BRIGHAM YOUNG UNIVERSITY

GEOLOGY STUDIES

VOLUME 40 • 1994

BRIGHAM YOUNG UNIVERSITY
GEOLOGY STUDIES

Volume 40, 1994

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A Publication of the
Department of Geology
Brigham Young University
Provo, Utah 84602

Brigham Young University Geology Studies is published by the Department of Geology. This publication consists of graduate student and faculty research within the department as well as papers submitted by outside contributors. Each article submitted is externally reviewed by at least two qualified persons.

ISSN 0068-1016
6-94 550 10461/11134

Sphinctozoan and Inozoan Sponges from the Permian Reefs of South China[1]

J. KEITH RIGBY
Geology Department, 258 ESC, Brigham Young University, Provo, Utah 84602

FAN JIASONG, ZHANG WEI, WANG SHENGHAI
Institute of Geology, Academia Sinica, P.O. Box 634, Beijing, 100029, China

ZHANG XIAOLIN
Yunnan-Guizhou-Guangxi Institute of Petroleum Geology, Kumming, 650200, China

ABSTRACT

Several localities produced fossil sponges from Permian reefs in South China, including the Upper Permian Jianshuigou reef of Huaying City, the Laolongdong reefs of Beipei of eastern Sichuan, the Upper Permian Jiantianba reef of western Hubei, the Middle and Upper Permian reefs of the Ziyun area of southern Guizhou, and Middle and Upper Permian reefs of Xiangbo in northwestern Guangxi Province. These localities produced most of the sponges described here, but a few additional isolated specimens are from other localities in southern Guizhou. Distribution and general structural and stratigraphic relationships and paleobiology of the reefs are presented, as well as the systematic paleontology of the various sphinctozoan- and inozoan-grade sponges.

The new species *Stylothalamia eleganta, Huayingia glomerata* n. gen., n. sp., *Rhabdactinia regulara, Rhabdactinia complexa,* and *Peronidella minima* are described, along with specimens of previously described species of *Polycystocoelia huaijaopingensis* Zhang, 1983; *Cystothalamia conica* (Termier and Termier 1977a); *Amblysiphonella* (?) *bullifera* Senowbari-Daryan and Rigby, 1988; *Colospongia cortexifera* Senowbari-Daryan and Rigby, 1988; *Subascosymplegma* sp., *Parauvanella paronai* Senowbari-Daryan and di Stefano, 1988; *Parauvanella minima* Senowbari-Daryan, 1990, *Imbricatocoelia elongata* Rigby, Fan, and Zhang, 1989b; *Tebagathalamia cylindrica* Senowbari-Daryan and Rigby, 1988; *Preverticillites columnella* Parona, 1933; *Preverticillites* sp. A; *Preverticillites* sp. B; *Intrasporeocoelia hubeiensis* Fan and Zhang, 1985; *Rhabdactinia columnaria* Yabe and Sugiyama, 1934; *Sollasia ostiolata* Steinmann, 1882; *Glomocystospongia gracilis* Rigby, Fan, and Zhang, 1989a; *Stylothalamia* sp., *Peronidella regulara* Rigby, Fan, and Zhang, 1989b; *Peronidella* spp.; *Peronidella cylindrata* (Wu 1991); *Grossotubenella parallela* Rigby, Fan, and Zhang, 1989b; *Intratubospongia typica*(?) Rigby, Fan, and Zhang, 1989b; *Intratubospongia tenuiperforata* Rigby, Fan, and Zhang, 1989b; and *Imperatoria*(?) sp. and *Stellispongia* sp. are described from Middle and Upper Permian occurrences in South China.

These sponges with calcareous skeletons play major roles in reef framestones of the area. This paper essentially completes description of the known common fossil sponges from the Permian reefs of South China. Most of these taxa are represented by specimens with strongly recrystallized skeletons, so much needs to be done on the initial mineralogy of the sponge skeleton. Much remains to be done, as well, on documentation of detailed distributions of sponges and other taxa within the numerous Permian reefs of South China.

[1]Supported by the National Natural Science Foundation of China.

INTRODUCTION

Permian reefs are widely distributed and excellently exposed in South China (fig. 1). Sphinctozoans, inozoans, and sclerosponges are important frame-building organisms in these reefs. They usually coexist with hydrozoans, as well as with minor frame-builders, like bryozoans and *Tubiphytes*, and binders, like *Archaeolithoporella*, to form rigid, wave-resistant frameworks.

The fossils described here were collected from several localities of Permian reefs in South China (fig. 1). Included are fossils from (1) uppermost Permian Jianshuigou patch reefs in eastern Sichuan; (2) Upper Permian reefs in Lichuan County, western Hubei; (3) uppermost Permian Laolongdong patch reefs in Beipei, northwest of Chongqing in eastern Sichuan; (4) Middle and Upper Permian Ziyun reefs in Ziyun County, southern Guizhou; and (5) Middle and Upper Permian Xiangbo reefs in Longlin County, northwestern Guangxi Province. Some isolated specimens were also collected from localities at Wangmo, Ceheng, Loudian, and Houchang, in southern Guizhou, where the sponges also occur in Permian reefs.

STRATIGRAPHY OF THE PERMIAN SYSTEM IN SOUTH CHINA

Marine Permian rocks are well exposed in South China, especially in southern Guizhou, where continuous Carboniferous-Permian successions have been documented and several stratotypes for the Permian System in South China were established. During recent years, researchers have conducted detailed investigations on the structure and stratigraphy of the region. These workers studied the stratigraphy of the Permian system, estab-

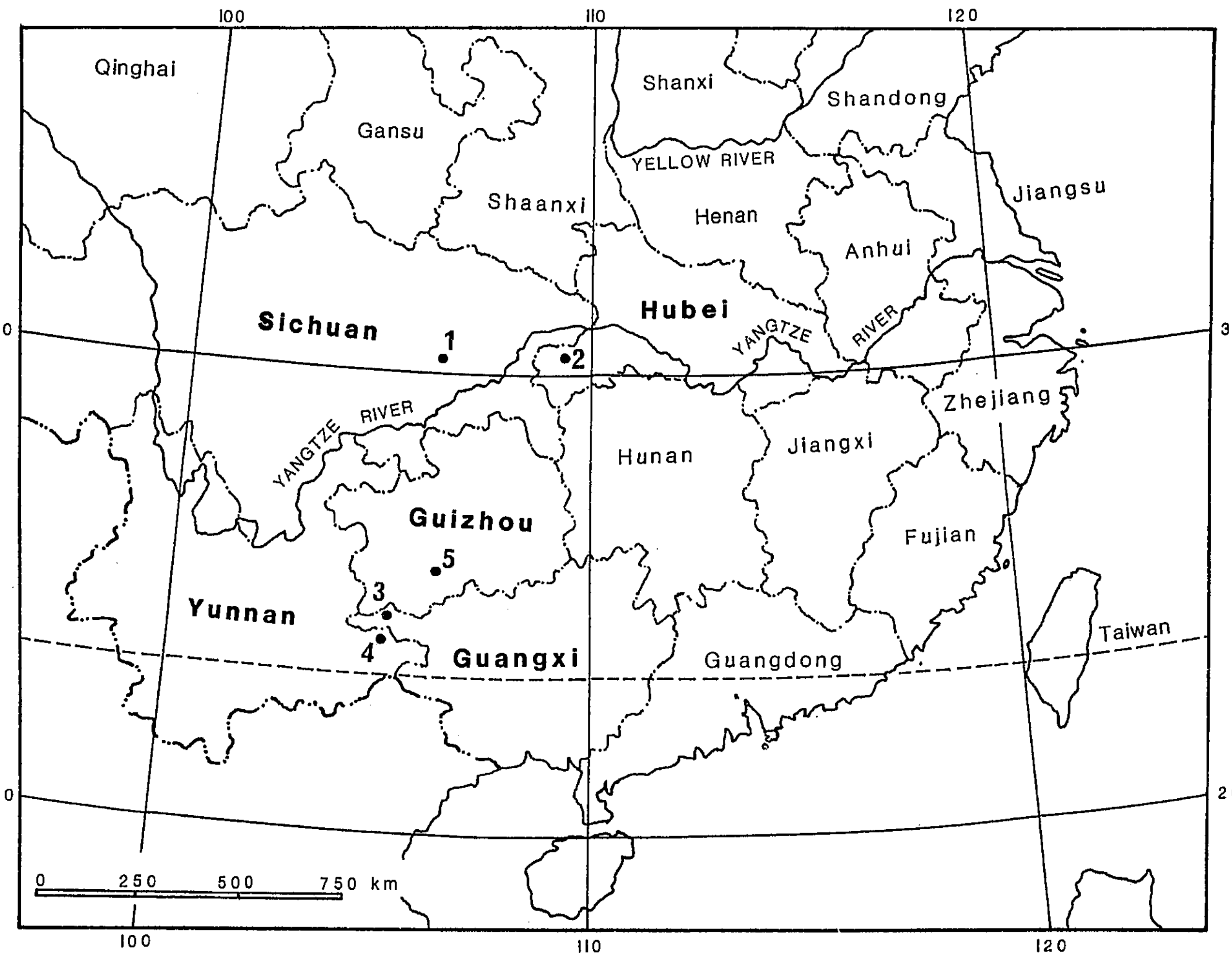

FIGURE 1.—*Index map to exposed Permian reef areas of South China. 1, Eastern Sichuan where reefs are exposed from the vicinity of Beipei—Laolongdong patch reefs are typical of those of the region; 2, western Hubei, Lichuan County area where the Jiantianba reef and associated reefs are exposed; 3, western Guangxi where the Xiangbo reefs are exposed in Longlin County; 4, eastern Yunnan near Guangnan; 5, southern Guizhou where Permian reefs are well exposed in the Ziyun, Cehung, Wangmo, and Luodian areas, among others.*

lished biozones in terms of various taxa, and defined and mapped the lower Permian boundary with underlying Carboniferous rocks and the upper Permian boundary with overlying Triassic rocks. Because of the abundance of various faunas in the Permian strata, detailed descriptions of fusulinids, corals, ammonoids, and conodonts have been made. These works provide a great amount of data for further classifying the Permian System (Zhang and others 1988).

Detailed research was recently published (in Chinese) by Zhang and others (1988) on Permian rocks in southern Guizhou. They studied some Carboniferous-Permian sequences that show continuous deposition across the systemic boundary. They classified Permian rocks into three series and erected separate biozones based on fusulinids, conodonts, corals, and ammonoids. Two new stages were proposed by them for the Lower Permian: the Zisong stage and Yangchang stage (fig. 2). These are briefly described below.

ZISONG STAGE

The standard profile for the Zisong stage is located at Huohongchong, an exposure northwest of the village of Yangchang, about 12 km south of the town of Ziyun County, South Guizhou. The sequence consists of gray and light gray, medium- to thick-bedded wackestones and packstones with some intercalated beds of grainstones. Cherty layers and chert nodules are common in these rocks. The type section has a thickness of about 200 m. Rocks of this stage yield abundant and diverse faunas, but fusulinids are the predominant fossils. Two range zones have been established for this stage: the *Pseudoschwagerina uddeni* range zone, below, and the *Sphaeroschwagerina*

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Pseudoschwagerina uddeni</td><td>Zisongian</td><td>Sakmarian
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FIGURE 2.—*Stratigraphic nomenclature of Permian rocks of South China and correlation to Russian and North American series (Sheng and others 1985, Zhao and others 1981).*

range zone, above (fig. 2). The latter zone can further be divided into three subzones, from the lower one upward: (a) the *Sphaeroschwagerina moelleri-Robustoschwagrina kahleri* subzone, (b) the *Sphaeroschwagerina sphaerica-Sphaeroschwagerina glomerosa* subzone, and (c) the *Eoparafusulina contracta-Zellia heritschi* subzone.

YANGCHANG STAGE

Stratotype of this stage is located at the same locality as the lower stage. The type section is composed of gray to dark gray, thin- to medium-bedded mudstones and wackestones or packstones. A few argillaceous mudstones or marls occur in the upper part, and some grainstones occur in the lower part. Abundant faunas occur in these rocks and include fusulinids, conodonts, corals, and ammonoids. The stage is characterized by the fusulinid *Chalaroschwagerina-Pamirina-Staffella* zone (fig. 2). Total thickness of rocks of this stage is about 90 m.

Classification of the Middle Permian section in South Guizhou (fig. 2) is the same as in other places in South China, according to the study of Zhang and others (1988). Two stages are included in the Middle Permian: the lower Qixian stage and the upper Maokouan stage.

The lower or Qixian stage is characterized by two fusulinid zones: the upper *Armenina* zone and the lower *Misellina* zone (fig. 2). The *Misellina* zone can be further divided into two subzones: the upper *Misellina claudiae* subzone and the lower *Misellina termieri-Misellina (Brevaxina) dyhrenfurthi* subzone.

Four fusulinid zones are recognized in the upper or Maokouan stage. These are the *Cancellina* zone, the *Neoschwagerina simplex* zone, the *Neoschwagerina kueichowensis-Yabeina* zone, and the *Neomisellina* zone, in an ascending sequence.

The traditional division of Upper Permian rocks into two stages in South Guizhou (fig. 2) was used by Zhang and others (1988). These are the Changxingian and Wujiapingian stages, which can be unquestionably correlated with rocks of those stages in other localities in South China.

The classification of Permian strata in South Guizhou and correlation with stages in other parts of the world are shown in fig. 2.

DISTRIBUTION OF PERMIAN REEFS IN SOUTH CHINA

Permian reefs are widely distributed in South China (fig. 1). With investigation and exploration for oil and gas, as well as for other mineral resources in South China, a great many reef outcrops have been discovered in recent years (Fan and others 1988; Fan and others 1990; Zheng and Liu 1984; Zheng and others 1984, 1988). Not only do these outcrops document very distinct reef fabrics and facies relationships, but they also yield rich and well-preserved faunas and floras. This indicates that research, present and future, on Permian reefs in South China has great potential for carbonate facies analysis and studies of biostratigraphy, paleoecology, and systematic paleontology.

Permian reefs exposed in eastern Sichuan, western Hubei, southern Guizhou, northwestern Guangxi, eastern Yunnan, and other localities are briefly described below.

