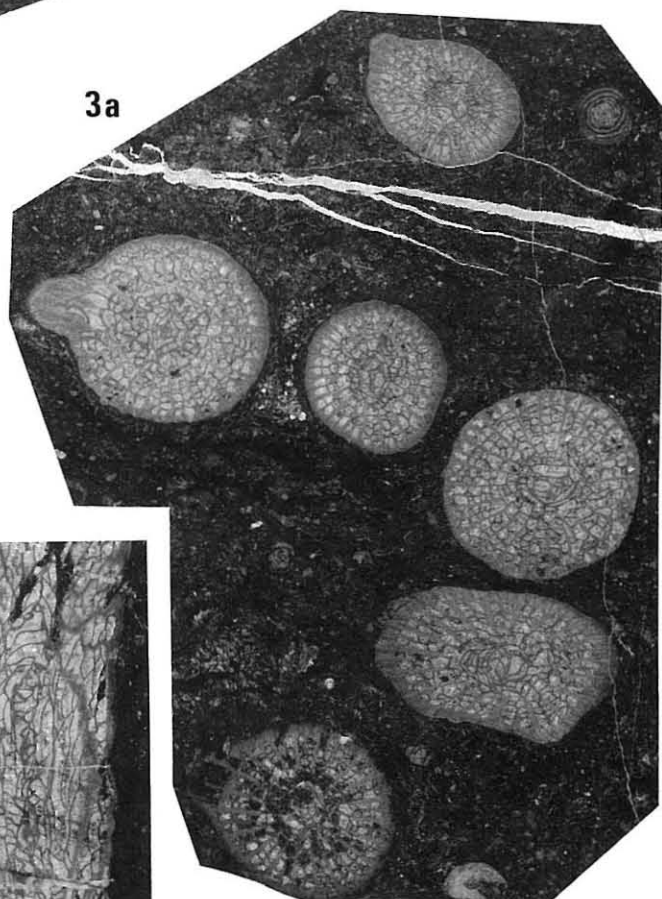
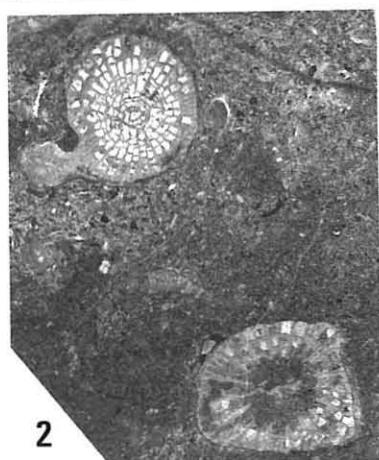
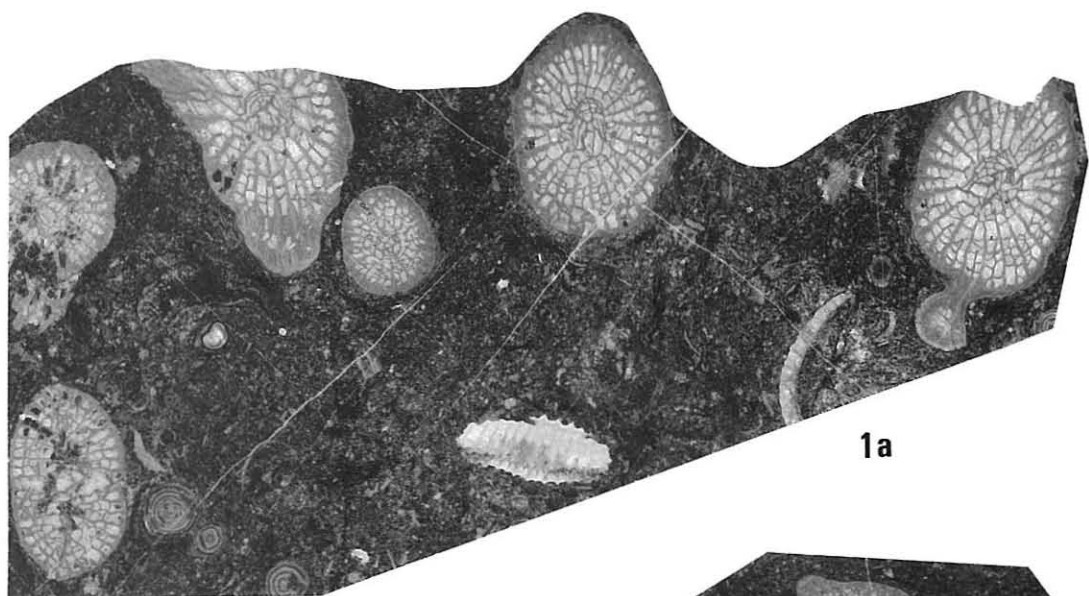
Fig. 1b Longitudinal section in distal part of corallite provided with deep calice, x4.

