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LATE PALAEOZOIC CORALS FROM THE HIMALAYAS

by

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(with 6 text-figures and 5 plates)

Abstract

Permian corals, representing 3 typical Tethyan genera (*Protomichelinia, Iranophyllum* and *Ipciphyllum*) are described from the Shyok Melange, near Shigar, Baltistan. The Carboniferous corals *Pseudozaphrentoides, Pseudotimania, Arachnolasmella* and *Bothrophyllum* (?), and a Devonian *Ceratophyllum* are also described from a Devonian-Carboniferous sequence developed near Tanze, Zanskar Region. These fossils form the first records of Late Palaeozoic corals from the above-mentioned regions of the Himalayas. The Permian corals are of Chihsian to Maokouan age, the Carboniferous corals are of late Viséan or early Namurian age, and the Devonian representative is of Famennian age.

Introduction

Occurrences of Palaeozoic corals in the Himalayas have been recorded occasionally in scattered reports, but very few specimens have been described and illustrated. The purpose of the present paper is to describe, for the first time, some Himalayan late Palaeozoic corals from two regions of the Himalayas, one in the Indus Suture Zone, and the other in the Zanskar Region (Text-fig. 1). Although these corals are fragmentary, few in number, and partly recrystallized, they are worth recording because they form the first records of Devonian, Carboniferous and Permian corals from these regions.

The study was initiated by Gupta, who made several thin sections of corals at Chandigarh. Later, some additional thin sections were prepared at Sapporo from specimens available to Kato. Described specimens are stored at the Centre of Advanced study in Geology, Panjab University, Chandigarh, India (CASG/VJG/F numbers).

Stratigraphy

1. Baumaharel river, near Shigar, Baltistan

A huge block of a relatively unmetamorphosed sequence of carbonate is exposed along the Baumaharel river, northeast of Shigar, Baltistan. This block is within the Shyok Melange, and yielded some Permian fossils (Brookfield and Gupta, 1984).

In the Shigar area, the Shyok Melange strikes northwest, and on the south, it is thrust over the Ladakh-Deosai batholith complex of mostly early Tertiary age. On the north, it is overthrust, and in places intruded by, the Karakorum batholith complex of mostly late Tertiary age. (Text-fig. 2)

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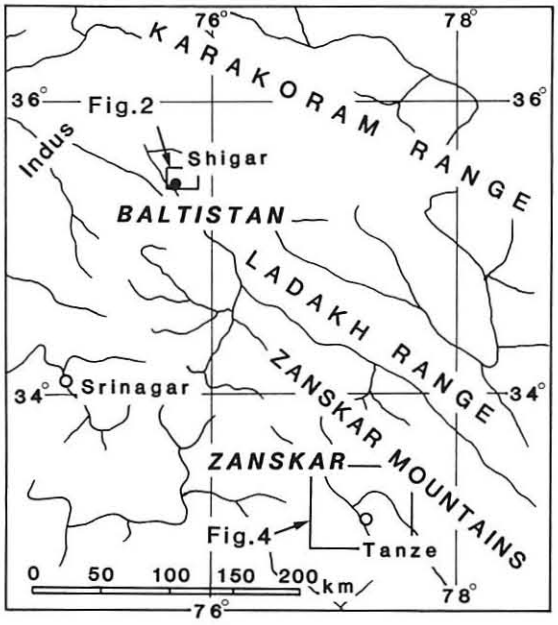


Text-fig. 1 Index map showing two areas from where corals were collected.

The Shyok Melange, in most places, is metamorphosed to greenschist and amphibolite facies, but some thrust units have escaped this metamorphism. One of such example is northeast of Shigar, along the Baumaharel river, where the high cliffs are formed of massive limestone (Text-fig. 3). Here, the stratigraphic sequence is, in descending order:

Unit 17 — unfossiliferous, blackish-gray arenaceous shale, about 200m thick.

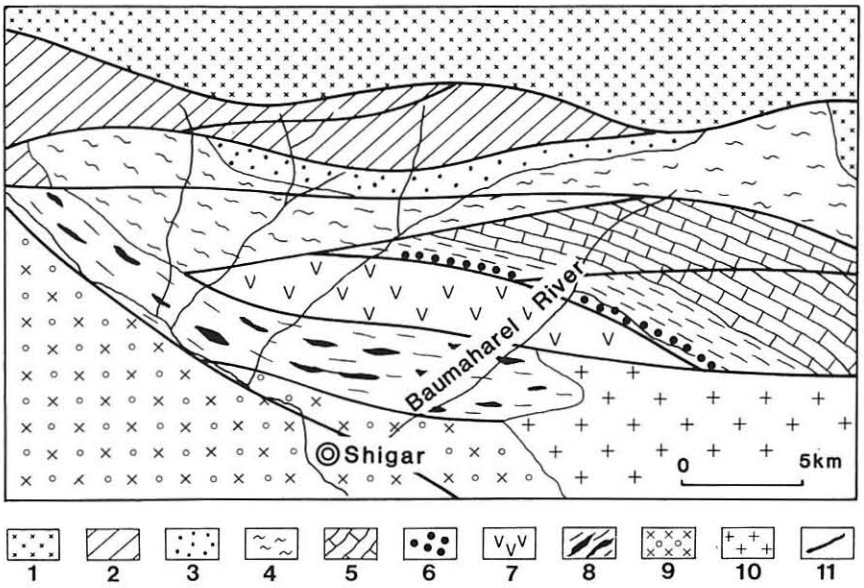
Unit 16 — unfossiliferous, purplish shale and thin-bedded fine-grained nodular limestone, about 100m thick.

Unit 15 — massive, thick, white to gray limestone, with bioclastic layers; at least 1,000m thick; containing few fossils [Fragments of *Xenodiscus carbonarius* (Waagen)]

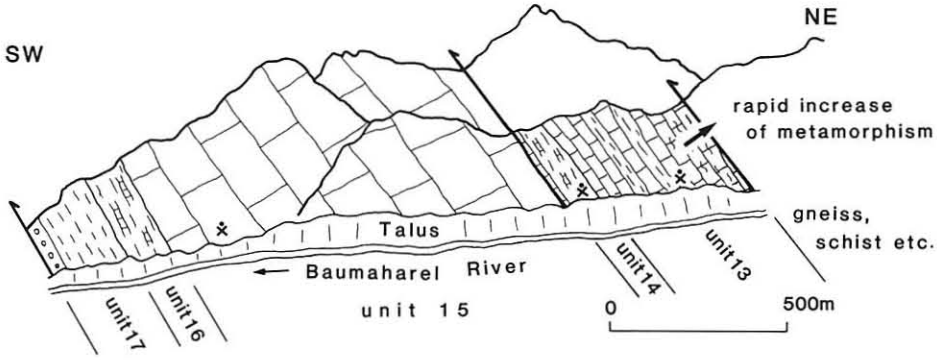
Unit 14 — alternating thin-bedded, fine-grained and bioclastic limestone and calcareous shales; about 50m thick. The shales are fossiliferous and contain:

Crinoidea — *Rhysocamax* sp.
Bryozoa — *Protoretepora ampla* Lonsdale
Thamniscus sp.
Brachiopod — *Spiriferella rajah* (Salter)
Lamnimargus himalayensis (Diener)
Punctocyrtella cfr. *vagrans* (Waterhouse and Gupta)
Anthozoa (herein described).
Ipciphyllum cfr. *fliegeli* Lange
Iranophyllum splendens Douglas
Protomichelinia elegans Lin

Judging from the stratigraphic occurrence of the identified and/or comparable forms of brachiopods and corals elsewhere, Unit 14 appears to contain several fossil horizons of slightly different ages, but this cannot be established with containtly. *Protomichelinia* is identified with a species from the Chinese Chihsian, and *Iranophyllum*



Text-fig. 2 Geologic sketch map of area around Shigar (After Brookfield and Gupta, 1984).
1 — Karakorum batholith granites and gneisses; 2 — Amphibolites; 3 — Quartzites; 4 — Micaschists; 5 — Limestone (marble to north-west); 6 — Slate and phyllite (limestone pebble conglomerate at base); 7 — Basic-intermediate volcanics and volcaniclastics; 8 — Ophiolite melange; 9 — Gabbro-diorite; 10 — Ladakh-Deosai batholiths and associated metamorphics.



Text-fig. 3 Sketch of right bank of the Baumaharel river, showing locations of fossil collection (X) (After Brookfield and Gupta, 1984).