EASTERN SICHUAN

Numerous patch reefs are widely distributed in eastern Sichuan (fig. 3). The geologic structure of this area is characterized by long, parallel, narrow folds, aligned approximately northeast–southwest. Reefs are often exposed on the flanks of these structures. The Laolongdong patch reefs are typical examples (Fan and others 1990, Qiang and others 1985, Rigby and others 1989a) and are exposed on the northwestern flank of the Guanyinxia anticline (fig. 4). Farther to the northeast, two additional patch reefs have been discovered and are called the Chunmoping patch reef and Jianshuigou patch reef (fig. 3); they probably

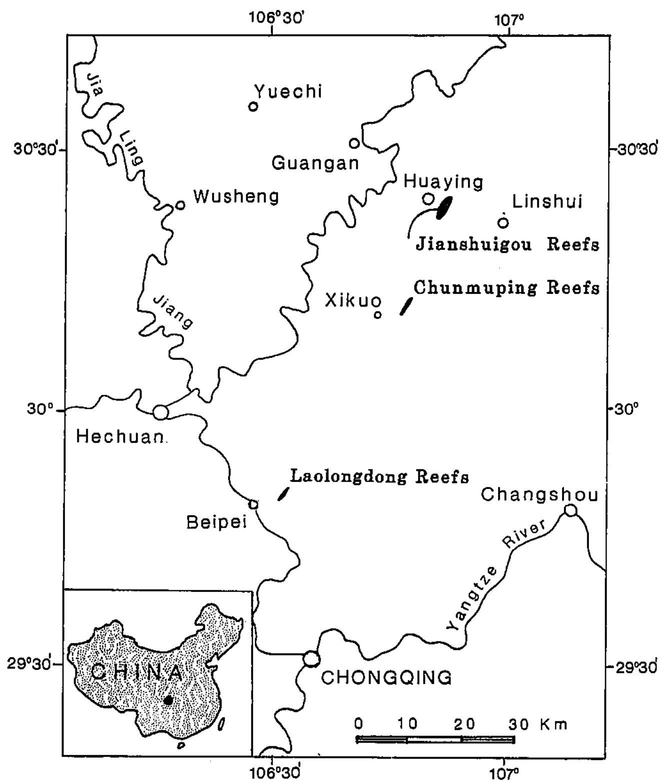


FIGURE 3.—*Distribution of exposed patch reefs in eastern Sichuan showing relative positions of the Laolongdong reefs, near Beipei, and northeastward to the Jianshuigou reefs near Huaying.*

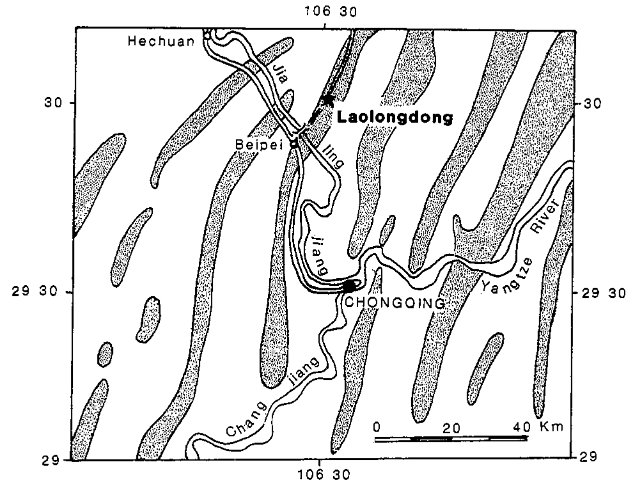


FIGURE 4.—*Index map to the Laolongdong reef locality in eastern Sichuan shows the locality on the northwest flank of one of the long, north–northeast-trending folds of the region. Anticlinal areas have been patterned (from Fan and others 1990).*

occur on the same flank of the Guanyinxia anticline as the Laolongdong patch reefs.

The typical shape of a Laolongdong reef is moundlike (fig. 5). Widths of a characteristic mound, at its base, are about 40 m, while heights at the center are about 50 m. The mounds are characterized by massive, nonbedded limestones and have greater thicknesses than off-mound equivalent rocks. Rocks of the mound are mainly sponge bafflestones and skeletal wackestones. Both kinds of limestone contain a high percentage of lime mud and fine bioclastic debris as interstitial material. The mounds occur in beds equivalent to the uppermost part of the Changxing Formation in the *Paleofusulina sinensis* zone. The mounds are overlain by Lower Triassic limestones and mudstones of the Fiexianguan Formation.

Development and growth of the Laolongdong mounds are divided into four stages, which comprise two cycles of sedimentation. Details have been described in Fan and others (1990).

The Jianshuigou reefs are exposed at the village of Xianghe, about 7.5 km east of Huaying City, in eastern Sichuan (fig. 3). They are among the best developed patch reefs in the patch reef chain that crops out in the Huaying Mountains. The reefs are exposed on the northwestern nose of the Gaodingshan anticline (fig. 6). The Jianshuigou reefs are typical mound shapes, and they have greatest heights or thicknesses of about 150 m at the center. Thicknesses decrease rapidly toward the margin of the reefs, and facies grade into off-mound nonreef rocks within distances of only 500 m. Rocks of the reefs are white to light gray, nonbedded, chert-free limestones. Equivalent nonreef rocks are dark gray to black, medium- to thick-

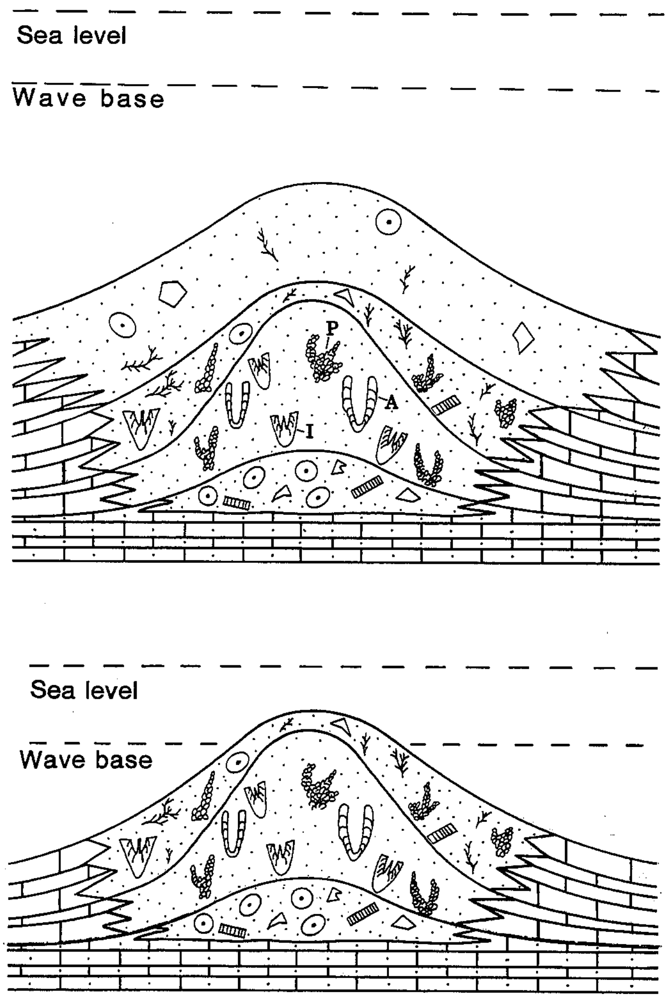


FIGURE 5.—*Generalized developmental model of characteristic reef mound at Laolongdong in the Upper Permian Changxing Formation. A, Sponge bafflestone mound developed on top of an early bank or shoal of echinoderm debris (1), which apparently acted as a substage and localized later mound development. Rocks of the later mound are mainly sponge or bryozoan bafflestones (2) with a high percentage of lime mud matrix. A and P, sphinctozoan sponges; I, inozoan sponges. B, Upper stage rocks record rapid drowning of the mound, where skeletal wackestones (4) accumulated over the mound crest and the bryozoan-echinoderm grainstones (3) draped over the bryozoan-sponge bafflestone core in the upper part. The grainstones accumulated when the mound surface reached above the wave base, but the wackestones at the crest record the transition from high-energy shallow to low-energy deep environments. These individual mounds may be approximately 50 m high and have average widths of approximately 40 m (modified from Fan and others 1990).*

bedded limestones that contain numerous cherty nodules and cherty layers. Main frame-building organisms within the reefs are sphinctozoan and inozoan sponges, sclerosponges (mainly Tabulozoa), hydrozoans, and bryozoans.

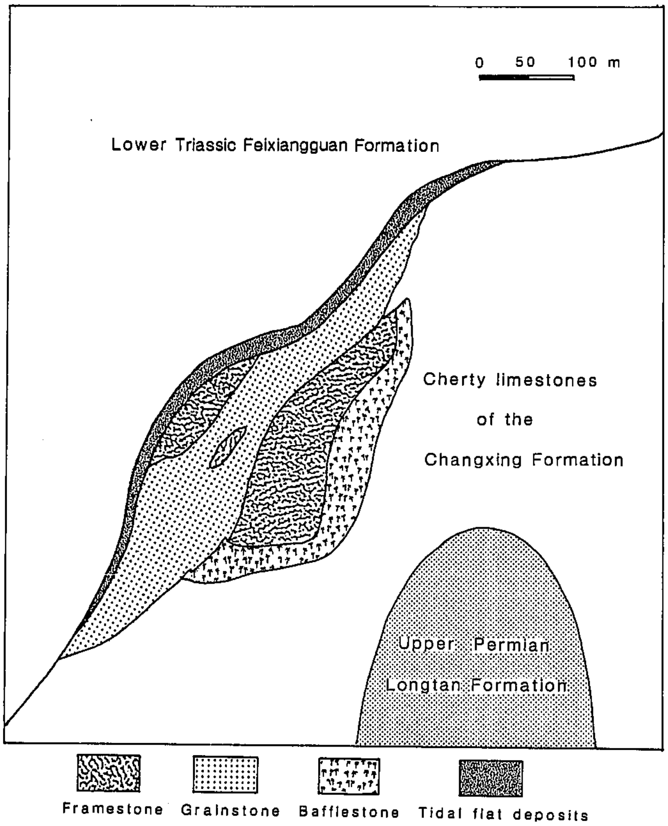


FIGURE 6.—*Geologic and lithologic facies map of the Jianshuigou reef exposed on the northwestern nose of the Gaodinshan anticline, with the Upper Permian Longtan Formation exposed in the core of the anticline. Bafflestones of an early part of the reef structure are overlain by sponge-, hydrozoan-, and bryozoan-framestones in which* Archaeolithoporella *is an abundant binder. Two cycles of reef development are recorded here, interrupted by deposition of grainstones. Tidal flat deposits of micritic dolomite and evaporites overlie the mound complex as basal beds of the Lower Triassic Feixianguan Formation.*

Archaeolithoporella crusts are abundant and bind framebuilders and various fragments to form rigid wave-resistant masses. Sometimes *Archaeolithoporella* forms encrusting layers up to about 5 mm thick. Accessory reef dwellers are echinoderms, brachiopods, foraminifers, gastropods, and ostracods.

Two cycles of sedimentation during reef development are documented in the Jianshuigou reefs. These are comparable to those of the nearby Laolongdong reefs near Beipei, and, thus, both patch reef complexes are interpreted to have formed in the same geologic setting in eastern Sichuan. Because of multiple exposure of the reefs above sea level during their development, vadose silts, solution cavities, and neptunian dikes are well developed in the reef rocks. A bed of tidal flat deposits, 7–10 m thick, caps the whole reef complex and suggests a period of distinct exposure and erosion that ended reef growth. The tidal flat deposits consist of micritic dolomite and evaporites that contain a specialized fauna of gastropods and ostracods, and a stromatolite flora.

The mounds occur in beds equivalent to the upper part of the Changxing Formation in the *Palaeofusulina sinensis* zone.

WESTERN HUBEI

Upper Permian reefs are widely distributed in the Lichuan district of western Hubei (fig. 7). Reefs are well exposed at Jiantianba, Huangnitang (Liu and Gao 1979), and Huangjindong in Lichuan County and are particularly well exposed on the southwestern flank of the large Yupize anticline (Fan, Liu, and others 1988; Fan, Ma, and others 1982; Fan and others 1990; Fan and Zhang 1985, 1987; Fan, Zhang, and others 1982a,b; Liu and Rigby 1992; Liu and others 1991; Rigby and others 1989a,b). The Jiantianba section is one of the best sequences exposed on the anticline. Reef outcrops there generally form an escarpment that extends from Jiantianba to Gongshan Pass along the southwestern flank of the fold.

Rocks of the reef core facies consist of gray to dark gray, nonbedded sponge framestones in which sphinctozoans, inozoans, sclerosponges, and hydrozoans are the frame-builders, and *Archaeolithoporella* and *Tubiphytes* are the binders, much as in the Guadalupe Mountains of

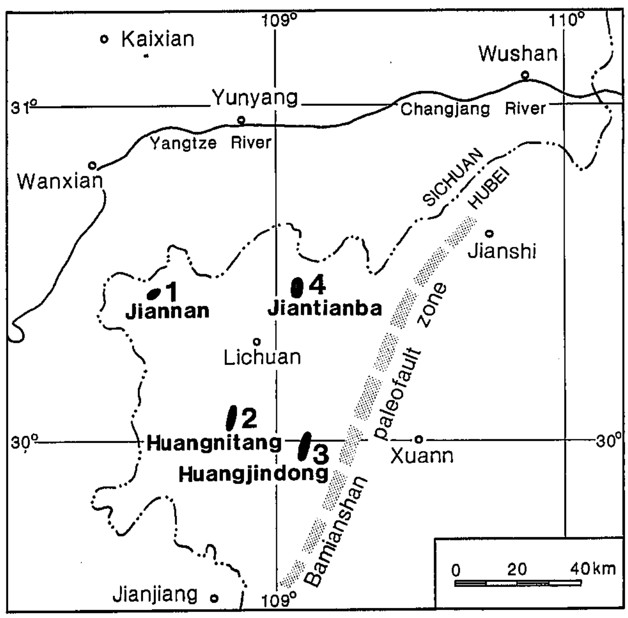


FIGURE 7.—*Index map to documented Permian reef exposures in the Lichuan area in western Hubei (from Fan and others 1990). The Jiantianba section (4) is one of the best exposed and most dramatic sequences of basin to reef and backreef transition exposed in the area.*

West Texas. Accessory organisms are abundant and include echinoderms, brachiopods, gastropods, bryozoans, and foraminifers. Frame-building organisms make up much of the rock volume and are well preserved, often in upright growth position. Binding organisms encrusted the frame-builders and bound individual elements of the reefs into rigid frameworks.

The reefs here occur in beds equivalent to the upper part of the Changxing Formation in the *Palaeofusulina sinensis* zone.

SOUTHERN GUIZHOU

During the 1970s Liu Bingwen and Wang Zhihua from the Guizhou Bureau of Petroleum Exploration and Exploitation made preliminary investigations of the Permian reefs that are well exposed in the Ziyun, Ceheng, Wangmo, Luodian, and Houchang areas (fig. 8). They recognized that these Permian reefs are composed mainly of sponges that are usually encrusted by algae (particularly *Archaeolithoporella*). Although their work was limited to a general geological survey, they provided an important base for further study on the Permian reefs in South Guizhou. In recent mapping and stratigraphic work (Wang and others 1994), we recognized that reefs at all of the localities cited above are characteristic Permian reefs. They exhibit not only very distinct reef facies and fabrics, but also contain abundant and diverse frame-building organisms.

Reefs exposed in the suburbs of the town of Ziyun County (figs. 9, 10) are among the best developed reefs in South Guizhou (Wang and others 1994). Three types of biogenic structures have been recognized, including barrier reefs, patch reefs, and biostromes, and they occur in three different horizons (fig. 11). The lower reef is a barrier reef in the Middle Permian Maokou Formation; the middle one is a biostrome made of rugose corals in the Upper Permian Wujiaping Formation; the upper reefs are barrier and patch reefs in the uppermost Permian Mobo Formation. Careful study of the reefs and detailed mapping of the study area show that the Permian reefs in Ziyun should be regarded as the reef type locality for southern China (Lin 1992, Wang and others 1994). These reefs can be used as examples that can be easily visited by reef researchers. Facies differentiation within the barrier reef complexes is clear. Basin or trough facies, reef-slope facies, reef-core facies, back-reef facies, and restricted carbonate platform facies of the Changxingian section can be observed. Textures and structures of reef rocks are well exposed and characteristic of Permian reefs, in general. Abundant frame-building organisms, binding organisms, as well as diverse accessory organisms, demonstrate that the biotas form typical reef communities. Detailed information on the Ziyun reefs was presented in Wang and others (1994).