Fig. 2 *Waagenophyllum (Waagenophyllum) virgalense* (Waagen & Wentzel), x4. UHR 30662

Fig. 3 *Waagenophyllum (Waagenophyllum) virgalense* (Waagen & Wentzel) UHR 30660

Fig. 3a Transverse section of some corallites, x4.

Fig. 3b Longitudinal section, x4. Note well developed large elongate dissepiments, steeply inclined clinotabulae, and transverse tabulae.



Remarks: The present form is characteristic in revealing simple skeletal construction. Absence of dissepiments in some corallites appears to be indicative of a primitive nature of the form now in question. Also simple axial structure appears as if it represents a degenerate feature.

Huang (1932, pl. V, fig. 1b) illustrated corallites of his *Yatsengia asiatica* in which skeletal elements are thin, axial structure is simple or even absent, and with no dissepiments. In these characters, therefore, the present Malaysian form shares commonness with *Yatsengia asiatica*, along with such features as the size of corallite and the number of major septa. However the above mentioned characters are in many ways much different from those in typical corallites of that species (Huang, 1932, pl. V, fig. 1a).

On the other hand simple axial structure in some corallites of the Malaysian form resembles even to such structure in *Yatsengia aberrans* Fontaine (1961, pl. XXXIII, fig. 4), to which it may also be related. The Malaysia form cannot be identified with any known species of *Yatsengia*.

Yatsengia sp. B

(Pl. 7, figs. 2a-c.)

Material: Single corallum firmly embedded in dark limestone matrix with such fusulinids as *Pseudodoliolina* etc. Three thin sections are available. (UHR 30667)

Description: Corallum compound, fasciculate and dendritic.

In transverse section, corallite is round, and consists of wall, dissepimentarium, tabularium and axial column. Corallite diameter reaches up to 7.3 mm in the largest corallite. Wall is thick and with smooth external surface. Dissepimentarium is narrow, less than 1 mm in width, consists of 0 to 4 rows of concentric and pseudoherringbone dissepiments. Tabularium is wide, well differentiated from the dissepimentarium. Dilation occurs along the outer margin of the tabularium. Septa are in two orders. They have diffuso-trabecular fine structure. Fossula indistinct. Major septa number 19 to 20 in full grown corallites. These septa are thick at their bases, but taper towards the axial column, with which they are often in contact. Minor septa alternate with the major, short, nearly confined in the dissepimentarium, or slightly intruded into the tabularium. Axial column is large, subround in outline, occupies about 2 mm in diameter in a large corallite. It consists of more than 10 septal lamellae and 4 to 5 rows of concentric axial column, is however variable in its construction, so that in a small corallite with 4.5 mm diameter it is almost reduced to simple axial structure with a few septal lamellae only.