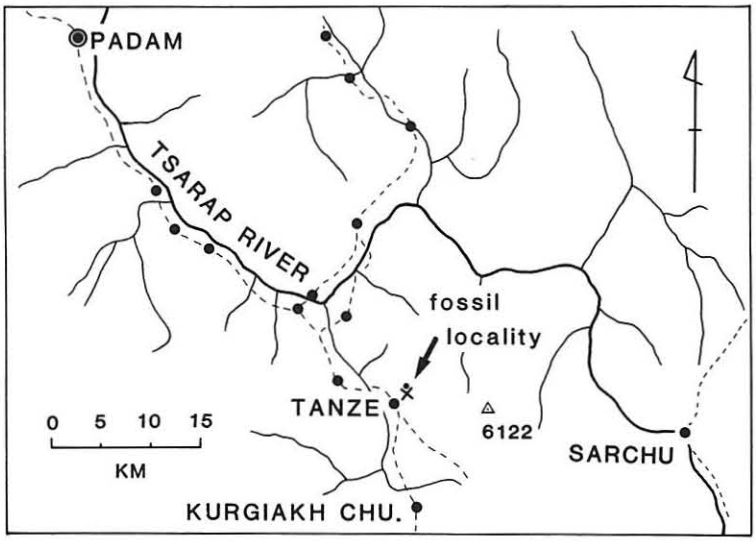
is common also in the Chihsian. *Ipciphyllum* is common in the Maokouan, whereas *Lamnimargus* is regarded as a representative form of the Punjabian (Waterhouse and Gupta, 1977).

The fossils are markedly Tethyan in their faunal character. Gupta has seen similar corals in the Sader Brangsa Formation of eastern Karakorum.

Unit 13 consists of thick-bedded fine-grained, rarely bioclastic limestone, several hundred metres thick. It contains abundant crinoid ossicles. A rapid increase in metamorphism occurs towards its northern thrust contact with gneisses and schists containing marbles and quartzites.

2. Tanze area, Zanskar Region.

The Palaeozoic formations are well developed in the Luneak valley of the Zanskar Region occupying an intermediate position between Srinagar and Spiti (Gupta, 1978) (Text-figs. 1 and 4).



Text-fig. 4 Map showing location of fossiliferous outcrop near Tanze. Geologic column is shown in Text-fig. 5.

The stratigraphic succession in the Luneak valley is:

Ralakung Volcanic Succession — Upper Carboniferous to Permian.

Luneak Formation — Upper Devonian to Middle Carboniferous.

Muth Quartzite — Middle to Upper Devonian.

Tanze Formation (quartzites, shales and conglomerates)
— Upper Silurian to Middle Devonian.

Karsha Formation (limestone with quartzite)
— Upper Ordovician to Silurian.

Phe Formation (phyllites and quartzites)
— Cambrian to Low. Ordovician.

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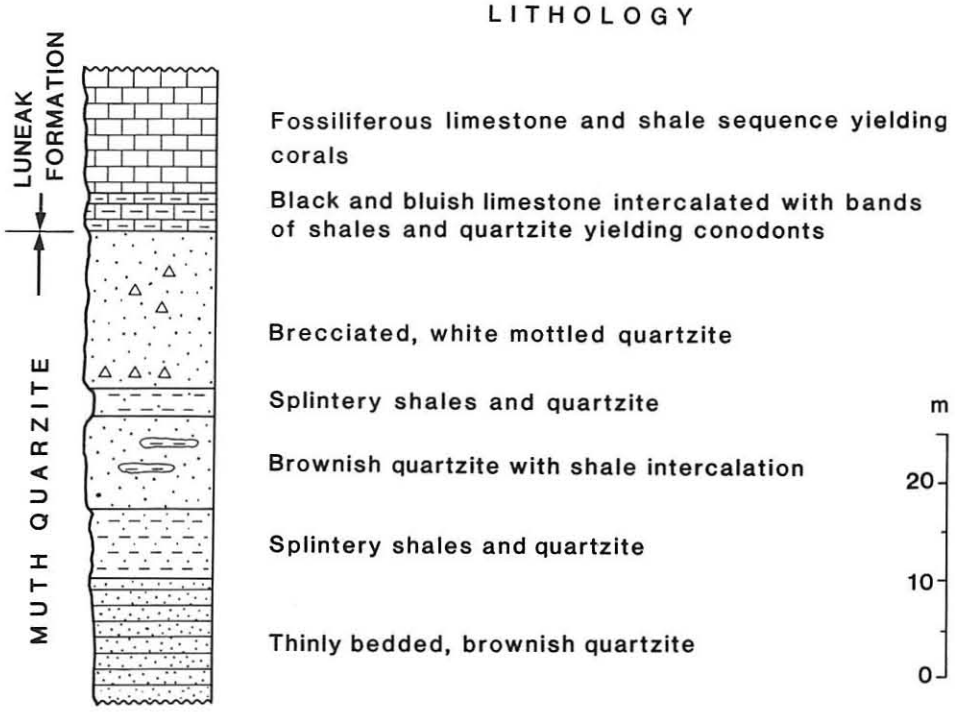
Suru Crystalline (gneisses and schists) — Precambrian

The lowermost units of the Luneak Formation, immediately overlying the Muth Quartzite, exposed near Tanze Village (Text-fig. 5) yielded several species of such conodont genera as *Palmatolepis* and *Polygnathus* denoting the Lower *Marginifera* Zone of the Famennian (Gupta and Uppal, 1984). These units also yielded a solitary rugose coral herein described as *Ceratophyllum* sp.

The beds yielding Late Devonian conodonts are conformably overlain by siliceous limestone from which the following conodonts were recorded (Gupta and Kachroo, 1979).

Elictognathus lacerata (Branson and Mehl)
Gnathodus bilineatus (Roundy)
G. defectus (Dunn)
G. cfr. *delicatus* (Branson and Mehl)
Idiognathodus cfr. *delicatus* (Gunnel)
Pseudopolygnathus prima (?) (Branson and Mehl)



Text-fig. 5 Geologic column showing detailed stratigraphic succession of Devonian and Carboniferous rocks exposed near Tanze (Mainly after Gupta and Uppal, 1984).

Siphonodella cooperi (Hass)
S. cfr. *duplicata* (Branson and Mehl)
Spathognathodus campbelli (Rexroad)
Ligonodina sp.

Although the assemblage was regarded as Tournaisian to Viséan in age by Gupta and Kachroo (1977), it seems to contain even younger elements.

The following corals have been identified from this siliceous limestone.

Bothrophyllum? sp.
Pseudotimania sp.
Pseudozaphrentoides juddi (Thomson)
Arachnolasmella cfr. *interuptocolumellata* Bikova

The first two forms belong to or are quite similar to genera that are mostly Late Carboniferous in age. *Pseudozaphrentoides juddi* is a common form in the Upper Viséan. The fourth form is comparable to a Russian species ranging from Viséan to Namurian.

As a whole, therefore, this coral assemblage, if the corals were obtained from a single horizon, denotes either late Viséan or early Namurian age. An Upper Carboniferous age for the Luneak Formation is also indicated by some of the conodonts listed above.

Systematic Description*

Subclass Rugosa Milne-Edwards and Haime, 1850
Order Stauriida Verril, 1865
Family Disphyllidae Hill, 1939
Genus *Ceratophyllum* Gürich, 1896

Type species (by original designation): *Ceratophyllum typus* Gürich, 1896.

Remarks: Fedorowski (1967), who restudied Gürich's material, describes the tabulae as concave in the type species. However, his illustrations of *Ceratophyllum typus typus* (pl. II, fig. 3) and *Ceratophyllum typus skalense* (pl. II, fig. 7) indicate that the tabulae are actually convex, though somewhat obliquely disposed. In transverse section, septa are pinnately arranged in these forms mentioned above, but they may be radial in some specimens (Fedorowski, 1967, pl. II, fig. 6). Hill (1981) and Pedder (1982) assumed that *Ceratophyllum typus* has rhipidacanthine septa. Rozkowska (1979) clearly states that her *Ceratophyllum kielcense* has rhipidacanthine septa, with distinctly convex tabulae. We are not quite certain about this point of septal structure. A tendency from uni-trabecular to multi-trabecular in septal fine structure is often observed in rugose corals (Kato, 1963). Rozkowska's illustration for *Ceratophyllum kielcense* (1979, pl. 3, figs. 10a-b) appears to show ordinarily trabecular septa. A simple definition of *Ceratophyllum* would include solitary disphyllids having trabeculae arranged in half-fans. Many previously described species in scattered genera would thus be grouped under the genus *Ceratophyllum*.

* Suprageneric classification is after Hill (1981).

Ceratophyllum sp.

pl. 1, figs. 1-5

Material: Single corallite with calice and epitheca well preserved, but tip portion is missing.* CASG/VJG/F1100.

Description: Corallum is solitary. Calice is moderately deep. Top surface of radially arranged septa is a little everted, slightly higher than the rim of corallite wall. Fine growth lines and faint septal grooves are observed on epitheca which periodically expands and shrinks at a vertical interval of 4 to 4.5mm.