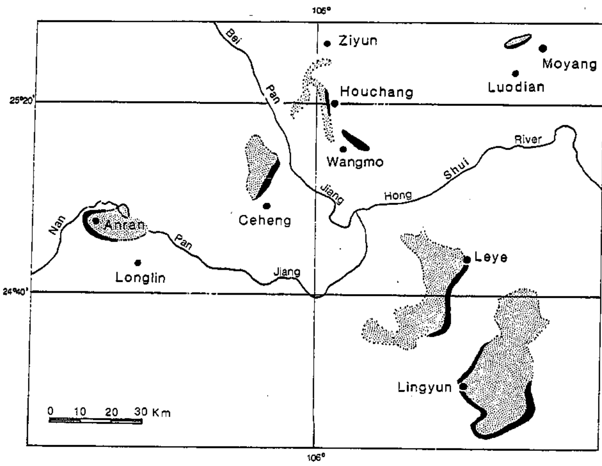


FIGURE 8.—*Exposures of Permian rocks (stippled) and reef tracts (black) in southern Guizhou and northwestern Guangxi Provinces. The Nan Pan Jiang and Hong Shui rivers form the boundary between Guizhou Province, on the north, and Guangxi Province, on the south. In general, the northern reefs are part of a major reef-carbonate platform margin around a major deep basin, in which isolated carbonate platforms, like those at Wangmo, Leye, and Lingyun, occur. Sponges described here are largely from the rocks of carbonate reef margin.*

The town of Ziyun County is situated about 70 km south of Anshun City, a major city in western Guizhou (fig. 9). The reef area is located at the southern end of the Baiyan-Tianba anticline. The area is broken by a strike-slip fault whose trace cuts in arcuate fashion across the southern part of the area (fig. 10).

Middle Permian barrier reefs of the Maokouan stage have a northwest–southeast trend through the Ziyun area. Sporadic outcrops occur at the villages of Qincaiyuan, Guanyinshan, and Yinshan, in the town, and in a quarry near Ziyundong, 2 km to the southwest of the town of Ziyun (fig. 10). Stratigraphic nomenclature of Permian rocks exposed here is shown in fig. 11.

Outcrops of the Maokouan reef core facies, the Ziyundong Limestone (figs. 10, 11), are scattered in Qincaiyuan and Ziyundong. Bafflestones, framestones, and rudstones can be distinguished. Main frame-building organisms are sponges, hydrozoans, *Tubiphytes,* and a few bryozoans, all of which were encrusted by *Archaeolithoporella* to form framestones.

Reef-slope facies rocks crop out in the southwestern part of the Ziyun area and are well exposed near Lawang (fig. 10). Three main types of rocks [(1) conglomerates, (2) rudstones and floatstones, and (3) wackestones and packstones] occur in this facies. Graded bedding is common.

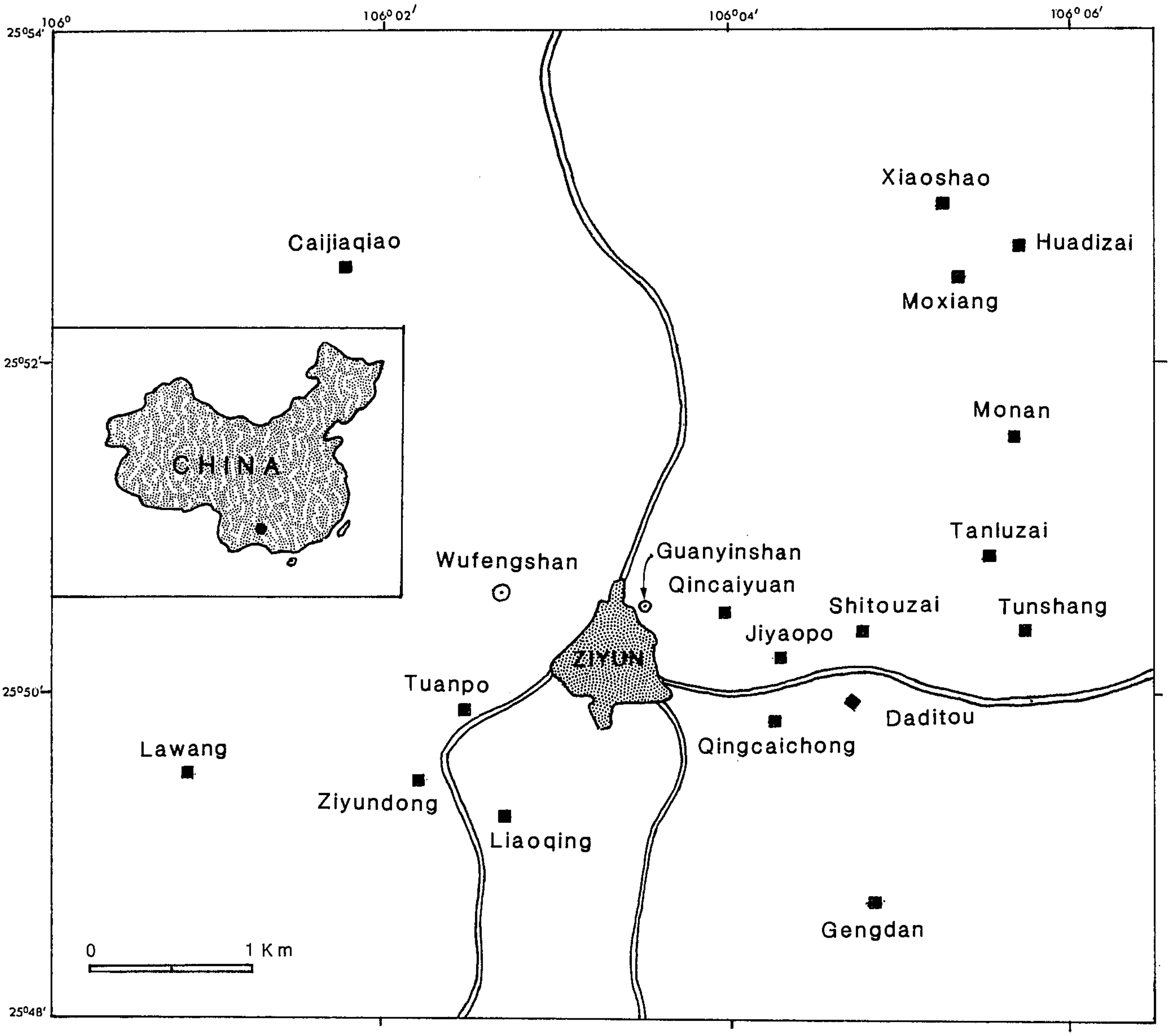


FIGURE 9.—*Index map to localities around Ziyun in southwestern Guizhou Province.*

Rocks of the back-reef carbonate shoal facies are widely exposed in the core of the Baiyan-Tianba anticline. Fossils in rocks of this facies are mainly fusulinids (50%–80%). These rocks locally served as the base for the overlying Changxingian Shitouzai reef core facies.

Basin facies rocks are well exposed around Wulibei (figs. 9, 10). Sections of this facies are composed mainly of thin- to medium-bedded, black lime mudstones and intercalated chert beds and nodular chert units. They contain calcispheres, but other fossils are rare.

Upper Permian coral biostromes of the Wujaipingian stage have been found in the Jiyaopo Formation (fig. 11). Excellent exposures of the biostromes are located near the village of Qincaiyuan (figs. 9, 10). The biostromes are traceable laterally for several tens of meters and maintain relatively uniform thicknesses. The biostromes are made up of the dendroid rugose coral *Pseudohuangia,* which forms fan-shaped patches. The patches are closely spaced to form coral thickets 0.5–1.5 m thick. Spaces between the branched corals were filled by bioclasts and lime muds.

Upper Permian reefs of the Changxingian stage are well exposed near the villages of Monan, Tanluzai, Tunshang, Shitouzai, and Qingcaichong, and northwest of Gengdan, on the eastern flank and southeastern plunging nose of the Baiyan-Tianba anticline (figs. 9, 10).

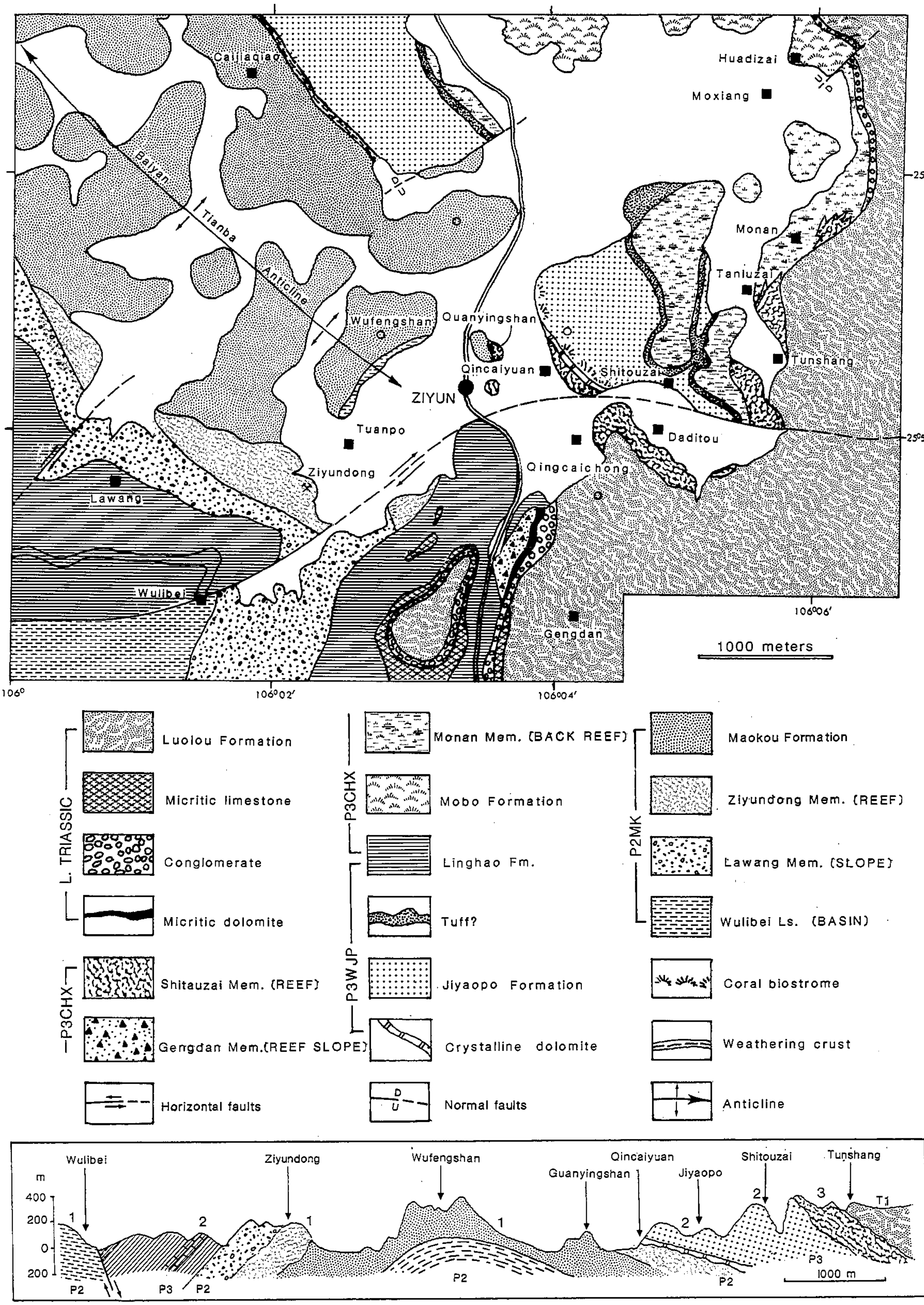


FIGURE 10.—*Geologic map and cross section of the Ziyun area (from Wang and others 1994).*

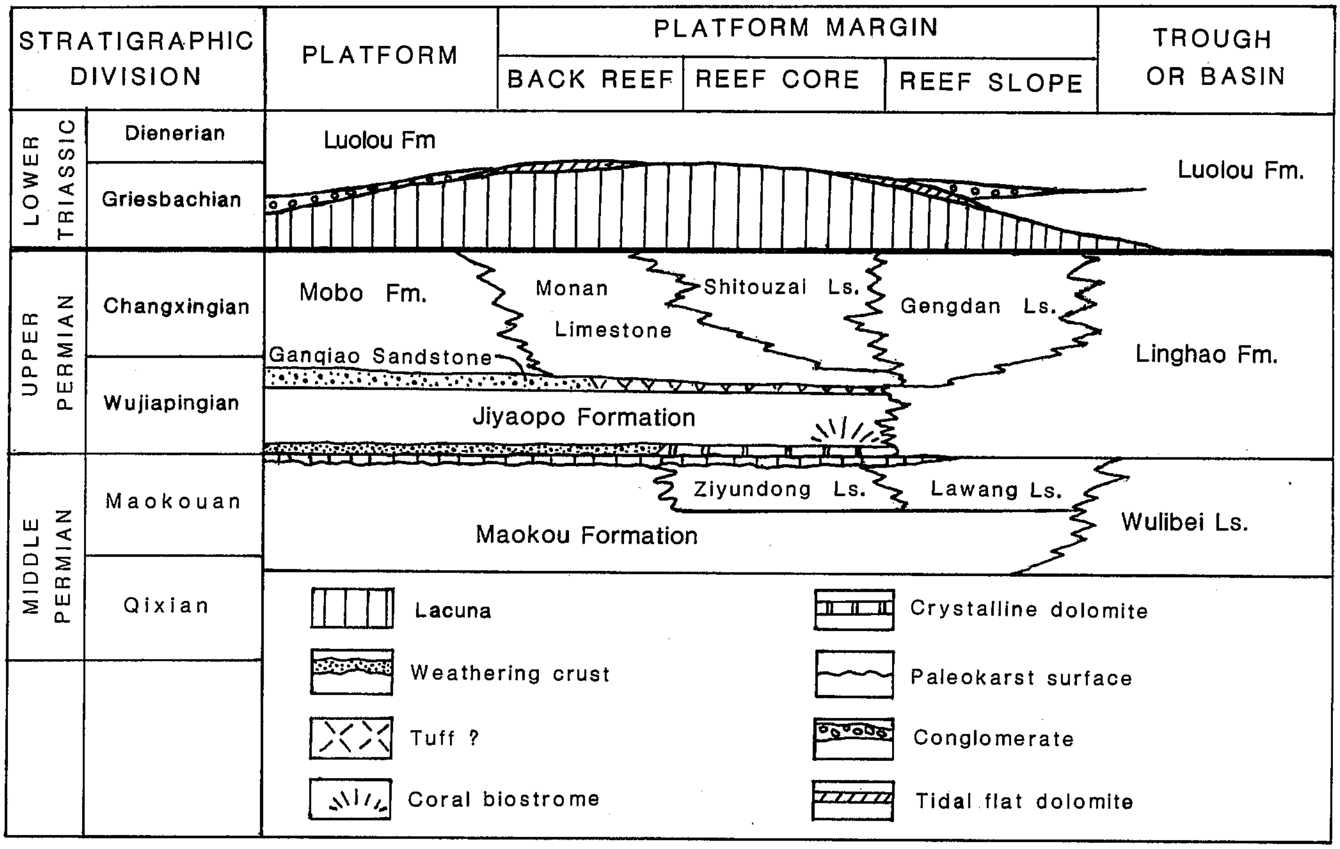


FIGURE 11.—*Diagram showing stratigraphic relationships and correlation of stratigraphic units in the Ziyun area. The Ziyundong and Lawang Members of the Maokou Formation are a Middle Permian reef complex, and several of the sponges described here are from the reef framestones of the Ziyundong Member. The Monan, Shitouzai, and Gengdan Members of the Mobo Formation are part of the Upper Permian Changxingian reef complex. Several of the sponges described here are from the Shitouzai reef member (from Wang and others 1994).*

Between Huadizai and Gengdan, a distance of about 6 km along the outcrop belt, facies of restricted platform, back-reef sand shoal, reef core, fore-reef slope, and deep-water basin or trough environments are exposed.