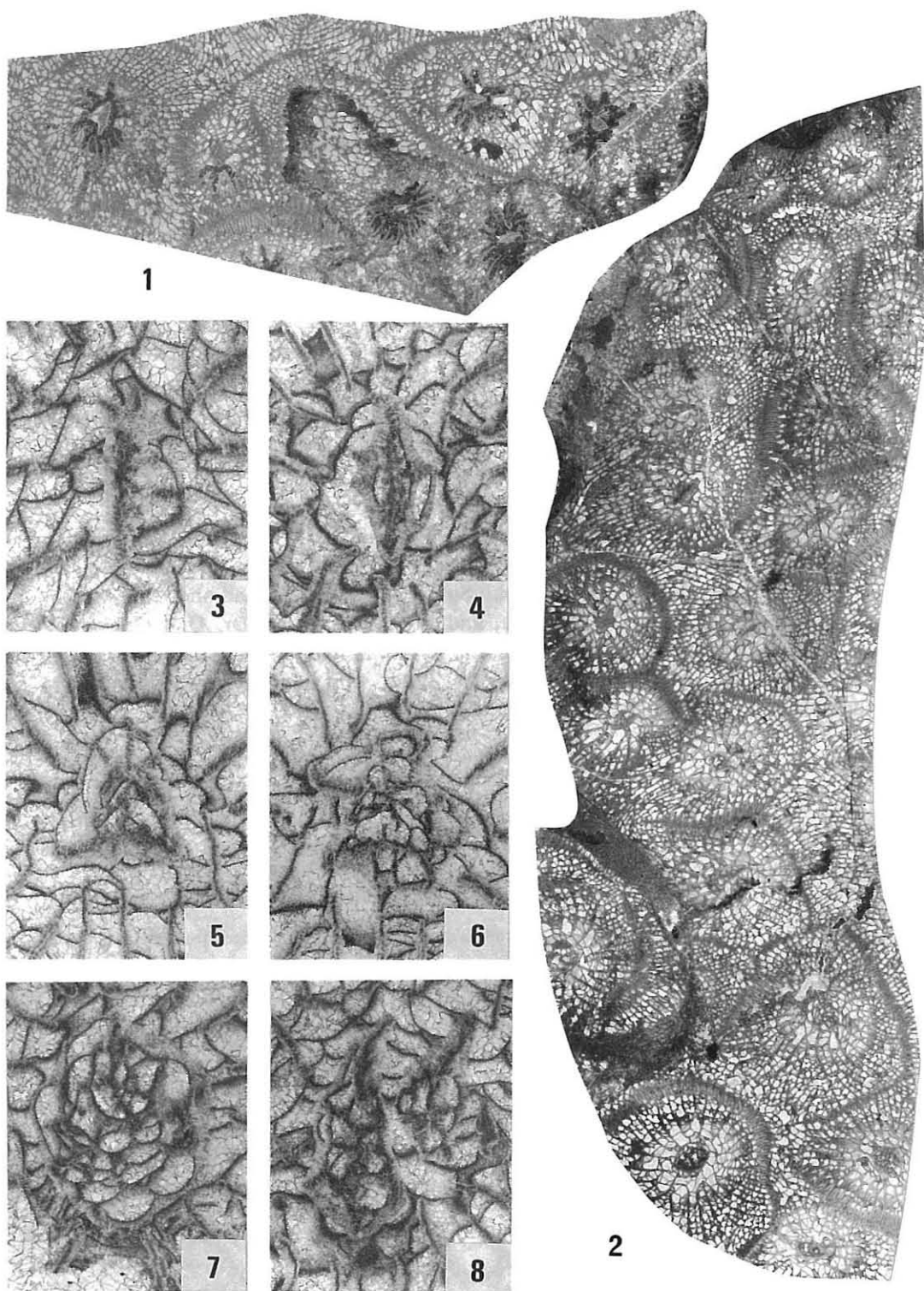
Explanation of Plate 5.

Wentzeloides fontainei, sp. nov.

Fig. 1 Transverse section of corallum, x3. UHR 30665

Fig. 2 Transverse section of holotype, x3. UHR 30663 (Holotype) Meandrine or pseudomeandroid feature is locally observed. Innerwall is distinct in each corallite.

Fig. 3-8 Various types of axial column in construction and outline; from simple, thickened columella to typical waagenophyllid axial column, x16.



In longitudinal section, wall is thick and undulated. Dissepimentarium is narrow, with a single row of dissepiments. Intrathecal dilation occurs on the internal surface of the dissepimentarium. Tabulae are gently or steeply ascending towards axis. They are fairly distantly spaced, complete or incomplete. Axial structure is constructed by cut edges of septal lamellae and steeply disposed axial tabellae. The axial structure is well differentiated from the tabularium in a corallite, while the distinction between them is not at all clear in another corallite.

Remarks: The present form may seem atypical for *Yatsengia* in that it has seemingly numerous septa and dissepiments, well bounded, closely constructed axial column. These characters are especially apparent in transverse section. Thus the form now in question resembles some species of *Heritschioides*. Yet, in fact, it more closely resembles such large species of *Yatsengia* as *Yatsengia hangchowensis* (Yoh & Huang, 1932) which has corallite diameter of 6 mm and has 18 major septa. The Chinese form is from the Lower Permian. We presume that the present Malaysian form represents an advanced form of *Yatsengia*, derived from a form like *Yatsengia hangchowensis*.