In transverse section, corallite is round in outline. Wall is moderately thick and crenulated. In one part, the corrallite is so extended that it gives double wall. This phenomenon probably corresponds to the lateral expansion of corallite. Dissepimentarium is wide, 2.5 to 3mm in width, and consists of herringbone and concentric dissepiments where minor septa are developed. Dissepiments are commonly lateral or periseptal on both sides of each septum. Inner wall is not distinct. Tabularium is wide, with open centre of 5mm in diameter, free from septa. Septa are radially arranged and in two orders. No fossula is observed. Major septa are 7 to 8mm in length, and 36 in number in the corrallite with 20mm diameter. Major septa are very thick, especially at boundary between tabularium and dissepimentarium; they taper axially and peripherally so that they show elongated spindle shape as a whole. Minor septa alternate with the majors, some intrude into tabularium but others are completely confined within dissepimentarium. Septa are trabecular and without carinae. The lateral surface of each septum is not always smooth, but slightly elevated.

In longitudinal section, wall is thick and sinuous. Dissepiments are large and hemicircular to small, globose, or vertically elongated. They are arranged almost horizontal near wall, but are steeply inclined at inner margin of dissepimentarium. Surface of some dissepiments, corresponding to expanded corallite, is notably thickened. Tabularium is wide, consists of two series of incomplete tabulae. Peripheral series is composed of axially inclined and transverse tabulae, whereas central series has more or less flat tabulae with upswollen series of marginal tabulae. Central tabulae are periodically thickened, and their vertical arrangement is uneven, being closer near thickened tabula. Septal trabeculae are almost vertical near wall, and are almost horizontal near periphery of the tabularium, so that they are arranged in a half-fan pattern.

Remarks: The small everted calice; thick, spindle-like trabecular septa arranged longitudinally in half-fans; and peripheral and central series of tabulae are the main characteristics of the present form.

A number of species hitherto referred to *Ceratophyllum, Temnophyllum, Mansuyphyllum, Charactophyllum, Sinodisphyllum, Keriophylum, Neostringophyllum* resemble the present form. This resemblance is either only superficial, or these species were so classified by different authors because of different taxonomic concepts of these authors, inspite of their actually close systematic relations.

Because little agreement seems to have been achieved on the generic or suprageneric

* For localities and horizons of the described corals, see the stratigraphy section of this paper.

classification of Devonian corals (*e. g.* Spassky, 1977; Birenheide, 1978; Hill, 1981), an evaluation of the genera mentioned above based on their type species is in order.

Temnophyllum shows almost horizontal trabeculae and axially sagging tabulae (Birenheide, 1978). Septa are thin and dissepiments are concentric in *Sinodisphyllum* (Sun, 1958). *Mansuyphyllum* has relatively thin septa and a wide dissepimentarium with herringbone dissepiments (Fontaine, 1961). *Neostringohyllum* has sagging tabulae with a central notch and has been often considered synonymous with *Acanthophyllum* (Birenheide, 1978). *Keriophyllum* has strong xyloid carinae on the septa, arched tabellae, and is synonymous with *Peripaedium* (Birenheide, 1963). *Charactophyllum,* as interpreted by Pedder (1982), shows charactophylloid trabeculae. Thus, our Himalayan form is not attributable to these genera, but is regarded as a species of *Ceratophyllum*. No species ascribed to the genus *Ceratophyllum* is identical with the present form, although *Ceratophyllum kielcense* and *Ceratophyllum heterophylloides* described by Rozkowska (1979) somewhat resemble the Himalayan form. *Neostringophyllum modicum* of Tsyganko (1981), which is not identical with *Mictophyllum modicum* Smith (1945), from the Frasnian of North Ural, closely resembles the present form, but still differs from it in having regularly and closely set horizontal tabulae in the central series of tabulae in the former species. *Cyathophyllum* (*Campophyllum*?) *chitralense* Reed (1922) most closely resembles the present form especially in characters in transverse section. But in longitudinal section, it differs from the latter in having a narrower dissepimentarium and a wider central series of convex tabulae. The Upper Devonian age of this Chitral form appears warranted because of its association with many phacellophyllids (Reed, 1922) whereas Gupta and Uppal (1984) regard the bed yielding the present coral as Famennian based on conodonts.

Family Bothrophyllidae Fomichev, 1953

Genus *Bothrophyllum* Trautschold, 1879

Type species: *Turbinolia conica* Fischer, 1830 *sensu* Trautschold, 1879.

Bothrophyllum ? sp.

pl. 2, fig. 6

Material: Single transverse section of calicular portion of a corallum. CASG/VJG/F1101.

Description: Corallum is solitary. In transverse section, corallite is round, 17mm in diameter. Wall is thin and smooth. Dissepimentarium is wide, ca. 4mm in width, consists of herringbone to irregularly concentric dissepiments. Small, flattened, lonsdaleoid dissepiments are present near the periphery. Small periseptal (= lateral) dissepiments are commonly attached to both sides of each septum. Dissepiments are closely distributed near boundary between dissepimentarium and tabularium. Diameter of tabularium is 10mm, where 37 short major septa are radially arranged. Cardinal fossula is prominent. Cardinal septum is short. A new major septum starts growing on one side of cardinal septum in fossula in dissepimentarium near boundary between dissepimentarium and tabularium. Major septa are sinuous and thickened in tabularium. Minor septa occur sporadically in middle of dissepimentarium. Outer side of tabulari-

um is filled with matrix, showing that tabulae are elevated upward. In open, central portion of corallite, cut edges of tabulae and some flexuous septal-lamellae-like plates are seen.

Remarks: At a glance the present form looks like a caninid, not very different from corals of the "*Caninia*" *juddi* group. In fact *Caninia juddi* var. *dawsoni* Lewis (1935) from Nova Scotia quite resembles the present form in having small lonsdaleoid dissepiments and well developed herringbone dissepiments. However, the present form has weak axial structure, presumably on the upper surface of elevated tabulae. In this respect, it is somehow related to *Bothrophyllum streeli* Poty (1981) from Belgium and *Bothrophyllum proteum* Semenoff-Tian-Chansky (1974) from Sahara, both of which show several thin septal-lamellae-like structures in the centre of the corallite in a mature stage. Minor septa are well developed in these species, which are therefore specifically different from the present form. Nova Scotian and Belgian forms mentioned above are all Viséan in age, whereas the Sahara species is Bashkirian. The present form has periseptal dissepiments as well as herringbone dissepiments. In this connection its dissepimentarium resembles that of *Neokoninckophyllum,* although minor septa are generally developed in the latter genus. Although much different from typical *Bothrophyllum* (Dobrolyubova, 1937, 1948) we place the present form under this genus with a query, in view of its similarity to the other above mentioned species assigned to the genus. This is probably a new species.

Family Cyathopsidae Dybowski, 1973

Genus *Pseudotimania* Dobrolyubova and Kabakovich, 1948

Type species (by original designation): *Timania mosquensis* Dobrolyubova, 1937

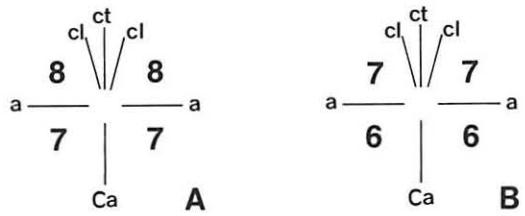
Remarks: One of the characteristic features of the genus is the presence of remarkably long cardinal and counter septa in the neanic growth stage. The same character is found during the ontogeny of *Caninia juddi* studied by Lewis (1924, pl. 28, fig. 1j), and of *Hornsundia* Fedorowski (1965). Thus all these genera, *Pseudozaphrentoides* (= *Caninia juddi* group), *Pseudotimania* and *Hornsundia,* are better included in the family Cyathopsidae with *Zaphrentites*-like ancestry. Shortening of the cardinal septum in the later growth stage occurs in many lineages of the family. Genus *Pseudotimania* has been thought to be confined to the Upper Carboniferous (Hill, 1981), but the range may be eventually extended. Gorsky (1951, fide Gorsky, 1978) introduced a new genus, *Pseudotimania* for his*Pseudotimania irregularis.* This is a homonym and may be a synonym of *Pseudotimania* Dobrolyubova and Kabakovich.

Pseudotimania sp.

pl. 2, figs. 4 & 5

Material: Two successive transverse sections of a corallite. CASG/VJG/F1102.

Description: Corallum is solitary. Transverse section of a corallite in mature stage is round in outline and 18.5mm in diameter. Wall is thin and smooth. Dissepimentarium is narrow, consists of one or two rows of concentric dissepiments, in which thin minor septa are confined. Inner wall is present. Major septa are pinnately arranged. Cardinal,



Text-fig. 6 Septal formula of *Pseudotimania* sp. 6A — Mature stage; 6B — Neanic stage; Ca — Cadinal septum; ct — Counter septum; a — Alar septa; cl — Counter lateral septa.

alar, and counter septa are long and meet at centre of corallite. Cardinal and alar fossulae are present. Major septa are long, but some of them extend only half-way to centre. Septal formula is as in Text-fig. 6A. Number of major septa is 36; counter septa are slightly accelerated. Major septa are dilated in tabularium, especially in cardinal quadrants.