Reef-core facies rocks crop out in or near the villages of Shitouzai, Tanluzai, Tunshang, Daditou, and Qingcaichong (fig. 10). Framestones of the facies are characterized by abundant frame-building and binding organisms that include sphinctozoans, inozoans, tabulozoans (sclerosponges), hydrozoans, and *Tubiphytes* as frame builders. Binding organisms include *Archaeolithoporella*, which locally attains thicknesses exceeding 5 mm, and *Tubiphytes*. Five kinds of submarine cement have been recognized in the Ziyun reefs, including (1) micritic peloid calcite, (2) acicular calcite, (3) botryoidal calcite, (4) radiaxial calcite, and (5) blocky calcite cement (Wang and others 1994).

Fore-slope facies rocks are exposed near Qingcaichong and Gengdan and are characteristically rudstones and floatstones. Graded bedded and associated depositional erosion surfaces are locally developed.

Back-reef bioclastic sand facies beds are mainly exposed between Tanluzai and Huadizai. Predominant organisms in these rocks include calcareous algae, such as *Gymnocodium, Permocalculus, Mizzia,* and *Pseudovermiporella,* and smaller foraminifers.

Carbonate platform facies rocks occur north of Huadizai and are generally medium- to thick-bedded, dark cherty mud-wackestones that contain foraminifers and calcareous algae.

Deepwater trough or basin facies rocks are mainly volcanic tuffs and siliceous rocks that contain great quantities of siliceous sponge spicules and conspicuous radiolarians. Interbedded packstones and floatstones do occur in the facies near Liaoqing.

Reefs in Luodian County are well exposed in Laochangba (figs. 8, 12, 13), a village about 10 km northwest of Moyang. Moyang is a small town about 15 km northeast of Loudian County, in southern Guizhou. Rocks of the reefs are exposed on the southeastern flank of a large, narrow anticline (fig. 13) that trends in a northeast direction

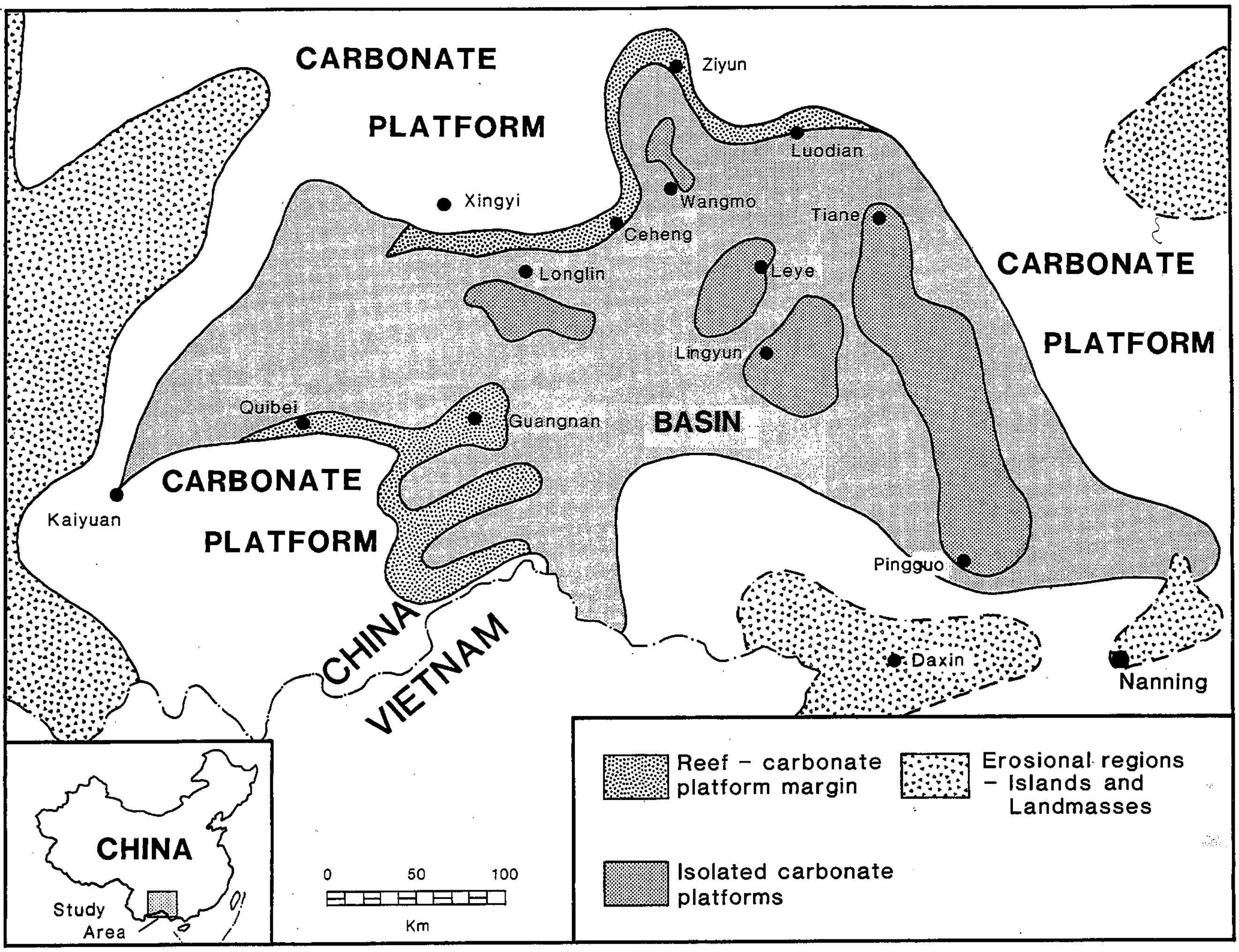


FIGURE 12.—*Paleogeographic reef facies map of Upper Permian rocks of South China shows barrier reefs at the carbonate platform margin and isolated carbonate platforms within the euxinic basin. Sponges described here from southern Guizhou came from the northern reef and carbonate platform deposits (from Fan and others 1990).*

in its eastern part, but curves to an east–west direction at its western part. Reef rocks are mainly gray to dark gray, thick-bedded or massive limestones with abundant frame-building organisms. These are mainly sphinctozoans, inozoans, tabulozoans, and hydrozoans. A few sphinctozoans have branches that grew to 5 cm across and 25 cm high. Thick *Archaeolithoporella* crusts usually cover various frame-builders. Distinct botryoidal calcite cements are particularly magnificent and are made of radially arranged elongate crystals that are several centimeters long. Many fissures in reef rocks are filled with elongate sparry calcite cements that grew perpendicular to the walls and extended toward the center of the opening. These fissures may be neptunian dikes.

Reefs near Wangmo County (figs. 8, 12) are well exposed at Pingyao, a village about 4 km north of the town of Wangmo County. Rocks of the reefs are best exposed along the highway from Wangmo to Ziyun and are characterized by typical framestones with distinct radiaxial fibrous calcite cements. Frame-building organisms are abundant and include, particularly, a characteristic platy hydrozoan. *Archaeolithoporella* crusts are also very clear. The Wangmo reefs are regarded as among the typical Permian reefs of South China.

Reefs near Ceheng County (figs. 8, 14) occur at Ceyang, a village about 4 km to the west of the town of Ceheng County. Reefs are well exposed along the eastern margin of the large Laizishan anticline (fig. 14) and stretch in an approximately northeast–southwest direction for about 22 km. Typical backreef bioclastic shoal facies are exposed northwest of the reef outcrops, and basin facies deposits are exposed to the southeast. Reef development started

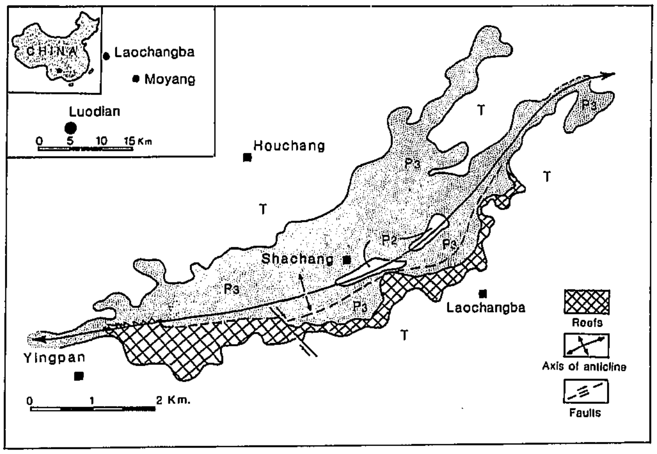


FIGURE 13.—*Geologic map showing reef distribution near Laochangba and Houchang (villages), approximately 50 km northeast of Luodian in southern Guizhou. Reef rocks are exposed along the southeast flank of a large anticline in which Upper Permian rocks (P3) are well exposed and Middle Permian rocks (P2) form more limited exposures along the crest of the structure northwest of Laochangba. Triassic rocks (T) are exposed away from the structure.*

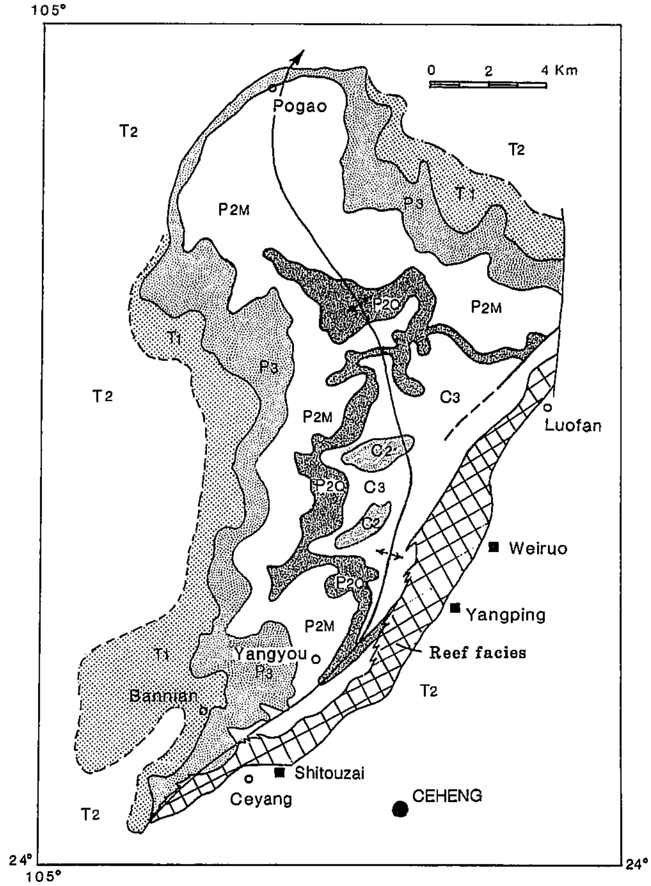


FIGURE 14.—*Geologic map of the area north of Ceheng County in southern Guizhou Province. Reefs are well exposed along the east margin of the Laizishan anticline, which exposes rocks as old as Middle Carboniferous (C_2) in the core of the structure flanked by Upper Carboniferous rocks (C_3) and overlying Middle Permian Qixia Formation (P_2Q) and Maokou Formation (P_2M). The Upper Permian Wujiapingian and Changxing Formations (P_3) are overlain by Triassic units (T_1, T_2) around the structure.*

during Middle Permian Maokouan time and continued until Late Permian Changxingian time. Substrates for Middle Permian Maokouan reefs were shoals or banks that are composed of bioclastic fusulinid and other grainstones. Rocks of the reefs are mainly composed of framestones that contain abundant sphinctozoans, inozoans, tabulozoans, and hydrozoans. Some slender, branched inozoans also occur. *Archaeolithoporella* crusts are extremely abundant in the framestones and usually encrust frame-builders to form rigid, wave-resistant frameworks. Reef textures are distinct and characterized by several generations of radiaxial fibrous calcite cement within framework pores.

NORTHWESTERN GUANGXI AND EASTERN YUNNAN

Middle and Upper Permian reefs are widely distributed and well developed in northwestern Guangxi and eastern Yunnan (fig. 1) (Fan and Qi 1990, Fan and others 1990, Sheng and others 1985, Yang 1987). Two types of Permian reefs are recognized. The first is a barrier reef belt that rims a carbonate platform on the northwest, west, and southwest of a major deepwater basin (fig. 12), and it is a typical carbonate platform margin reef. Within this belt, reefs have been discovered on the Anran structure near Xiangbo in Longlin (fig. 15) and at Guangnan. The Xiangbo reefs in Longlin County are among the most typical reef outcrops of this region. The second type includes smaller barrier reefs that rim isolated carbonate platforms. Such platforms have been mapped and identified at Wenliu, Longlin, Dee, Shechang, Leye, Lingyun, and Tiane-Pingguo (Fan and others 1990). These carbonate platforms occur irregularly within the widespread basin-facies deposits. Smaller reefs are of various shapes; some are barrier-shaped and some are horseshoe-shaped atolls.

The reefs exposed on the Anran anticline in northwestern Guangxi are part of a carbonate platform-margin reef. The Anran structure is a typical anticline with its longitudinal axis oriented approximately east–west (fig. 15). It is cored by exposed Upper Carboniferous rocks. Lower, Middle, and Upper Permian carbonate rocks are exposed successively outward on its flanks. The reefs crop out on

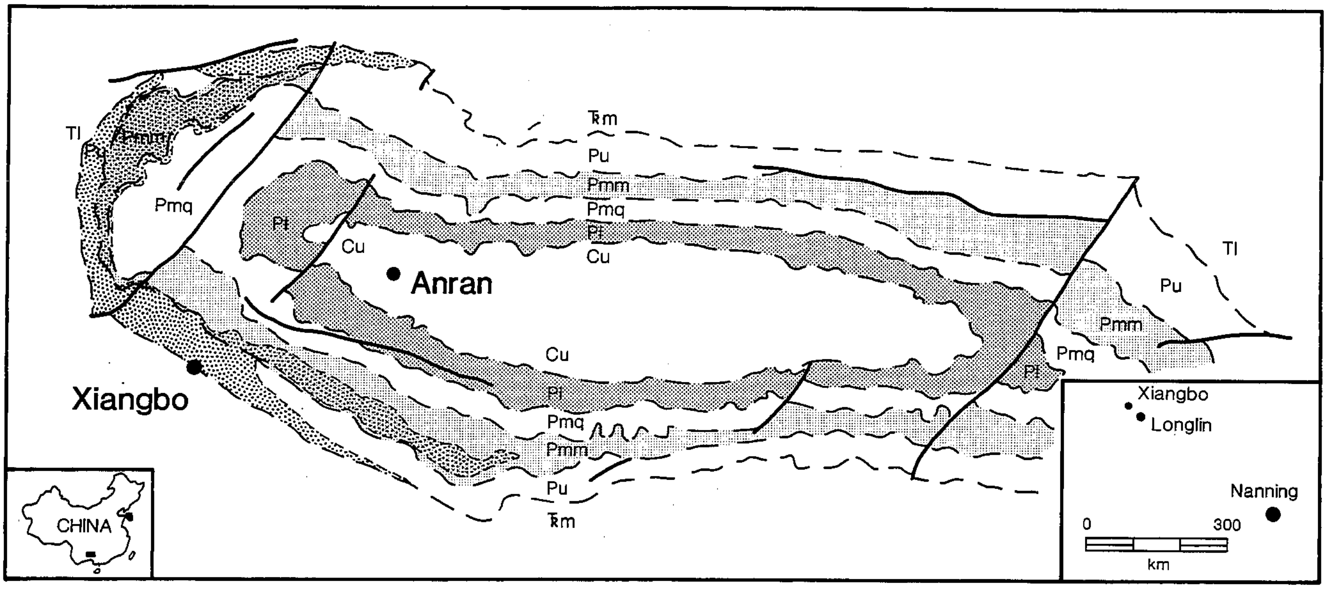


FIGURE 15.—*Geologic map of the east–west Anran structure showing distribution of exposures of the Middle and Upper Permian reefs (coarse dotted pattern) around the nose of the structure near Xiangbo, northwest of Longlin in northwestern Guangxi Province. Carboniferous, Permian, and Triassic rocks are exposed in the structure. Middle Triassic rocks rest unconformably over Upper Permian rocks on the south flank of the doubly plunging structure (from Fan and others 1990).*

the northwestern flank of the anticline, as well as on the western nose and southwestern flank of the structure. The Xiangbo reef stratigraphic section is located on the southwestern flank, and the Kefeng section is on the western nose of that anticline.