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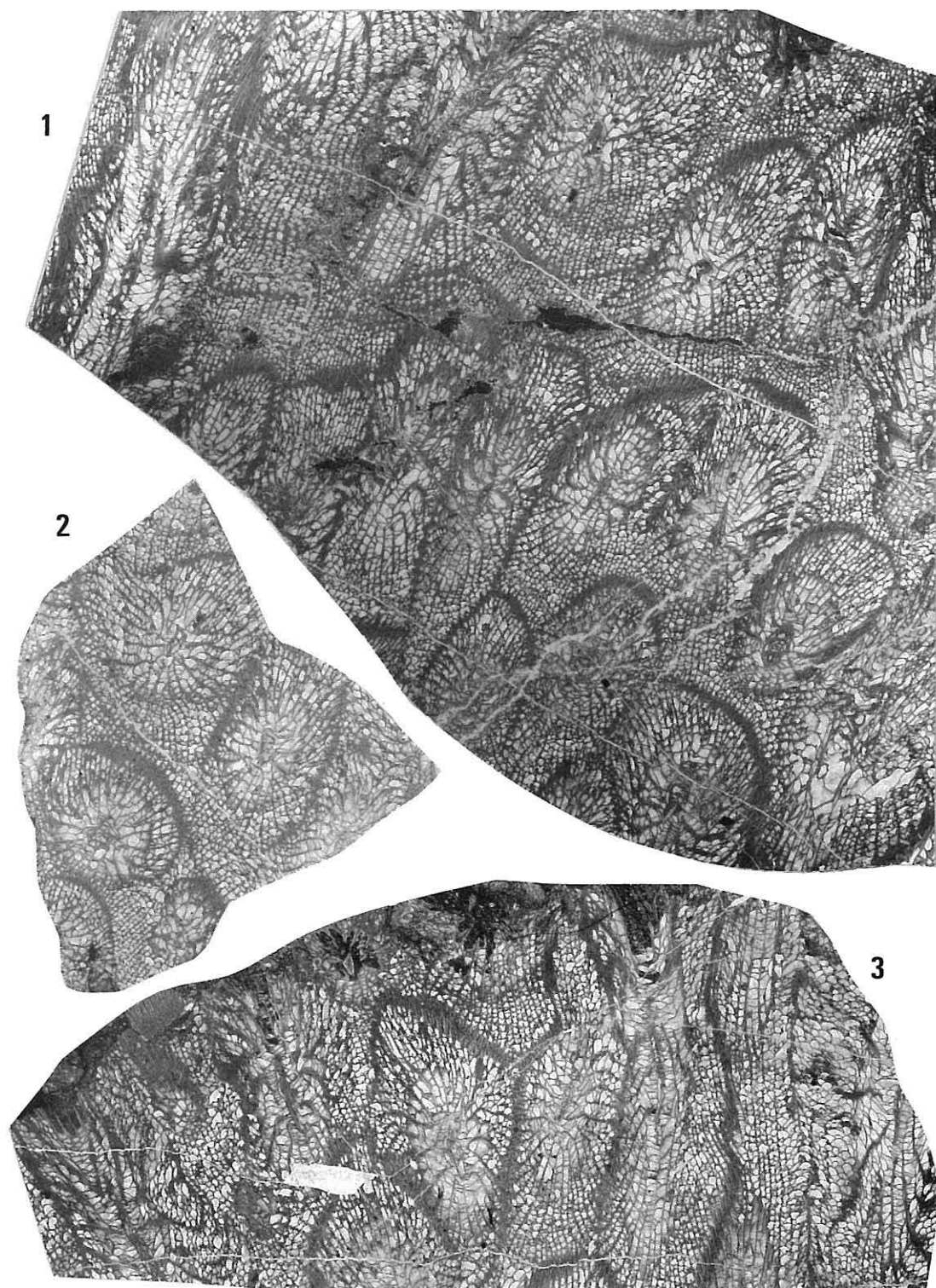
Explanation of Plate 6.

Wentzeloides fontainei, sp. nov.

Fig. 1 Section showing both longitudinal and oblique features of holotype, x3. UHR 30663 (Holotype)

Fig. 2 Transverse section of corallum, x3. UHR 30664

Fig. 3 Oblique and longitudinal section of a corallum, x3. Dissepimentarium composed of small dissepiments is rather wide. UHR 30665



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Explanation of Plate 7.