In neanic corallite (pl. 2, fig. 5) only one row of concentric dissepiments starts to develop in one side, whereas on the other side, relatively thick wall with low projection of minor septa is seen. Cardinal, counter, and both alar septa are long and meet or nearly meet at centre of corallite. Major septa are thick and especially so dilated in cardinal quadrants that they are almost in contact laterally. Number of major septa is 32. Septal formula is shown in Text-fig. 6B. Pinnate arrangement of septa is clearly observable. Septal fine structure is fibro-lamellar, with diffuso-trabecular axis.

Remarks: Th present form resembles *Pseudotimania mosquensis* Dobrolyubova (1937) and *Pseudotimania kasimovi* Dobrolyubova and Kabakovich (1948), especially in the neanic stage which reveals a narrow, concentric dissepimentarium, thick major septa, and notably long cardinal and counter septa. A similar morphology is seen in the young neanic corallite of "*Caninia*" *juddi* figured by Lewis (1924). The present form differs from the above forms in having a less-well-developed dissepimentarium and long major septa in mature stage. It may represent an early form of the genus, possibly derived from a zaphrentitid ancestor.

Genus *Pseudozaphrentoides* Stuckenberg, 1904

Type species (by monotypy): *Pseudozaphrentoides jerofeewi* Stuckenberg, 1904.

Remarks: The genus corresponds to the *Caninia juddi* group. The type species was restudied by Fedorowski (1975). For us it is synonymous with "*Caninia*" *juddi,* but has prominent intrathecal dilation of septa particularly in cardinal quadrants. Many species of *Caninia auctt.* would be best placed under the present genus, which is widely distributed in the Carboniferous of Eurasia and North America.

Pseudozaphrentoides juddi (Thomson)

pl. 2, fig. 1

1893 *Campophyllum juddi* Thomson, p. 711, fig. 3

1904 *Pseudozaphrentoides jerofeewi* Stuckenberg, p. 33, pl. VIII figs. 5a-c; pl. LX,

fig. 7a. (in the explanation of Plate the species is spelt as *Pseudozaphrentoides Jerofejewi*).

1906 *Campophyllum derbiense* Vaughan, p. 139 (*fide* Lewis, 1924)

1924 *Caninia juddi,* Lewis, p. 391-397, pls. XXVII-XXIX, pl. XXX, (figs. 1-2.)

1939 *Caninia juddi,* Hill, pl. 198-110, pl. V, figs. 16, 17. (see for further synonymy).

1945 *Caninia juddi,* Sloss, p. 311-312, pl. 48, figs. 1-4.

1952 *Caninia inostranzewi,* Dobrolyubova, p. 62-83. pls. I-IV.

1960 *Caninia juddi,* Vassiljuk, p. 57-58, pl. XIII, figs. 4-4b.

1974 *Pseudozaphrentoides juddi,* Semenoff-Tian-Chansky, p. 190-192, Text-fig. 70, 72; pl. 47, fig. 6; pl. 49, figs. 4, 5; pl. 72, fig. 2.

1975 *Pseudozaphrentoides juddi,* Poty, p.54, pl. XXV, fig. 1.

Material: Single transverse section from a fragmentary corallite. CASG/VJG/F1103.

Description: Corallum is solitary. No external characters are known.

In transverse section corallie is broken, but may have been originally subround in outline. It is 16mm across as far as it is preserved. The corallite is composed of dissepimentarium and tabularium; in the central part of the latter there is wide open space free from septa. Wall is thin, with slight notches corresponding to septal grooves. Dissepimentarium is wide, 3.3mm in width, composed of several rows of herringbone and irregularly concentric dissepiments. Closely arranged dissepiments and slight dilation make inner wall between dissepimentarium and tabularium. Tabularium is wide, 12.5mm in minimum diameter. Major septa are intrathecally thickened, especially in cardinal quadrants. Cardinal fossula is prominent, in which relatively thin, short cardinal septum is situated. Alar fossula is weakly developed. Seven and eight major septa are on both sides of the cardinal septum in cardinal quadrants. Septa do not extend to the centre and are fewer, although the exact number is not known. Minor are developed only near the periphery in the dissepimentarium, where some are discontinuous. All the septa are flexuous and thin in the dissepimentarium. Septal fine structure is diffuso-trabecular.

Remarks: Hill (1939) merged various forms of "*Campophyllum*" created by Thomson with "*Caninia*" *juddi.* The species typically has less dilated, short major septa. But Lewis (1924), in view of ontogenetical change and individual variation, expanded the conception of the species considerably so as to include forms with long, dilated major septa, especially in cardinal quadrants. A number of species have been described and attributed to *Pseudozaphrentoides,* together with many forms of *Caninia s.l.* These are not unlike *Pseudozaphrentoides juddi.* Detailed ontogenetical study of them can only resolve true systematic relation amongst these otherwise similar forms. The present Himalayan form has a fairly wide and loosely constructed dissepimentarium, intrathecal dilation of fewer major septa in cardinal quadrants, and a thin, short cardinal septum. From these characters the form deviates slightly from the typical *juddi,* and is more similar to *Caninia inostranzewi* described by Dobrolyubova (1952) from the Moscow Basin. Species of *Caninia* established by Stuckenberg (1904) from the same region closely resemble each other, which caused Dobrolyubova (1952) to claim syn-

onymity for *Caninia inostrnazewi* and *jerofeewi*. Typical "*Caninia*" *juddi* occurs in the Upper Viséan in the United Kingdom (Lewis, 1924; Hill, 1939); in Belgium (Poty, 1981); in West Sahara (Semenoff-Tian-Chansky, 1974); and in Donetz Basin (Vassiljuk, 1960). The present form may also be Upper Viséan.

Family Aulophyllidae Dybowski, 1873

Genus *Arachnolasmella* Bikova, 1966

Type species (by original designation): *Arachnolasmella interuptocolumellata* Bikova, 1966.

Remarks: *Arachnolasmella* was established as a subgenus of *Arachnolasma* (Bikova, 1966), and was raised to generic rank by Sayutina (1973). The genus was synonymized with *Amygdalophyllum* by Fedorowski (1970), and by Hill (1981) with query. As far as the type species is concerned, it is different from typical forms of *Amygdalophyllum* in having a small axial structure in which septal lamellae and axial tabellae are developed along with a thickened median plate. Axial ends of major septa do not touch the peripheral margin of the axial column. Thus the form now in question looks similar also to *Koninckophyllum* to some extent, though it has a more complicated and larger axial structure compared to the latter. The genus bears resemblance to *Ekvasophyllum,* especially to *Ekvasophylum turbineum* Parks (1951), but in *Ekvasophyllum,* the major septa extend to the columella, which intrudes into the elongated cardinal fossula. Alar fossulae are also prominent. Ekvasophyllidae was created by Hill (1981) to include *Ekvasophyylu, Turbophyllum, Zaphriphyllum* and *Faberophyllum*. Bikova (1966) included in her *Arachnolasmella* 3 species: *Arachnolasmella interuptocolumellata* Bikova, *Arachnolasmella gigantea* Bikova and *Arachnolasma clisaxophylloides* var. *compactocolumellata* Volkova (1941), but minor septa are poorly developed in the latter two forms, which are all from Kazakhstan. Sayutina (1973) described *Arachnolasmella interuptocolumellata* and *A. intermedia* Sayutina from Northern Ural. The former, however, is not identical with the said species, and even its generic assignment to *Arachnolasmella* is questionable. The latter is probably a new species which is correctly assigned. These forms are all Viséan to Namurian in age. The present Himalayan occurrence is the first outside the USSR.

Arachnolasmella cfr. *interuptocolumellata* Bikova

pl. 2, figs. 2 & 3

1966 cfr. *Arachnolasmella interuptocolumellata* Bikova, p. 121-125, pl. 16, figs. 4, 5, pl. 17, fig. 2.

Material: Two transverse sections from a fragmental corallite. CASG/VJG/F1104.

Description: Corallum is solitary. External characters unknown. Corallite is round in transverse section, where triareal arrangement of skeletal elements, namely axial column, tabularium and dissepimentarium, is clearly seen. Epithecal part is eroded away. Dissepimentarium is narrow, consists of several rows of concentric dissepiments.

	Diameter mm.		Width mm.		Number of major septa
	corallite	tabularium	axial column	dissepimentarium	
pl. 2, fig. 2	18.4	14.6	1.5	2.2	48
pl. 2, fig. 3	15.6	8.0	1.4	1.5	44

Tabularium is wide, well differentiated from dissepimentarium by an inner wall. Septa are in two orders. Major septa do not reach the center of corallite, and are 4 to 4.5mm in length in the tabularium, leavng a wide or narrow open space around the axial column. Axial parts of major septa rotate around the axial column in a young stage. Cardinal fossula is prominent, where short cardinal septum is located. Alar septa are discernible but not counter septum. Major septa show slight acceleration in cardinal quadrants. Twenty four or twenty six septa are present in the cardinal quadrants versus twenty or twenty two septa in the counter quadrants. Minor septa alternate with major septa, almost confined to the dissepimentarium, but slightly intruding into tabularium on one side of corallite in a mature stage. All septa are slightly thickened in tabularium. They are diffuso-trabecular in fine structure. Axial column is small and elliptical in outline. It is almost free from the other skeletal elements, consists of a thick median plate, several septal lamellae as short projections on the median plate, and 2-3 axial tabellae.