Recent regional geological surveys in southwestern China documented the reef distribution. For example, Middle Permian barrier reefs occur on the eastern margin of the Leye isolated carbonate platform (figs. 8, 12), and Middle Permian atoll-like reefs occur along the eastern margin, the southern margin, as well as the western margin of the isolated Lingyun carbonate platform (figs. 8, 12). Additional small, isolated carbonate platforms or reefs have been discovered within the basin facies deposits. They are mainly Lower Permian reefs with distinct reef fabrics and a diverse fauna. A typical example is the isolated Gaolung reef, which is totally surrounded by Triassic clastic rocks.

MAIN FEATURES OF PERMIAN REEFS IN SOUTH CHINA

Some generalizations on Permian reef development in South China can be made. They include:

1. Three types of organic structures are recognized: barrier reefs, patch reefs, and biostromes. Barrier reefs are well developed in western Hubei, southern Guizhou, and northwestern Guangxi. They usually formed spectacular escarpments that extended tens or several tens of kilometers along the margins of carbonate platforms. Patch reefs are usually smaller and have a moundlike shape. They occur in eastern Sichuan. A patch reef, however, was found in back-reef facies in the Ziyun reef complex. Biostromes are rare. A typical example is the rugose coral biostrome near Ziyun County, in southern Guizhou.

2. Three horizons of reef development have been demonstrated (fig. 2): the lowest in the Middle Permian Maokouan stage, the middle in the Upper Permian Wujiapingian stage, and the upper in uppermost Permian Changxingian stage rocks. No known reefs occur in sections of the early Middle Permian Qixia stage, nor in Lower Permian rocks. Permian reefs in eastern Sichuan and western Hubei generally occur in the upper part or uppermost part of the latest Permian Changxing Formation in beds equivalent to the *Palaeofusulina sinensis* zone. Middle Permian reefs have not been discovered yet in these areas. The Permian reefs in eastern Sichuan are probably stratigraphically higher than those in western Hubei.

Permian reefs in southern Guizhou, northwestern Guangxi, and eastern Yunnan occur not only in the Upper Permian Changxing Formation, but also in the Middle Permian Maokou Formation in rocks of the *Neoschwagerina* zone. Some reefs or biostromes occur in the Upper Permian Wujiaping Formation (Yang 1987) in rocks of the *Codonofusiella* zone. Recent research on the Permian reefs in western and northwestern Guangxi, however, indicates that Middle Permian reefs are more developed there than are the Upper Permian ones.

3. Except for the Laolongdong patch reefs and scattered isolated mounds in eastern Sichuan, which are baffled mounds, all of the reefs in western Hubei, Yunnan, Guizhou, and Guangxi Provinces have typical reef textures. Frame-building organisms and frame-builders are usually coated by binding organisms, such as *Archaeolithoporella*, which, in turn, are coated by several generations of fibrous or radial-fibrous calcite cements. The remaining reef cavities were later filled by blocky sparry calcite. Micritic peloids locally play additional roles in filling openings in reef frameworks, making Permian reefs of Ziyun County into solid structures.

4. The Permian reefs in South China have abundant reef frame-building organisms and binding organisms that formed typical reef communities. Frame-building organisms include sphinctozoans, inozoans, sclerosponges (mainly tabulozoans), hydrozoans, and bryozoans. Minor binders, such as *Tubiphytes*, also acted as frame-builders. Binding organisms include *Archaeolithoporella*, *Tubiphytes*, and fistuliporid bryozoans. *Archaeolithoporella*, especially, played an important role in binding various builders, fragments of builders, and rock debris into a rigid wave-resistant framework. Their encrusting habits provided strength to the frame-building elements. *Tubiphytes* is also a common binder in Permian reefs of South China. Fistuliporid bryozoans usually encrust other organisms and are important binders, especially in eastern Sichuan mounds or patch reefs. Reef-dwelling organisms are diverse and include echinoderms, brachiopods, gastropods, bryozoans, foraminifers, rugose corals, trilobites, serpulid worms, ostracods, nautiloids, calcareous algae (particularly dasycladaceans, gymnocodiaceans, and solenoporaceans), and various problematica. Biostromes exposed near Ziyun are composed mainly of rugose corals that are densely packed to form tickets.

5. Permian reefs of South China clearly exhibit distinct cycles of sedimentation and reef growth. Such a pattern is well shown in the Xiangbo reefs, Longlin County, northwestern Guangxi, where each cycle consists of an interbedded reef framework facies and reef-flat facies. Two such cycles are recorded for Middle Permian Maokouan time and four cycles for Late Permian Changxingian time. Patch reefs in eastern Sichuan are also characterized by cyclic sedimentation during reef growth. Two cycles have been observed in the Laolongdong reefs and Jianshuigou reefs. Such cyclic sedimentation of reef growth is interpreted to reflect sea level fluctuations.

6. Substrates of the Middle Permian Maokouan reefs were banks or shoals. This is a general relationship that has been observed in eastern Yunnan, northwestern Guangxi, and northern Guangxi. Typical is the shoal exposed at the base of the Xiangbo reefs that developed during Middle Permian time. The shoal is made up of a variety of grainstones, including skeletal and intraclastic grainstones, phylloid algal grainstones, lump grainstones, and fusulinid grainstones. Common organisms in these well-washed rocks include fusulinids, smaller foraminifers, gastropods, echinoderms, *Tubiphytes*, and dasycladacean algae. Interstitial spaces between grains and skeletal debris are largely filled with sparry calcite cement. Micrite and micritic peloidal matrix occurs only locally. The thickness of these shoal rocks in the lower part of the Xiangbo measured section is at least 50 m. The entire bank or shoal sequence may be thicker than that. This relationship can be observed also in the Guangnan and Lingyun reefs and other reefs of the region.

7. Typical tidal-flat deposits or paleokarst surfaces are well developed on tops of the Permian reefs in southern China. This indicates that the reefs were subjected to extensive uplift above sea level at the end of reef growth and were exposed or became tidal flats and supratidal environments in which typical deposits accumulated. Because of long periods of exposure, no early Early Triassic deposits accumulated over tops of the Permian reefs. Typical tidal flat deposits are well exposed in several localities, such as at the Tuidiya buildup and Jianshuigou reefs in eastern Sichuan, in the Ziyun reefs in southern Guizhou, and in the Xiangbo reefs of northwestern Guangxi. In the Tuidiya buildups, the massive reef facies is overlain by a sequence several meters thick in which algal limestones first accumulated, followed upward by evaporitic mudstones and wackestones. At least one hiatus of unknown duration is documented by supratidal facies and subaerial exposure over tops of Upper Permian buildups (Flügel and Reinhardt 1990, Reinhardt 1988). A typical tidal flat deposit caps the top of the Jianshuigou reefs. Rocks of these tidal flat deposits consist of micritic dolomite and evaporites, which are underlain by an obvious erosion surface cut into the reefs (Wang and others 1994, Wang and Qiang 1992). Paleokarst surfaces have been observed at the tops of the Maokouan and Changxingian reef complexes in Ziyun, and long periods of exposure have been proposed for development of those surfaces. Typical tidal flat deposits accumulated on top of the Changxiang reef complex near Ziyun. These deposits are characteristic supratidal, laminated, micritic dolomites that contain pseudomorphs of anhydrite crystals. Typical laminated wackestones of tidal flat deposits with mud cracks cap tops of the Changxingian reefs at Xiangbo.

8. Periodic, temporary exposures were common during reef growth, and resulting ancient weathering crusts have been observed in the Ziyun reefs. Multiple generations of vadose silts and dissolution voids are substantial evi-

dences of intermittent exposure. Such features have been observed in reefs at Xiangbo and Kefeng, Longlin County, in northwestern Guangxi, as well as in the Ziyun reefs, in southern Guizhou.

Class DEMOSPONGEA Sollas, 1875
Subclass CERACTINOMORPHA Lévi, 1973
Order VERTICILLITIDA Termier and Termier, 1977a
Family VERTICILLITIIDAE Steinmann, 1882
Genus STYLOTHALAMIA Ott, 1967

Original diagnosis. "Porate Sphinctozoen mit trabecularen Stutzgewebe aus entfernt stehenden, schlanken, oft röhrig ausgebildeten Pheilern. Stammchen asiphonat oder retrosiphonat" (Ott 1967, p. 44).

Emended diagnosis. Porate, single, branched sphinctozoans; central tube retrosiphonate or absent; chambers with trabecular filling structure. Pillars slender, may appear reedlike, vesiculae may occur in chambers, as well as in central tube.

Type species. Stylothalamia dehmi Ott, 1967.

STYLOTHALAMIA ELEGANTA n. sp.
pl. 12, figs. 4, 6, 7; pl. 14, fig. 2

Diagnosis. Cylindrical sponge with low chambers and broad retrosiphonate central tube; exterior segmentation indistinct; chambers contain thin reedlike trabecular filling structures. All walls profusely perforated. Vesiculae rare and only in lower part.

Description. Cylindrical sponge to 21 mm wide and at least 40 mm high; exterior segmentation indistinct. Chambers low, range about 1 mm high. Exowalls thin at chamber base, 0.15–0.30 mm thick but double that in zone of overlap; exopores 0.08–0.12, most 0.10 mm in diameter, separated 0.06–0.10 mm in uniform but not geometric pattern. Interwalls of chambers thin, 0.10–0.25 mm thick, and closely perforated; interpores generally 0.06–0.10 mm in diameter, with most approximately 0.08 mm in diameter, and spaced regularly 0.06–0.08 mm apart so 7–8 occur per mm, measured horizontally along a wall.

Central tube distinct, about 5–6 mm wide, and is retrosiphonate. Endowalls 0.6–0.8 mm thick and densely perforated, endopores straight to curved and interconnected, generally about 0.10 mm in diameter but range 0.08–0.18 mm across.

Chambers contain thin, widely spaced, pillarlike trabecular filling structures. Pillars 0.06–0.08 mm wide and with widths like elements between pores in interwalls; commonly upward branched with Y-shaped pattern, 0.2–0.3 mm below interwall, less common H- and X-shaped pillars occur. Vesiculae rare and only in lower part between pillars, as upward-arched plates 0.10–0.02 mm thick.

Discussion. This new species is characterized by a broad central spongocoel and relatively low chambers in which occur thin, reedlike trabecular filling structures. In general structural makeup, it appears similar to *Stylothalamia dehmi* Ott, 1967, with thin porous walls and long, thin pillars in trabecular filling structures. However, *Stylothalamia dehmi* is an irregular form, without a prominent central tube, and has chambers approximately 1.5 mm high, with pores 0.10–0.15 mm. Size of these structures in the type species is somewhat similar to the Chinese form, but the irregular growth form and lack of a central spongocoel in this type species immediately separates the forms.

Stylothalamia columnaris (le Maitre 1935) is also a very irregular form that may be multiple branched and has a growth form significantly different than the uniform cylindrical structure seen in the Chinese specimen. *Stylothalamia hydriotica* Senowbari-Daryan, 1990, is a cylindrical form, but it has relatively coarse pillars as trabecular structures in the more or less catenulate chambers that lack the small overlap, so that chambers bulge into the spongocoel, as well as have shelflike bulges of segmentation on the exterior. Pillars in *S. hydriotica* range 0.2–0.3 mm across and are more or less regularly arranged, and in a structure somewhat coarser than in the Chinese species.

The only Permian species of the genus described to date is *Stylothalamia permica* Senowbari-Daryan, 1990, from Sicily. It is a single to branched asiphonate form and so contrasts sharply with the Chinese specimen in that general plan. Its filling structures of relatively thin pillars, however, is somewhat similar, as are the general dimensions with the pores noted in the skeleton. Chambers in the Permian species from Sicily are also approximately 1 mm high, so in general structure within single chambers, the species may look similar, but development of a pronounced central tube within *Stylothalama eleganta* n. sp. immediately differentiates the forms.

Wu (1991, p. 86) proposed the new genus *Stylocoela* for some Permian sponges of China that fit well within the genus *Stylothalamia* Ott, 1967. The type species, *Stylocoelia circopora* Wu, 1991, is moved to *Stylothalamia. Stylothalamia circopora* (Wu) has a growth form like *Stylothalamia eleganta,* described here, but has chambers only 0.15–0.30 mm high, instead of about 1 mm high, and has a narrow spongocoel, only 1.3–2.0 mm wide, in contrast to one 5–6 mm wide within the new species described here. Interpores are coarser in *S. circopora,* and its walls are finer than in *S. eleganta* n. sp., but pillar dimensions and spacing are similar in the two species. Both species are from the Middle Permian Maokou Formation, but Wu's samples are from Guangxi and our material is from Guizhou.

Senowbaridaryiana hydriotrica Senowbari-Daryan, 1990, may appear somewhat similar at first glance, with prominent lower ringlike chambers arranged around the broad central spongocoel, but *Senowbaridaryana* has a complex reticulate filling structure instead of the simple pillarlike trabecular structure seen in our Chinese species, and so could be immediately differentiated. *Preverticillites columnella* Parona, 1933, in our collections, has a general filling structure somewhat transitional into a reticulate net rather than the simple, isolated, free-standing pillars in *Stylothalamia.*

Interiors of chambers are rimmed with isopachous fibrous calcite cements.

Material. Two specimens, the holotype and paratype, are on a single thin section ZYD-17, from the Middle Permian Maokou Formation, Ziyundong, Ziyun County, southern Guizhou.