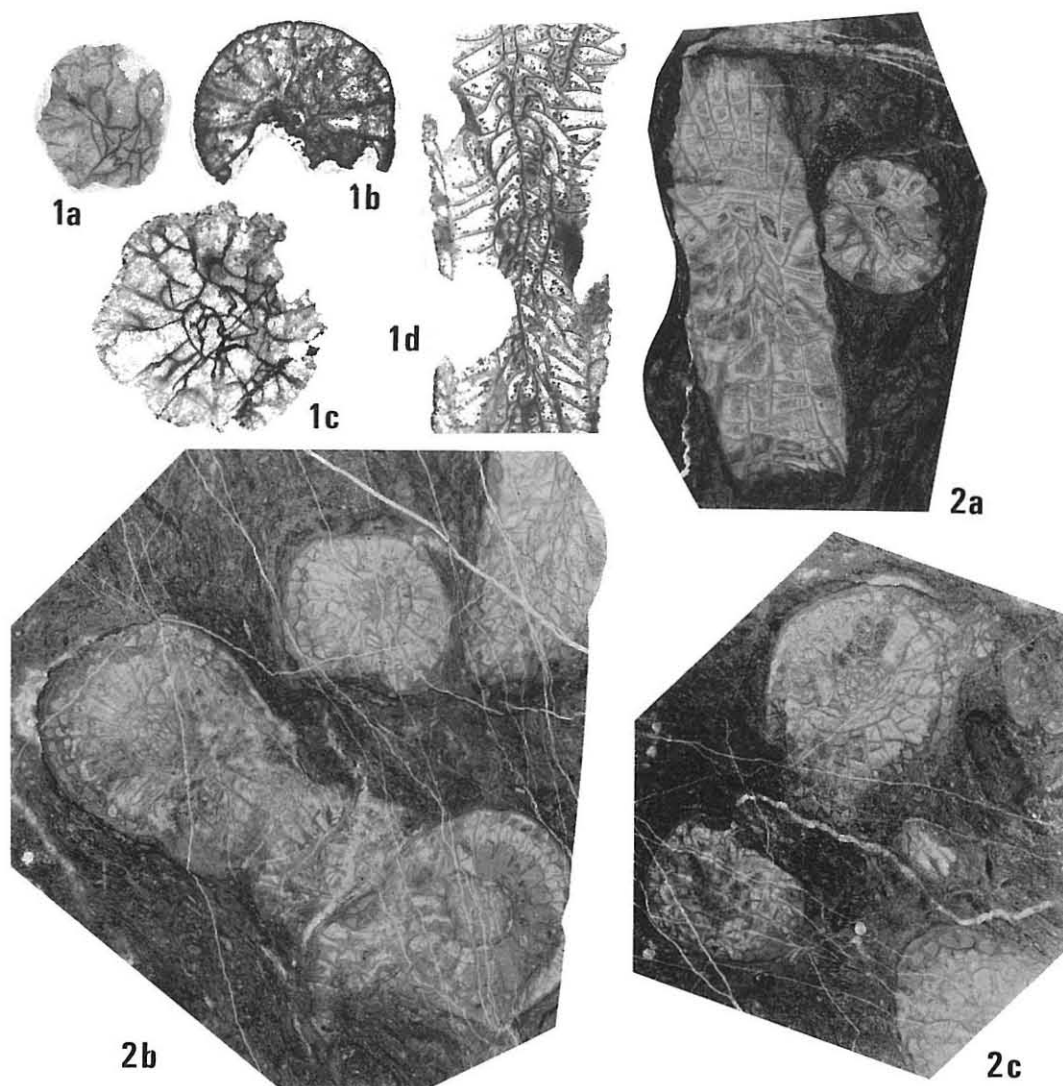
Fig. 1 *Yatsengia* sp. A UHR 30666

Fig. 1a-c Transverse sections denoting simple axial structure, which consists of irregularly twisted septal lamellae and major septa, x5.

Fig. 1d Longitudinal section of a fragmentary corallite. Aial column is simply constructed but not persistent, x5.

Fig. 2 *Yatsengia* sp. B UHR 30667

Fig. 2a-c Transverse and longitudinal sections of some corallites showing prominent intrathecal dilation, x4.



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