Remarks: The present form is assigned to *Arachnolasmella,* but the validity of this genus is problematical. At any rate, we failed to find any previously described forms of *Arachnolasmella, Koninckophyllum, Amygdalophyllum* or *Ekvasophyllum,* that are identical with the present form. Only *Arachnolasmella interuptocolumellata* is comparable to the present form, but differs slightly from the latter in having no inner wall and no intrathecal dilation in major septa. Otherwise, the axial columns are quite comparable, in the two forms. In the absence of longitudinal section as in case of the present Himalayan form, we refrain the identification as such.

Family Waagenophyllidae Wang, 1950

Genus *Ipciphyllum* Hudson, 1958

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

Remarks: *Aridophyllum* Zhao (1976) is differentiated from *Ipciphyllum* in having a thick septal wall. *Atopophyllum* Zhao and Wang (1978) is distinguished from *Ipciphyllum* by its peculiar type of septa, which are often intermittent.

Ipciphyllum is distributed widely in the Permian of Tethys (Minato and Kato, 1965). Termier, Termier and Vachard (1977) described one species, *Ipciphyllum arnouldi,* from Tunisia. If we include *Aridophyllum* in *Ipciphyllum,* the genus ranges from the Chihsian to the Wuchiapingian in China (Zhao, 1976).

More than 36 forms have been ascribed to the genus from China alone (*e. g.* Yü et al, 1983; Zhao, 1981), mostly from South China. Therefore Wu, Liao and Zhao (1982)

designated the *Ipciphyllum* fauna as the Yangtze fauna, although *Ipciphyllum* is by no means limited to that region alone.

Ipciphyllum cfr. *fliegeli* Lange

pl. 3, figs. 1-4

1983 *Ipciphyllum* cfr. *fliegeli,* Fontaine, p. 5-6, pl. 5, figs. 1-2.

Material: A small fragment of a single corallum, the top surface of which is weathered out to show wall of prismatic corallites. CASG/VJG/F1105.

Description: Corallum is compound, massive and cerioid.

In transverse section, corallites are polygonal, 5 to 7 sided and 6.7mm in maximum diameter. Wall is zigzag and thin to moderately thick. Septa are in two orders. Major septa are 16 to 20 in number. Minor septa are a slightly thinner than major septa, about 2/3 the length of the major septa to even subequal. Small lonsdaleoid dissepiments are seen at the corner of large corallites. Dissepiments are concentric to angulo-concentric between the septa. Dissepimentarium occupies 1.2 to 1.8mm of corallite diameter. Tabularium is not clearly differentiated from dissepimentarium, the diameter of which measures 4.3mm in a corallite of 6.5mm diameter. Septal dilation is discernible in major septa in tabularium. Septal fine structure is diffuso-trabecular. Axial column is distinct from axial ends of major septa, large, 1.0 to 1.9mm in minimum diameter, and consists of a median plate, several septal lamellae, and a few axial tabellae.

In longitudinal section, triareal arrangement of internal elements is clear. Dissepimentarium consists of 2 to 5 rows of globose and slightly flattened dissepiments. Elongate dissepiments are not observed. Tabularium is wide, consists of clinotabulae, transverse tabulae, and periaxial tabellae, which are either complete or incomplete. Some 13 to 15 tabulae occur in a vertical distance of 5mm. Axial column is constructed of cut edges of septal lamellae and domed axial tabellae that are steeply or gently inclined exteriorly.

Remarks: The present form is characterized by relatively small corallites with long minor septa, wide tabularium occupied by clinotabulae, and transverse tabulae. Elongate dissepiments are almost lacking, and lonsdaleoid dissepiments are locally developed. It is best included in the *Ipciphyllum subtimoricum* group. It differs from *Ipciphyllum laosense* in having less-well-developed lonsdaleoid dissepiments and a large axial column with a distinct median plate. The present Himalayan form only differs from the typical *Ipciphyllum subtimoricum* in its smaller corallites, which are 6.5mm in diameter compared to 8mm in the latter.

Fontaine (1983) restudied *Lonsdaliea fliegeli* Lange (1925), and concluded that it was a species of *Ipciphyllum* and was synonymous with *Wentzelella subtimorica* Huang (1932). *Ipciphyllum fliegeli* is said to have corallites of 6 to 9mm across, and a loose axial column with a less distinct median plate. Our form is almost identical with *Ipciphyllum* cfr. *fliegeli* (Fontaine, 1983, pl 5, figs. 1-2) in the size of the corallites and relatively large axial column having many axial tabellae. *Ipciphyllum kwangsiense* Wu (1963) also resembles the present form, but it has more well developed clinotabulae.

Genus *Iranophyllum* Douglas, 1936

Type species (by original designation): *Iranophyllum splendens* Douglas, 1936

Remarks: The genus *Iranophyllum* may be simply defined as solitary waagenophyllids having tertiary or more orders of septa, and without lonsdaleoid dissepiments.

When Minato and Kato (1965) prepared a monograph of the family Waagenophyllidae, the genus contained only four species, but 22 species have since been ascribed to this genus.

Minato and Kato (1965) created *Pavastehphyllum* (*Thomasiphyllum*) based on *Iranophyllum spongifolium* having vesicular septa. This vesicular feature of the septa can be seen, though to a lesser extent, in the present Himalayan form. *Iranophyllum spongifolium* clearly has tertiary septa, and we now consider that *Thomasiphyllum* is synonymous with *Iranophyllum*. *Zhenganophyllum* King (1978) is essentially very similar to *Iranophyllum* except for having all of its skeletal elements notably thickened. *Iranophylloides* Lin (1983) shows strong intrathecal dilation in septa, but otherwise does not essentially differ from *Iranophyllum*. *Parairanophyllum* Lin (1983) is said to differ from *Iranophyllum* in having vesicular septa, which however seem to be thin septa of higher orders leaning upon long neighbouring septa. *Parairanophyllum* may be a synonym of *Iranophyllum*.

Iranophyllum occurs from Iran to Japan, almost everywhere in the Tethyan region, where it ranges from the *Pseudoschwagerina* to *Yabeina* Zone in the fusulinid zonation. In China, it is common in the Chihsian strata which correspond to the *Pseudofusulina, Parafusulina,* and a part of *Neoschwagerina* Zones.

Iranophyllum splendens Douglas

pl. 1, figs. 6 & 7

1863 ?*Clisiophyllum indicum* de Koninck, p. 3, pl. 2, fig. 4
1913 *Cyathophyllum* cf. *multiplex,* Mausuy, p. 23, pl. III, fig. 13
1936 *Iranophyllum splendens* Douglas, p. 81, pl. 1, figs. 4, 5
1941 *Iranophyllum splendens,* Smith, p. 5, pl. 1, figs. 8-9.
1950 *Iranophyllum splendens,* Douglas, p. 20.
1961 ?*Iranophyllum splendens,* Fontaine, p. 194 (no illustration).
1965 ?*Iranophyllum indicum,* Minato and Kato, p. 172-173.
1965 *Iranophyllum splendens,*Minato and Kato, p. 173.

Material: Single fragmentary corallum. CASG/VJG/F1106.

Description: Corallum is solitary, may be gently tapering ceratoid, though calicular and tip portions are missing.

In transverse section corallite is subquadrate in outline, more than 28.5mm in minimum diameter, and consists of axial column, tabularium and dissepimentarium. Thin epitheca is only partially preserved. Dissepimentarium is wide. Dissepiments are numerous, and are concentric, angulo-concentric, periseptal, or lonsdaleoid. Tabularium is also wide and is not well differentiated from dissepimentarium. Inner wall does not develop. Septa are numerous and in many orders. Major septa are 38 in number.

They are intrathecally dilated, almost straight, fall short of or slightly touch the axial column. Some major septa show cavernous feature in middle of their length, near margin of tabularium. Minor septa and tertiary septa are equally developed, and lean upon longer septa; their axial ends are in the tabularium. Within dissepimentarium all septa are equal in thickness. In some cases, as many as 10 septa are between the space of two neighbouring major septa. This means that quaternary and even 5th order septa are present. Septa become flexuous, zigzag or xyloid and even discountinuous in dissepimentarium where periseptal or auxiliary dissepiments are incorporated with irregularly flexuous and intermittent septa. Septal fine structure is diffuso-trabecular. No fossula is discernible. Axial column is subround in outline, and consists of many fine axial tabellae on which discontinuous septal lamellae are present, and without median plate. Minimum diameter of axial column is 6.9mm. An obliquely-cut section reveals longitudinal characteristics of present form. Axial column is large, well differentiated from tabularium, and consists of closely-set axial tabellae that are gently domed upward. Only discontinuously-cut edges of septal lamellae are seen in axial column. Tabularium is wide. The diameter of tabularium is 15.5mm. Clinotabulae are well developed. No discrete zone of transverse tabulae is discernible. Dissepiments are numerous and small. Dissepimentarium appears to be not clearly differentiated from the tabularium. As a whole, however triareal arrangement of internal elements is clearly recognized.