Order PERMOSPHINCTA Termier and Termier, 1974
Suborder PORATA Seilacher, 1962
Family SEBARGASIIDAE de Laubenfels, 1955
(pro SPHAEROSIPHONIIDAE Steinmann, 1882)

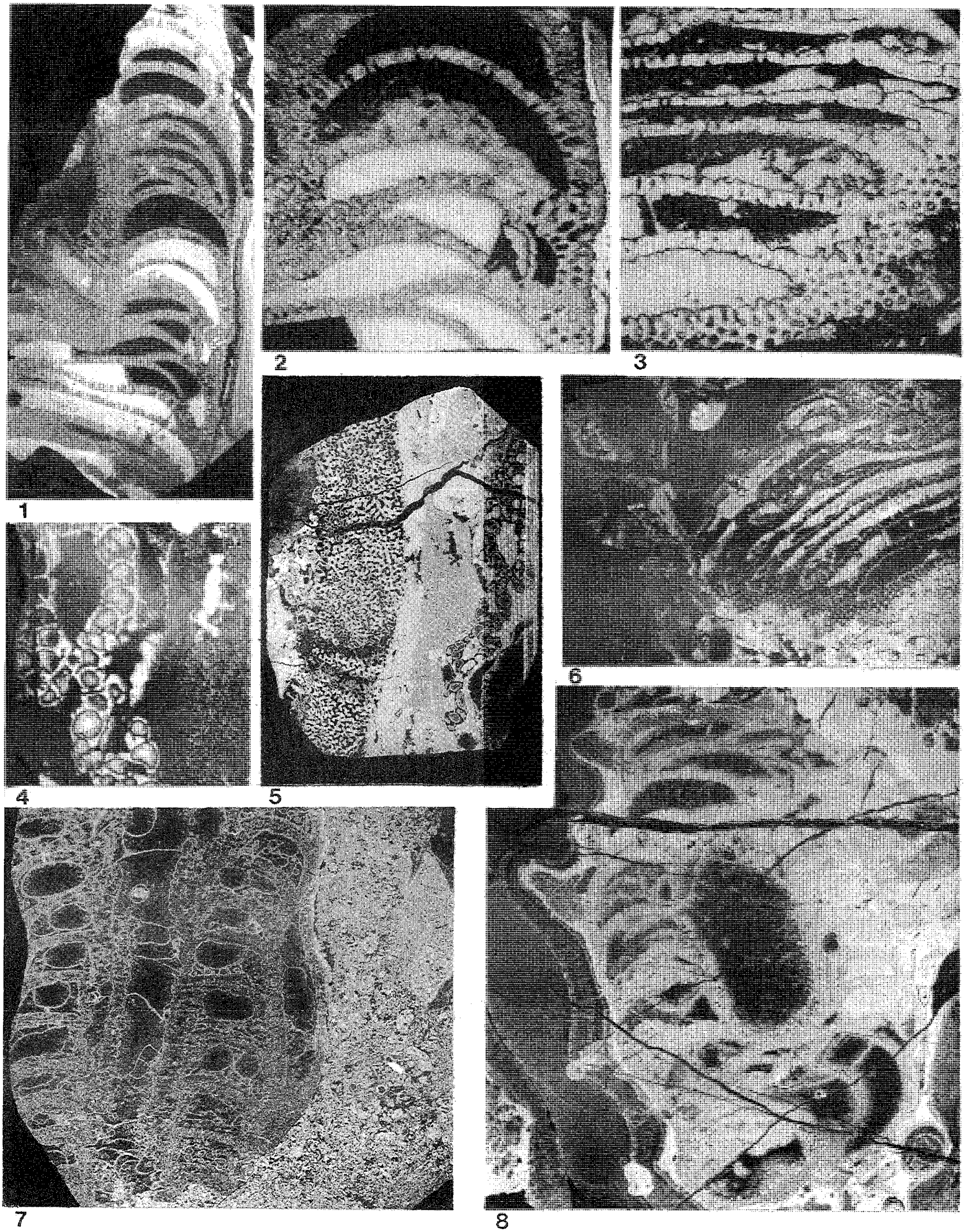
Senowbari-Daryan (1990, p. 52) placed the Cystothalamiidae Girty, 1908, and Stromatocoeliidae Zhang and Fan, 1985, into synonymy within the family Sebargasiidae and discussed the reason for that development. He noted that the family is included in the suborder Porata Seilacher, 1962, which was raised by Pickett and Rigby (1983) from superfamily to suborder ranking. In his diagnosis, Senowbari-Daryan (1990, p. 52) noted that the family includes those sphinctozoans with chambers arranged in catenulate or glomerate arrangements, in one or more layers around an axial spongocoel, and chambers that lack filling structures, except perhaps relatively rare vesiculae, with a basal skeleton, so far as it is known, made of aragonite.

Subfamily CYSTOTHALAMIINAE Girty, 1908

Senowbari-Daryan (1990) included within the subfamily those sponges in which the skeleton is made of glomerately arranged chambers and that have one or more central canals, with the type genus as *Cystothalamia* Girty, 1908. Senowbari-Daryan (1990) also erected the new subfamily Sebargasiinae to include those sponges in which the chambers are arranged in catenulate or single chainlike arrangements around one or more central canals. He separated the subfamilies basically on a glomerate vs. catenulate chamber organization.

EXPLANATION OF PLATE 1

Polycystocoelia, Cystothalamia, Peronidella, and *Amblysiphonella.* Figs. 1–3, 6.—*Polycystocoelia huajiaopingensis* Zhang, 1983; figs. 1, 2, specimen JS009, Changxing Formation, Jianshuigou, Huaying City, Sichuan. *1,* projection print showing general growth form and overlapping scalelike chambers, characteristic of the genus and species, with prominent pores in the interwalls, X2; 2, photomicrograph shows overlapping chambers and coarse pores through the exowalls on the right and endowalls on the left between arched interwalls, from lower right part of *1,* X5; *3, 6,* specimen 5030, unit 33, Maokou Formation, Xiangbo, Guangxi; *3,* photomicrograph shows moderately low chambers and uniformly coarsely perforate exowall on lower right and interwalls between chambers in the center and upper left, X5; *6,* projection print, orientation reversed from 3, showing low, broad chambers in near-tangential cut, with coarsely perforate exowall near the bottom and specimen encrusted by calcite cements in the upper part; thin interwalls also porous, X2. Figs. 4, 5.—*Cystothalamia conica* (Termier and Termier 1977a), Maokou Formation, Xiangbo, Guangxi, specimen 5225, unit 29; *4,* photomicrograph showing porous chambers arranged in single layer around an axial spongocoel in irregular undulating sponge; calcareous clastic matrix on the right, X5; *5,* projection print reversed from *4* with *Cystothalamia* on the right and *Peronidella* on the left; separated by coarse clastic carbonate matrix; irregular undulating form of *Cystothalamia* produces irregular sections of axial spongocoel; defined by more or less complete layer of globular chambers; *Peronidella*(?) sp. on the left, with skeleton as dark elements that define more or less regular canals filled with sediments. Section may be tangential to cylindrical form, X2. Figs. 7, 8.—*Amblysiphonella*(?) *bullifera* Senowbari-Daryan and Rigby, 1988; *7,* projection print of nearly vertical section with prominent axial spongocoel bordered by cross sections of ringlike chambers, each with thick perforated walls and distinctive vesicular and beaded to bubblelike spherical filling tissues; aberrant, vertical, oblique chamber overlaps outer margin of the sponge on the lower right; chamber walls largely recrystallized; specimen Z-1 (22), Changxing Formation, Ziyun, Guizhou, X2; *8,* projection print of oblique section shows ringlike chambers, in part, with scalelike appearance in the upper part, where chambers have some irregularity, thick perforate walls, and where distinctive vesicular fillings are less well developed; large axial spongocoel filled with spar; specimen encrusted with microorganisms and coated by layered calcareous cements, specimen JS-106, Changxing Formation, Jianshuigou, Huaying City, eastern Sichuan, X2.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Genus CYSTOTHALAMIA Girty, 1908

Original diagnosis. "Kammern mehrschichtig (polyglomerat) um ein oder mehrere den schwamm in der gesamten Länge durchziehendes Zentralrohr angeordnet. Zentralrohr retrosiphonate. Vesiculae fehlen oder sind selten. Aragonitisches Basalskelett mit sphärolitischer Mikrostructur. Ein spiculäres Skelett is bis jetzt nicht bekannt" (Senowbari-Daryan 1990, p. 54).

Sponges straight to bent or branching cylindrical to conical bodies that have one or more retrosiphonate central tubes. Chambers arranged in two or more layers around the central tube or tubes; exowall perforated by numerous small pores. Sponge exterior nodular with each knob corresponding to a chamber on the interior. Vesiculae may be present or rare. Aragonitic basal skeleton with sphaerolitic microstructure. Spicules within the skeleton are not yet known.

Type species. Cystothalamia nodulifera Girty, 1908.

CYSTOTHALAMIA CONICA
(Termier and Termier 1977a)
pl. 1, figs. 4, 5

Synonymy. Racemina conica Termier and Termier, 1977a, p. 42, pl. 10, fig. 6; Termier and Termier, 1977b, p. 76, text fig. 22, pl. 8, fig 4(?).

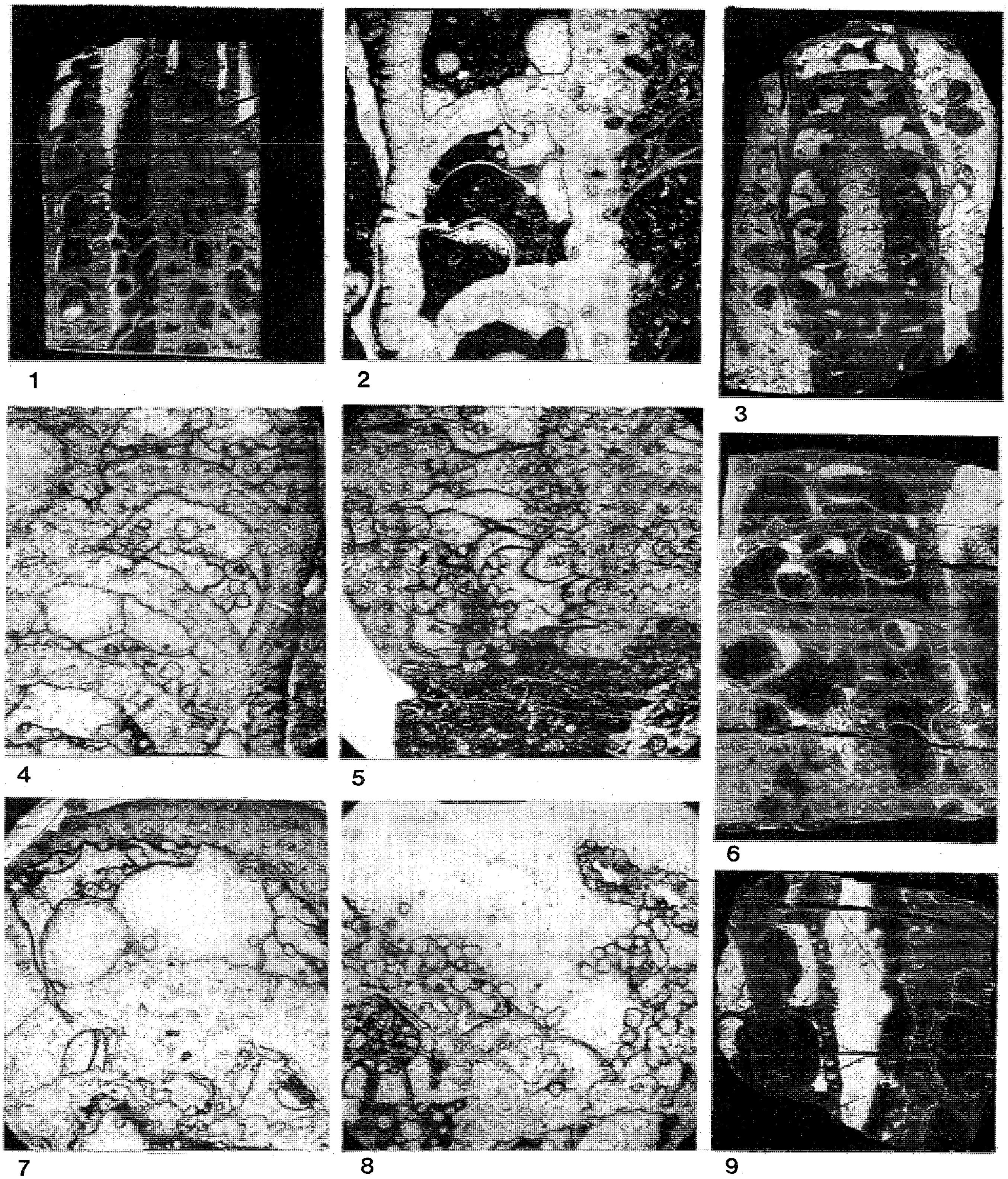
Cystothalamia conica Senowbari-Daryan and Rigby, 1988, p. 190, pl. 32, figs. 1–5.

Emended diagnosis. Slender cylindrical nodular-appearing stems, 3–5 mm in diameter, with central tubes to 2 mm in diameter; stem and central tubes increase in size upward; chambers generally in one layer but may be to three chambers thick locally, chambers globose to small egg-shaped and 0.8–1.0 mm across and 0.7–1.0 mm high; all walls perforated by a few coarse pores. Scattered vesicular filling structures in a few chambers.

Description. Sponges upward-expanding curved subcylindrical, 2–3 mm in diameter near bases and approximately 5 mm in diameter in upper parts. Spongocoels near base about 1 mm in diameter, expand to 2 mm across in upper parts. Sponges with nodular exteriors produced by globose exowalls, sponge composed of 1–3 layers of rounded, upward-arched chambers. Chambers 0.8–1.0 mm across and 0.7–1.0 mm high, and usually with several relatively coarse pores within walls of each chamber. In general, 2–3 openings occur in each chamber wall in our sections, but some may have less. Exowalls and endowalls, as well as interwalls, 0.10–0.15 mm thick. Vesicular filling tissue in only a few chambers, usually as curved, subvertical, plates 0.02–0.03 mm thick.

EXPLANATION OF PLATE 2

Amblysiphonella (?) *bullifera* Senowbari-Daryan and Rigby, 1988. Figs. 1–9.—*1*, projection print of specimen ZS-20, from Shitouzai Member, Changxing Formation, Ziyun County, Guizhou, shows prominent axial spongocoel with coarse endowalls and thick interwalls and exowalls, all perforated, and prominent vesiculae in both chambers and spongocoel; sporelike filling structures are attached and included as beadlike structures on vesicular plates, X1.25; *2, 3*, specimen LD-6, Changxing Formation, Luodian County, southern Guizhou; *2*, photomicrograph shows coarsely perforate endowalls, on the right, abutted by upward-arcuate vesiculae in the spongocoel; thick exowalls and interwalls also perforated, but with smaller openings; chambers contain upward-arcuate vesiculae to which bead- or sporelike filling structures are attached, as characteristic of the species, X5; *3*, vertical section showing prominent open spongocoel with upward-arched vesiculae surrounded by ringlike chambers with thick walls; partially filled with vesiculae that have attached bead- or sporelike filling structures; coarse endopores show in tangential section of the endowall in the upper and lower center; sponge surrounded by clastic matrix, X1.25; *4, 5*, photomicrographs of specimen Z-1 (22), with prominent vesiculae and bead- or sporelike combined filling structures in the thick-walled chambers, Shitouzai Member, Changxing Formation, Ziyun County, Guizhou, both X5; *6*, projection print of specimen ZS-20 (4); vertical oblique section showing broad, coarsely walled chambers in the upper part and tangential cut of endowall and part of central spongocoel in lower center, bordered by upward-arcuate chambers on lower right and left; characteristic vesicular beaded and sporelike filling structures occur in each of the chambers, Changxing Formation, Ziyun County, Guizhou, X2; *7*, photomicrograph of specimen Z-1 (17) showing clear thick wall and vesicular filling structures with attached beaded or sporelike elements characteristic of the species, Changxing Formation, Ziyun County, Guizhou, X5; *8*, photomicrograph of specimen Z-1 (22) showing filling structure in a broad chamber above the coarsely perforate wall in the lower right, Changxing Formation, Ziyun County, Guizhou, X5; *9*, projection print of specimen ZS-20 (5) shows characteristic large axial spongocoel with coarsely perforate endowalls bordered by high chambers that have somewhat more finely perforate exowalls and interwalls and that contain vesicular filling structures to which are attached the bead- or sporelike elements characteristic of the species, Changxing Formation, Ziyun County, Guizhou, X2.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Discussion. Cystothalamia conica (Termier and Termier 1977a) was redescribed by Senowbari-Daryan and Rigby (1988, p. 190) from samples of Upper Permian age from Tunisia, and is also a distinctly similar form. The cylindrical to occasionally conical sponge is made of egg-shaped to subspherical chambers, in 2–4 layers around the long central tube. Entire stems are generally only 2–3 mm in diameter but do range up to 5 mm in diameter, essentially like the sponge here, and the small chambers are about 1 mm across, but do range up to 1.5 mm across. *Cystothalamia conica* also is a distinctly curved form and appears to have about the same numbers of pores as seen in chambers in the Chinese specimen. Pore diameters of 0.1–0.5 mm, and separation of these pores by about 0.15 mm, are essentially like those seen in the Chinese specimen.

Cystothalamia nodulifera Girty, 1908, is a relatively robust, cylindrical form that may have stems to over 2 cm across, but with a relatively small central canal. It is a considerably larger species than the Chinese form described here and has consistently larger and more numerous series of chambers making up the structure. *Cystothalamia adrianensis* Senowbari-Daryan, 1990, is a polyglomerate sponge within the genus, but has a spongocoel that may contain up to 10 tubules, each about 1 mm in cross section, arranged as the central opening, in a structure distinctly different than the single opening seen in the Chinese specimen.

A more similar form is *Cystothalamia distefanoi* Senowbari-Daryan, 1990, which was described out of the Middle Permian of Sicily. It is a small species, with stems only up to approximately 7 mm in diameter, with individual chambers 1.0–1.5 mm across around a central opening only 1 mm in diameter. In gross size and structure, this species is distinctly similar to the Chinese form, but it appears to have more pores per chamber than the few scattered openings seen in walls of the Chinese specimen.

Cystothalamia ramosa Senowbari-Daryan and Rigby, 1988, is also a relatively small form but has distinctly more porous chambers and, more definitively, there are usually 4–8, areally clustered small exhalant tubes in the exhalant system, in a structure not evident in the Chinese specimen nor in *Cystothalamia conica.*

Material. Figured specimen on 5225, unit 29, of the Middle Permian Maokou Formation, at Xiangbo, Longlin County, northwestern Guangxi.

Subfamily SEBARGASIINAE
Senowbari-Daryan, 1990
Genus AMBLYSIPHONELLA Steinmann, 1882

Emended diagnosis. Straight or branched porate sphinctozoans with distinctly porous exowalls, interwalls, and endowalls; generally one prominent retrosiphonate central tube extends almost length of sponge; chambers ringlike around central tube and with hemispherical or crescentic cross sections; chamber interiors and retrosiphonate central tube may contain vesiculae and, rarely, sporelike filling structures; exterior smooth to only slightly constricted. Skeletal microstructure sphaerolitic aragonite.

Type species. Amblysiphonella barroisi Steinmann, 1882.

AMBLYSIPHONELLA(?) BULLIFERA
Senowbari-Daryan and Rigby, 1988
pl. 1, figs. 7, 8; pl. 2, figs. 1–9

Synonymy. Amblysiphonella(?) *bullifera* Senowbari-Daryan and Rigby, 1988, p. 181–82, pl. 24, figs. 1, 2, text fig. 6.

Diagnosis. "Cylindrical sponges with ringlike perforated chambers and a central tube. Outer segmentation of the sponge is poorly developed. Chamber walls contain single exopores. Interiors of chambers contain bubblelike spherical elements (filling tissue? or a special kind of vesiculae?) that are connected with one another by small tubelike or rod-elements. The endopores are larger than the exopores" (Senowbari-Daryan and Rigby 1988, p. 181).

Description. Sponges cylindrical with ringlike chambers, stacked in vertical series around porous central tube; all chambers only sparsely perforated, most have distinct, widely spaced vesiculae and free or variously attached sporelike filling structures.

Dimensions of several characteristic specimens are shown in table 1. In specimen Z-1 (21), chambers upward arcuate, radially, overlapping, vertically stacked, and crescentic in cross section; central tube extends through whole sponge, becomes slightly larger upward. Some uneven, oblique vesicular plates, 0.2–0.5 mm thick, occur in interior of central tube, some with attached spherical beadlike or sporelike filling structures to 0.8 mm in diameter, or some within vesiculae plates as spherical swellings; elsewhere sporelike filling structures glomerate in clumps or "sheets" of same general size. One side of sponge body with oblique overlapping shinglelike chambers on the exterior of sponge body. Interiors of chambers with common thin vesicular plates and attached or associated glomerate to free sporelike structures that are round to oval and range up to about 0.4–0.5 mm in diameter.

Specimen Z-1 (22), body cylindrical with ringlike chambers, stacked in vertical series around porous central tube, skeleton extensively recrystallized, and microstructure obscured. Central tube partially separated into two sections by coarse vertical partition, 1.5–1.6 mm thick, and

Table 1.—Dimensions of characteristic specimens of Amblysiphonella(?) bullifera *Senowbari-Daryan and Rigby, 1988, from southern Guizhou. Measurements are in millimeters.*

Specimen	Chamber Height	Chamber Width	Spongocoel Diameter	Interwall Thickness	Interpore Diameter	Endowall Thickness	Endopore Diameter	Exowall Thickness	Exopore Diameter
2-1(21)	3.7–5.5	9	10–13	1.3–2.0	0.1–0.2	—	0.1–0.3	—	—
2-1(22)	2.5–2.8	5.4–6.5	3.5–5.0	1.0–1.6	0.1–0.2	1.0–2.5	0.1–0.2	—	0.1–0.28
25-20(6)	4.5–6.9	5.1–5.5	7	1.1–1.8	0.1–0.2	1.8–2.2	0.2–0.5	1.5–1.8	0.1–0.2
25-20(7)	1.2–2.0	—	—	1.6–1.9	0.1–0.3	—	—	—	0.1
LD-6	4.2–6.2	4.5–5.0	6.2–6.5	1.4–1.5	0.2	1.6–2.0	0.3–0.5	1.3–1.8	0.1–0.2

partially composed of sporelike filling structures. Curved vesicular plates fill lower central tube, plates very thin, arcuate upward or concave to nearly horizontal, with attached beadlike or glomerate sporelike structures, most common in lower part of sponge. Chambers with common thin vesicular plates and sporelike filling structures range from isolated to attached and glomerate. A vertical, oblique chamber overlaps outer margin of sponge body on one side.

Specimen ZS-20 (6) with chambers arcuate upward, all chamber walls perforated; thinnest at chamber summits; endopores tube- or funnel-like; expand toward interior, endopores clearly tubular through endowalls. Lower part central tube with thin vesicular plates, usually concave, oblique, and only 0.1 mm thick. Chambers filled with concave or arcuate to bubblelike vesicular filling structures that extend vertically between interwalls to horizontally across chambers. Sporelike structures attached onto or included as part of beadlike structures of these vesicular plates. Some endopores sealed by small vesicular plates within pores, others by larger chamber-filling plates.

Sponge body of specimen LD-6 cylindrical and more than 50 mm long and 22 mm wide, with ringlike chambers stacked in vertical series around porous central tube. Central tube filled with upward-arcuate vesicular filling structures, usually 0.1–0.2 mm thick. Chambers filled with common, bubblelike vesicular filling structure and some rare beadlike or sporelike filling structures. Vesicular plates to 0.4 mm thick, thicker than those in central tube. Sporelike structures usually 0.4–0.5 mm in diameter.

Specimen ZS20 (07) a vertical tangential section of cylindrical to conico-cylindrical sponge about 40 mm high and at least 22 mm in diameter in middle part of sponge body. Chambers broad, low, crescentic, arcuate upward, and overlapped as vertically stacked crescents in cross section. A tangential skeletal interruption of part of central tube visible only in lower part of sponge, dimensions of tube not measurable. Exowalls pierced by abundant exopores, about 0.1 mm in diameter, producing pitted, almost spinose-appearing surface.

Discussion. The species *Amblysiphonella* (?) *bullifera* was described by Senowbari-Daryan and Rigby (1988, p. 181–82, pl. 24, figs. 1–2, text fig. 6), and was based on cylindrical, moderately coarse sponges from the Djebel Tebaga region of Tunisia. The species is characterized by ringlike chambers that contain bubblelike or sporelike spherical structures attached to tubular or vesicular filling structures within the chambers. This is the only species of the genus that contains these types of filling structures, but sporelike features are well known in the often associated *Intrasporeocoelia hubeiensis* Fan and Zhang, 1985, and the several species of *Rhabdactinia* Yabe and Sugiyama, 1934. These sporelike filling structures were considered diagnostic of the family Intrasporeocoeliidae Fan and Zhang, 1985. The Chinese form described here, like the species described from Tunisia, corresponds in gross morphology to the genus *Amblysiphonella,* but differs from other species of the genus and also from other genera of sphinctozoans in having the spherical filling elements within the interior of the ringlike chambers. *Intrasporeocoelia* lacks a central tube, and in that genus the filling structures are not commonly connected by the tubelike or vesicular filling structures, as they are here. For that reason, we continue to include the species here within the genus *Amblysiphonella,* but with some question.

Material. Figured specimens Z-1 (17, 21, 22, 23), ZS-20 (4, 5, 6, 7) from Upper Permian Shitouzai Limestone, Ziyun County, and LD-6 from the Changxing Formation, Loudian, southern Guizhou; and JS106 from Jianshuigou, Huaying City, eastern Sichuan.

Reference specimens include XII-Ch, 5023, from Xiangbo, Longlin County, northwestern Guangxi; and Z-1 (24), Ziyun County, southern Guizhou, all from the Upper Permian Changxing Formation.

Genus POLYCYSTOCOELIA Zhang, 1983

Emended diagnosis. Cylindrical to cup-shaped, stemlike sponge; chambers low, flattened, broad elements, superposed or diagonally arranged with low scalelike appearance; chamber walls single-layered, coarsely perforate, with markedly thickened endowall of retrosiphonate central tube; vesiculae and other filling structures absent.

Discussion. Polycystocoelia Zhang, 1983, was proposed for cylindrical to branching stems composed of caplike or low, flattened chambers, but are superimposed one upon the other with a retrosiphonate or poorly developed central tube and with walls pierced by many moderately large interpores and exopores. Senowbari-Daryan (1990, p. 63) noted that *Polycystocoelia* may appear somewhat similar to *Amblysiphonella,* except *Amblysiphonella* has complete ringlike chambers, where *Polycystocoelia* has wide chambers that extend partly around the circumference of the sponge, and it has very low chambers as well. Senowbari-Daryan (1990, p. 63) concluded that *Sinocoelia* Zhang and Fan, 1985, and *Stromatocoelia* Zhang and Fan, 1985, are synonyms of *Polycystocoelia.* He concluded that *Sinocoelia* does not have reticular filling structures, such as reported by Fan and Zhang (1985, p. 15). Senowbari-Daryan also noted that *Sinocoelia variabilis* Zhang and Fan, 1985, has chamber walls that lie so close, one upon the other, that it appears gradational to the Inozoa, but it appears to us to be clearly a sphinctozoan that perhaps should not be included within the genus *Sinocoelia.*

Senowbari-Daryan (1990, p. 63) also concluded that *Stromatocoelia* Zhang and Fan, 1985, must also be included with *Polycystocoelia* as a synonym. *Stromatocoelia* was initially differentiated by Zhang and Fan based on presumed differences in filling structures in *Stromatocoelia* and *Sinocoelia.* However, the absence of filling structures in both suggests that they belong to the same genus. Senowbari-Daryan noted that shapes of segments are not generic characteristics within the sphinctozoans. The modified definition and usage of *Polycystocoelia* is adopted here, and the genus would include the type species *Polycystocoelia huajiaopingensis* Zhang, 1983, and *Polycystocoelia sinica* Zhang, 1983, *Polycystocoelia lepida* (Zhang and Fan 1985), *Polycystocoelia variabilis* (Zhang and Fan 1985), *Polycystocoelia asiatica* (Zhang and Fan 1985), and *Polycystocoelia norica* Senowbari-Daryan and Reid, 1987, as suggested by Senowbari-Daryan (1990, p. 60).

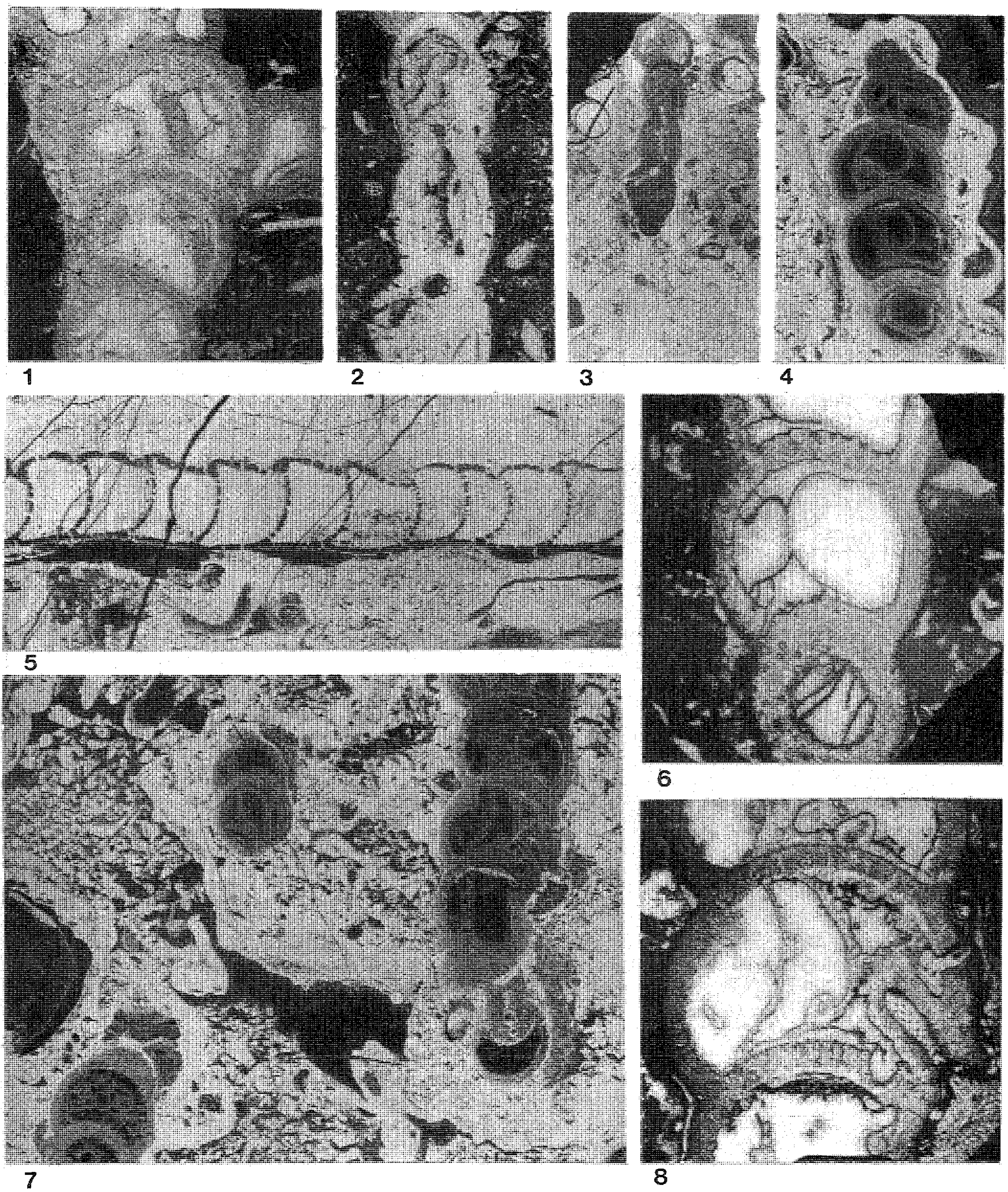
Type species. Polycystocoelia huajiaopingensis Zhang, 1983.