Remarks: From amongst the hitherto established species of*Iranophyllum,* some resemble *Iranophyllum splendens* Douglas from Iran. Li and Liao (1979) described 3 forms from the Qinghai Province of China: *Iranophyllum xinghaiense* Li and Liao, *Iranophyllum qinhaiense* Li and Liao, and *Iranophyllum splendens.* They are similar to one another, and are different from typical *Iranophyllum splendens* only in having a dense axial column. *Iranophyllum exquisitum* Cai (1983) from the Kansu Province and *Iranophyllum xainzaense* Lin (1983) from Tibet are essentially identical with *Iranophyllu splendens.*

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 (by subsequent designation by Lang, Smith and Thomas, 1940):

Explanation of Plate 1

Ceratophyllum sp. (CASG/VJG/F1100)

Fig. 1 Longitudinal thin section. X4

Fig. 2 Transverse thin section showing double wall feature on the right part of corallite. X4

Fig. 3 Weathered out calice. X2

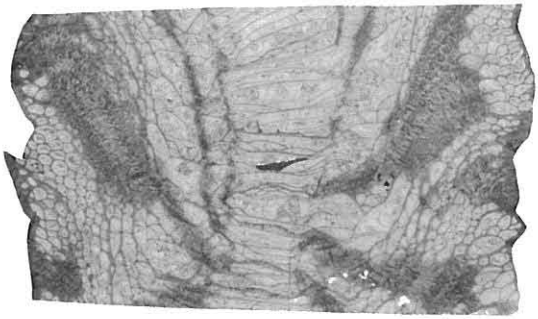
Fig. 4 Oblique thin section

Fig. 5 Transverse thin section

Iranophyllum splendens Douglas (CASG/VJG/F1106)

Fig. 6 Transverse thin section. X2

Fig. 7 Oblique thin section. X2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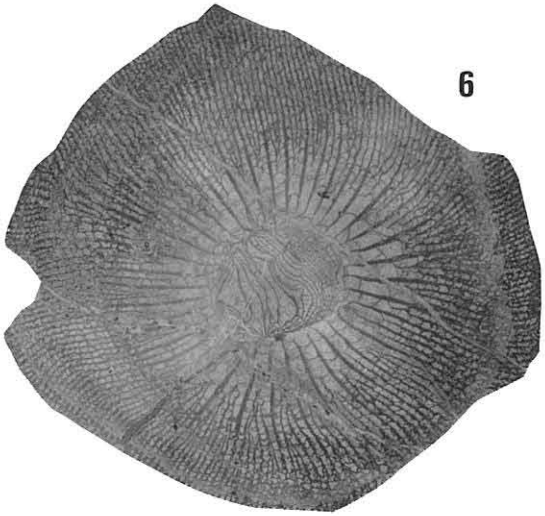
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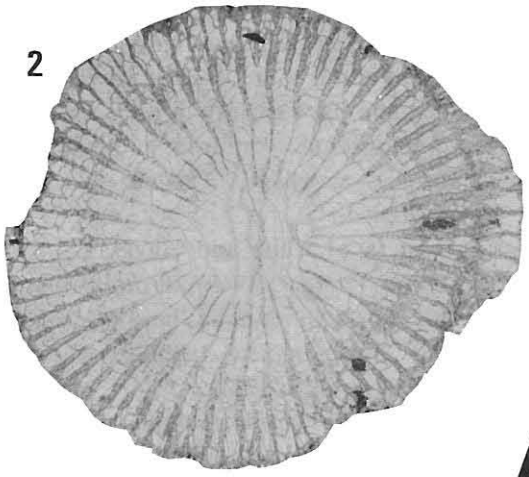
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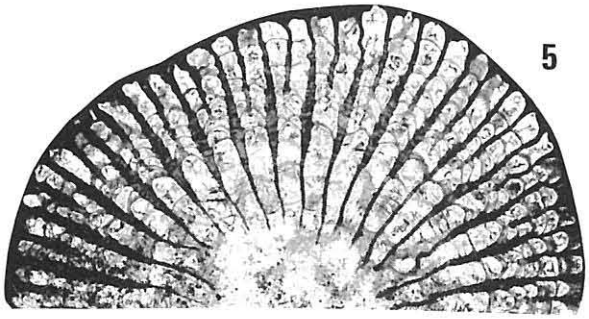
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Michelinia (*Protomichelinia*) *microstoma* Yabe and Hayasaka, 1915.

Remarks: Reliable criteria for distinguishing genera and species in favositoid corals are yet to be established. *Michelinia favositoides* Girty (1907, 1913), one of the old species of *Michelinia* from Asia, has a corallite wall that is partly thick and has septal spines, and partly thin, and without spines. Yabe and Hayasaka (1915) created 3 subgenera, *Eumichelinia, Protomichelinia* and *Michelinopora* within *Michelinia,* but, certain morphologically gradational forms linking these subgenera may be expected to be present. *Michelinia favositoides* may stand between *Protomichelina* and *Michelinopora. Michelinia* (*Protomichelinia*) *microstoma* Yabe and Hayasaka (1915) reveals quite similar characters with *Michelinia favositoides,* and may be synonymous with the latter, as already pointed out by Yabe and Hayasaka themselves. This species was later chosen as the "genolectotype" of *Protomichelinia* (Lang, Smith and Thomas, 1940). A topotype specimen of *Protomichelinia microstoma,* presumably sent to Lang, Smith and Thomas by Yabe and Hayasaka has been kept at the British Museum of Natural History, registered as R 23726. This was figured by Smith (1941, pl. 11, fig 7) as *Pleurodictyum microstoma.* Kato examined the specimen in London, which had fibrous wall, long septal spines, domed tabulae which are partly incomplete, and mural pores. It is a little deviated form from *Protomichelinia microstoma* figured by Yabe and Hayasaka (1920). It is provided with thick wall and is more like *Michelinia pecteniformis* Huang (1932), though the latter appears to have slightly larger corallites. Hudson (1958) described and figured *Michelinia favositoides* from Iraq, and he considered the species contained a number of local varieties, to which *Michelinia microstoma, Michelinia mansuyi* Reed (1925) etc. were included.

Although original contention of three subgenera of Yabe and Hayasaka, *Eumichelinia* (=*Michelinia s. str.* by Lang, Smith and Thomas, 1940), *Protomichlinia* and *Michelinopora,* is not very clear (Smith, 1940), *Michelinopora* has been often synonymized with *Protomichelinia* which typically has complete tabulae, whereas *Michelinia s. str.* has incomplete, vesicular tabulae (*e.g.* Hill, 1981).

We provisionally classify all Permian Micheliniids into *Protomichelinia* (thick wall and numerous septal spines) and *Michelinopora* (thin wall and no septal spines). Admittedly, the distinction between these two groups is not sharp as exemplified in the case of *Michelinia favositoides* and *Protomichelinia microstoma.*

Explanation of Plate 2

(All figures X4)

Pseudozaphrentoides juddi (Thomson) (CASG/VJG/F1103)

Fig. 1 Transverse thin section.

Arachnolasmella cfr. *interuptocolumellata* Bikova (CASG/VJG/F1104)

Fig. 2, 3 Successive transverse thin sections.

Pseudotimania sp. (CASG/VJG/F1102)

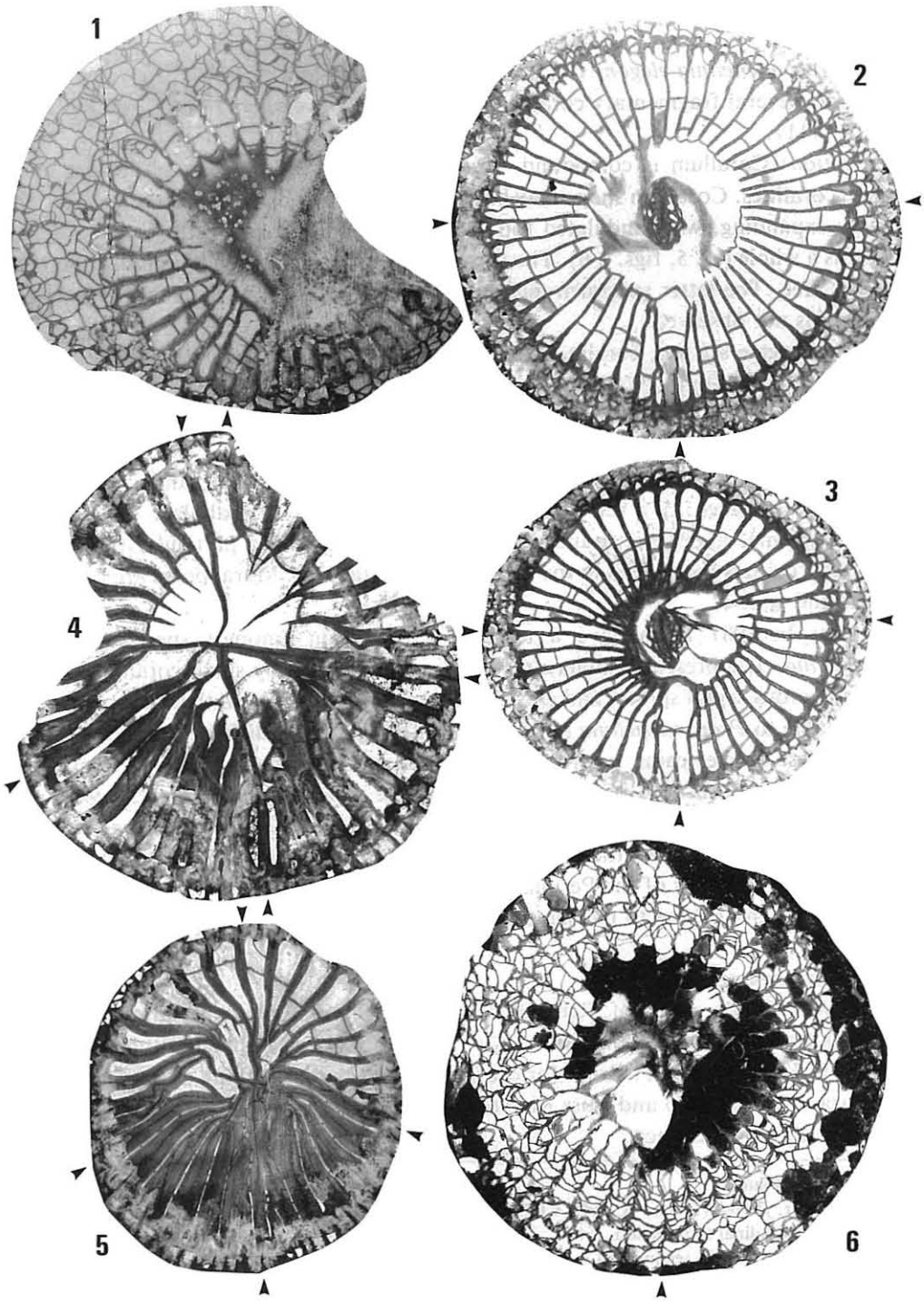
Fig. 4 Transverse thin section. Mature stage.

Fig. 5 Transverse thin section. Neanic stage.

Bothrophyllum? sp. (CASG/VJG/F1101)

Fig. 6 Transverse thin section.

Note: Arrows indicate positions of protosepta recognized.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Protomichelinia elegans Lin

pl. 4, figs. 1-4; pl. 5, figs. 1-6

1962. *Protomichelinia elegans* Lin, p. 212, pl. IV, figs. la-b.

Material: Several fragmentary coralla, partly or wholly weathered out. CASG/VJG/F1107~1111.

Description: Corallum is compound, massive, cerioid, and consists of slender and curved corallites. Corallum shape may be hemispherical, with vaulted lower surface, or rapidly expanding, with undulated top surface, resulting in an overturned umbrella shape as a whole (pl. 5, figs. 4-6). The former type is thus encrusting in nature and the latter is free. The latter specimen measures 45mm in diameter and 14mm in height. Epitheca is not observed.

In transverse section, corallites are polygonal, subequal, and small. Corallite diameter is 1.5 to 2.0mm. Wall is very thick (0.2—0.3mm), fibrous, having numerous long septal spines. Mural pores are sporadic, and occur near the corners of some corallites.

In longitudinal section, tabulae are domed upward, complete and incomplete, rather closely spaced. In a vertical distance of 5mm are 14—18 tabulae.

Septal spines appear as round dots lined up vertically. No particular pattern of seasonal growth is recognized in the arrangement of tabulae. Mural pores are round in outline and sparse.

Remarks: In 1981 Zhao gave a table of comparison amongst species of *Protomichelinia*. The present Himalayan form is characterized by small corallites, thick wall, numerous septal spines, and closely set domed tabulae. From these characters, it is assignable to *Protomichelinia elegans* Lin, although it has slightly larger corallites. This Chinese species came from the Early Permian Chihsian of Szechuan Province. The Himalayan form also bears some resemblance to *Pleurodictyum microstoma* of Smith (1940), *Protomichelinia submicrostoma* Lin (1962), and *Michelinia hexianensis* Zhao and Chen (1963). All these forms come from the Chihsian or equivalent formations, and are elements of the Permian Tethys. Thus the present specimens may be of the same age and belong to the same biogeographical province.

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Explanation of Plate 3

Ipciphyllum cfr. *fliegeli* (Lange) (CASG/VJG/F1105)

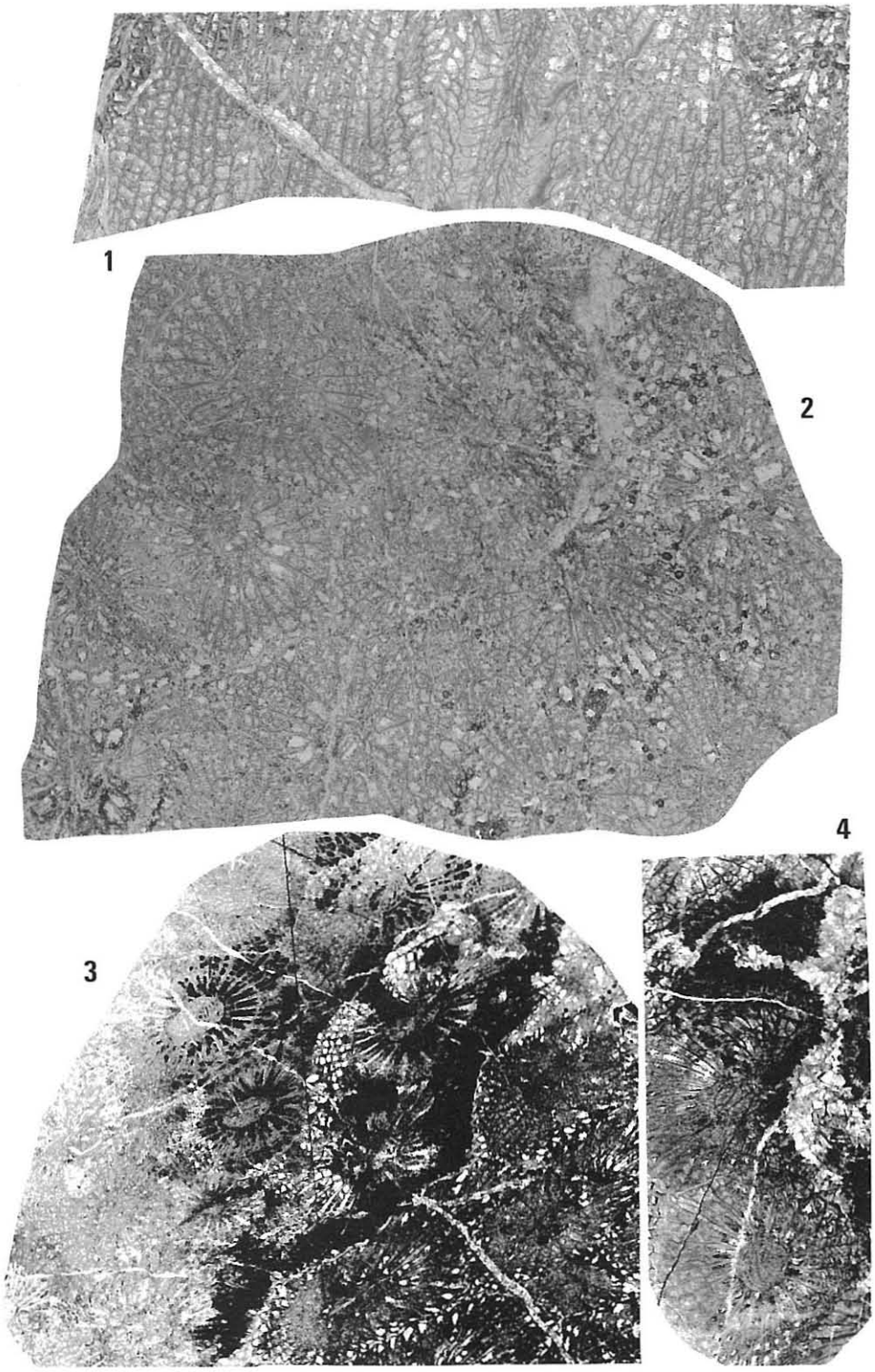
Fig. 1 Longitudinal thin section. X4

Fig. 2 Transverse thin section. X4

(Figs. 1 and 2 are from the same corallum.)

Fig. 3 Oblique thin section. X3

Fig. 4 Transverse thin section. X3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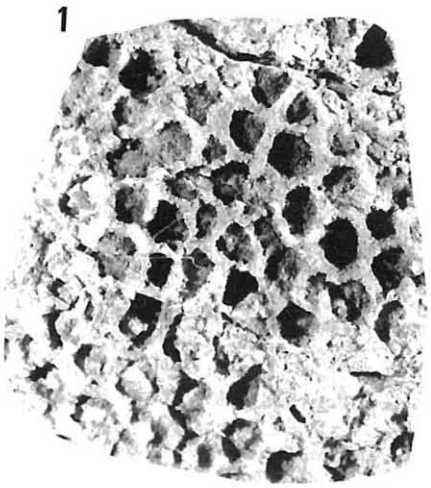
* For literatures written only in Chinese provisional titles marked by " " are given in English.

Explanation of Plate 4

Protomichelinia elegans Lin

Fig. 1 Weathered surface of a corallum (CASG/VJG/F1107) showing polygonal corallites with thick wall. X5

Fig. 2-4 Partly longitudinal and partly oblique thin sections of different coralla (CASG/VJG/F1107 ~9). Note the vaulted lower surface of corrallum shown in fig. 4. X4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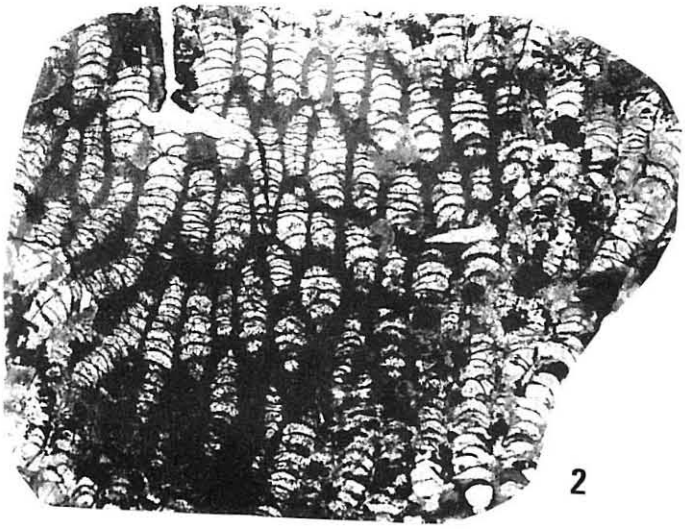
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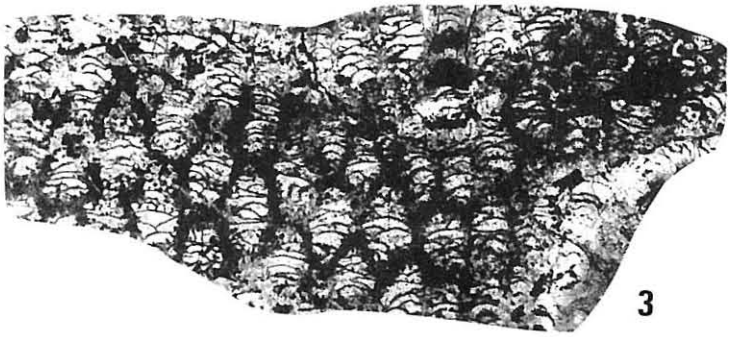
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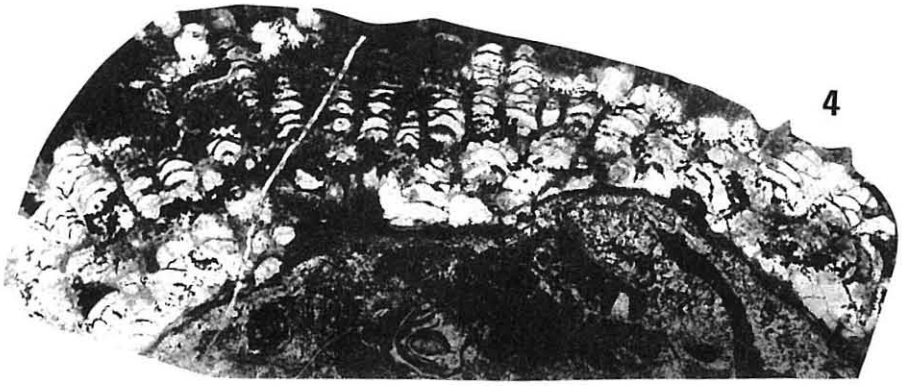
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Explanation of Plate 5

Protomichelinia elegans Lin

Fig. 1 Transverse thin section of a much recrystallized corallum (CASG/VJG/F1110). Note calice on top corallites filled with matrix.

Fig. 2 Transverse thin section showing thick corallite wall with long spines.

Fig. 3 Longitudinal thin section.

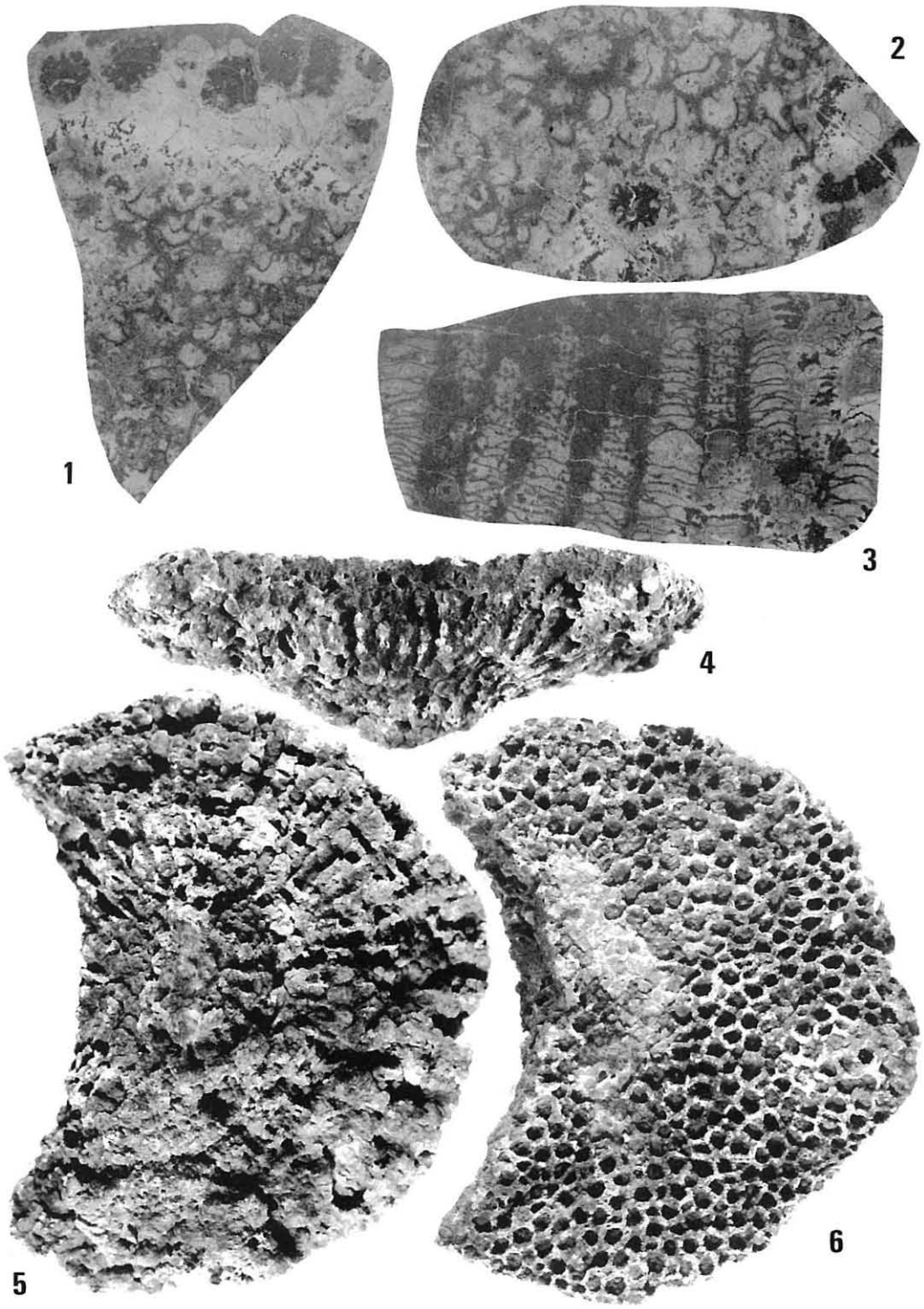
(Figs. 1-3 are from the same corallum. X5)

Fig. 4-6 External views of a corallum (CASG/VJG/F1111). X2

Fig. 4 Lateral view.

Fig. 5 Bottom view.

Fig. 6 Top view.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