POLYCYSTOCOELIA HUAJIAOPINGENSIS
Zhang, 1983
pl. 1, figs. 1–3, 6; pl. 4, figs. 4, 5, 8

Synonymy. Polycystocoelia huajiaopingensis Zhang, 1983, p. 7; Fan and Zhang, 1985, p. 12–13, pl. 3, figs. 4–6, pl. 4, fig. 2; Rigby, Fan, and Zhang, 1989a, p. 425, figs. 15.1, 15.3, 16.1–16.3.

EXPLANATION OF PLATE 3

Colospongia and *Subascosymplegma.* Figs. 1–4, 6–8.—*Colospongia cortexifera* Senowbari-Daryan and Rigby, 1988; *1,* specimen ZYD-1 shows bifurcation of the normal, moniliform sponge, with small branch on the right, from the main stem of globular chambers, each with relatively thick walls perforated by pores, and each containing vesiculae; black dots are bubbles in the mounting medium; Middle Permian Maokou Formation, Ziyundong, Ziyun County, Guizhou; *2, 3,* specimen JS0007, immature(?) chambers, Changxing Formation, Jianshuigou, Huaying City, Sichuan; *2,* photomicrograph shows elongate, barrel-shaped chambers with numerous moderately fine pores in the chamber walls and characteristic lack of a central tube, X5; *3,* projection print shows entire specimen of globular chambers in moderately coarse, clastic matrix, X2; *4,* projection print of specimen ZYD-18, with globular, relatively thick-walled chambers; walls perforated by fine pores and interior of chambers with characteristic bubblelike vesiculae, Maokou Formation, Ziyun County, Guizhou, X2; *6–8,* specimen ZYD-2, Maokou Formation, Ziyundong, Ziyun County, Guizhou; *6,* photomicrograph with subtangential section in the lower part showing vesiculae in the chambers and round exopores and interpores in the chamber walls; interpores are cut more nearly longitudinally in the upper part of the next chamber wall, near the center; thin vesiculae occur in all of the chambers, a fine cortex shows on the right exterior of the lower chamber, X5; *7,* projection print of nearly complete thin section showing parts of three moniliform examples of the species, all with relatively thick globular walls around chambers in which vesiculae are common, all in clastic matrix, X2; *8,* photomicrograph of middle part of the specimen in the right of *7,* section shows characteristic, numerous, fine pores in interwalls and exowalls, along with vesiculae in the chambers; bryozoans have been encrusted and coated by the sponge in the lower right, X5. Fig. 5.—*Subascosymplegma* sp., section shows the characteristic cross section of tabular or platterlike form, with chambers of various shapes; chamber walls perforated by moderately coarse pores; presumed upper surface is undulating because chamber walls are offset slightly in the overlap zone; specimen ZS-19, Shitouzai Member, Changxing Formation, Ziyun County, Guizhou, X1.25.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Diagnosis. Cylindrical sponges with retrosiphonate central tube composed of scalelike chambers of irregular width, but up to approximately 25 mm across. Chambers generally low, but may range to slightly over 2 mm high in crescentic crests, with walls perforated by numerous pores; interpores to 0.3 mm across; exopores slightly larger and may range to 0.4 mm across. Netlike endowall with numerous endopores, mostly approximately 0.2 mm in diameter, that may combine to produce tubes in complex endowall. Filling structures generally not present or rare as vesiculae.

Description. Sponges cylindrical to cup-shaped, with broad spongocoel, composed of low, overlapped, scalelike chambers of irregular width; those in specimen 5030 3–22 mm across and 0.9–2.1 mm high as lenticular or weakly crescentic-shaped openings. Chambers in JS 0009 at least 18 mm wide in tangential section near the base of sponge and to 10 mm wide and 1.3–3.0 mm high in vertical section of cylindrical forms where chambers strongly upward crescentic and overlapping. Section shows two walls of retrosiphonate central spongocoel.

Interwalls generally 0.5–0.7 mm thick in specimen 5030 and 0.5–1.0 mm thick; in specimen 5031, walls pierced by numerous fine, funnel-like interpores 0.04–0.30 mm across; pores 0.1–0.3 mm apart with uniform distribution, may connect 2–3 chambers in zone of overlap of walls. Specimen 5031 composed of low, extensively overlapped, scalelike chambers irregularly 1.0–14.0 mm wide and 0.9–3.0 mm high. Interwalls 0.6–1.1 mm thick and pierced by fine pores 0.1–0.2 mm across.

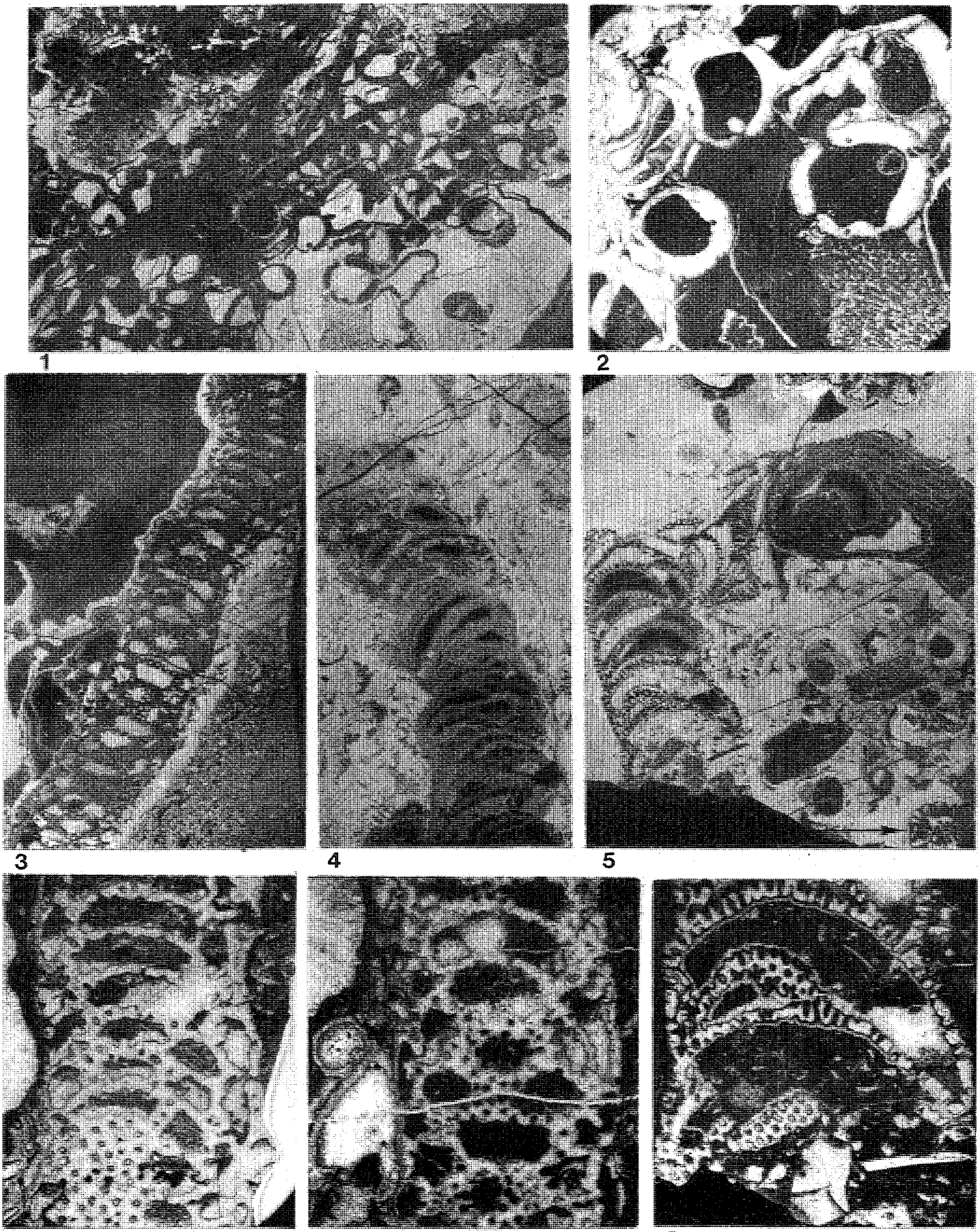
Exowalls generally 0.5 mm thick but range to 1.5 mm thick where chamber walls overlap; exopores abundant, most commonly 0.3 mm in diameter, and range 0.1–0.4 mm across, separated 0.1–0.4 mm. Only oblique section of endowall present in section JS0009, irregular porous netlike wall pierced by abundant endopores, mostly 0.15–0.20 mm in diameter, as cross-connected openings and tubes to at least 2 mm long but commonly shorter. Tubes both irregularly radial and vertical within endowall.

Discussion. Nature of the skeleton composed of low, overlapped scalelike chambers, and their dimensions suggest inclusion of the present specimen in the type species *Polycystocoelia huajiaopingensis.*

Material. Figured specimens include 5031, unit 33, from the Middle Permian Maokou Formation, at Xiangbo, Longlin County; STZ-10-B and ZS5 (08), both from the Shitouzai Member, Changxing Formation, Ziyun County, Guizhou; and specimen JS009 from the Upper Permian Changxing Formation, Jianshuigou, Huaying City, eastern Sichuan. Reference specimens include examples on 5272, unit 36, from the Maokou Formation, and 5030, unit 53, from the Changxing Formation, at Xiangbo, Longlin County, Guangxi.

EXPLANATION OF PLATE 4

Parauvanella, Imbricatocoelia, and *Polycystocoelia.* Figs. 1, 2.—*Parauvanella paronai* Senowbari-Daryan and di Stefano, 1988, JS0090, Changxing Formation, Jianshuigou, Sichuan; *1,* projection print showing numerous subglobular, moderately thick-walled, isolated to attached chambers in loosely glomerate form, best exposed in the middle and lower right; fractured in the upper and lower left, where fractures are filled with crystalline calcite, here dark in projection print; coarse ostia show in some chambers in the lower center, which are also shown in *2, Parauvanella minima* Senowbari-Daryan, 1990, is the chamber cluster in the upper left of *1,* X2; *2,* thick walls of chambers perforated by coarse ostia, perhaps best shown in chamber in the right center, which has been coated by an attached inozoan sponge, probably *Peronidella,* X5. Figs. 3, 6, 7.—*Imbricatocoelia elongata* Rigby, Fan, and Zhang, 1989a, specimen 5058, unit 53, Changxing Formation, Xiangbo, Guangxi; *3,* projection print of nearly complete section shows numerous overlapping crescentic to elliptical chambers in regular spacing, some cut essentially in midchamber and others as subtangential, with latter walls showing abundant coarse interpores and exopores, X1.25; *6, 7,* photomicrographs of middle and upper part of section, X5. Figs. 4, 5, 8.—*Polycystocoelia huajiaopingensis* Zhang, 1983; *4,* projection print of specimen STZ-10-B, from the Shitouzai Member, Changxing Formation, Ziyun, Guizhou, shows characteristic broad overlapping chambers that are crescentic in linear series; chamber walls moderately coarsely perforate, best shown in lower center and lower right; entire skeleton complexly replaced, X1.25; *5, 8,* specimen ZS-5 (08), Shitouzai Member, Changxing Formation, Ziyun County, Guizhou; *5,* projection print shows characteristic form in the left, as cut in near vertical section, and in subtangential horizontal section, a more irregular form in the upper right shows lack of central spongocoel and development of coarsely perforate interwalls and exowalls in shield-shaped, low chambers; specimen in the upper right filled with calcite cement and strongly recrystallized; small specimen of *Tebagathalamia cylindrica* Senowbari-Daryan and Rigby, 1988, occurs in the lower right corner (arrow); fragments of *Peronidella* show in the center and lower right, X2; *8,* photomicrograph of middle part of the specimen in lower left in *5* showing arcuate, broad, shieldlike chambers and coarsely perforate interwalls and exowalls; chambers partially filled with dark, bioclastic wackestones and mudstone, X5.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Family COLOSPONGIIDAE
Senowbari-Daryan, 1990
Subfamily COLOSPONGIINAE
Senowbari-Daryan, 1990
Genus COLOSPONGIA Laube, 1865

Original diagnosis. "Diese Gattung . . . unfasst Formen, welche aus kugelförmigen übereinander sitzenden, nach oben an Gröze zunehmenden Individuen gebildet werden. Eine starke, glatte und glänzende Epitheke umhüllt dieselben, und es ist auf dem ganzen Scheitel von zahlreichen, gleichmässig runden und feiner Osculen durchbohrt" (Laube 1865, p. 237–38).

Emended diagnosis. "Single, rarely branched stems consisting of numerous catenulate or beadlike spherical chambers. Exowalls of the segments are two-layered, segment interwalls are three-layered. Exopores and interpores branch several times dichotomously. Exowalls and interwalls have a thin cortex and lack ostia. Interiors of chambers are filled by vesiculae" (Senowbari-Daryan and Rigby 1988, p. 183).

Type species. Manon dubium Münster, 1841.

COLOSPONGIA CORTEXIFERA
Senowbari-Daryan and Rigby, 1988
pl. 3, figs. 1–4, 6–8; pl. 11, fig. 1; pl. 12, fig. 5

Synonymy. Steinmannia gemina Waagen and Wentzel, 1888, Parona, 1933, p. 40, pl. 11, figs. 9–11.
Waagenella gemina Waagen and Wentzel, Termier and Termier, 1955, p. 618, fig. 2d–g.
Girtycoelia sp., Seilacher, 1962, pl. 73, pl. 2, fig. 4.
Polytholosia? cf. *gemina* (Waagen and Wentzel), Termier and Termier, 1977a, p. 44, pl. 10, fig. 26.
Polytholosia gemina (Waagen and Wentzel), Termier and Termier, 1977b, p. 79, fig. 26.
Colospongia cf. *gemina* (Waagen and Wentzel), Aleotti, Dieci, and Russo, 1986, p. 230, pl. 6, fig. 5–6.
Colospongia cortexifera Senowbari-Daryan and Rigby, 1988, p. 183–84, pl. 27, figs. 1–13.

Description. Small unbranched sponges consisting of elongate, catenulate chambers that lack central tubes. Immature(?) chambers 3.2–4.2 mm high and 2.5–4.9 mm wide in Jianshuigou specimens, become more globose in upper chambers 2.7 mm high and 3.7 mm wide. Exowalls 0.4–0.5 mm thick with abundant exopores about 0.10–0.12 mm across. Some chambers with vesicular plates.

Specimen ZYD (18) with four more mature-size catenulate chambers, each 6.5–8.2 mm wide, and 4.0–5.5 mm high. Exowalls and interwalls range 0.9–1.0 mm thick and perforated by abundant pores 0.14–0.20 mm in diameter, with nearly all approximately 0.16 mm across, separated only 0.10–0.30 mm apart. Interior of chambers with vesicular filling structure, plates 0.2–0.10 mm thick, nonporous. Interwalls approximately 1.0 mm thick, with numerous interpores 0.10–0.16 mm in diameter.

Thin cortex produces two-layered wall, particularly well preserved in ZDY (2); occurs in both exowalls and interwalls as fine screen 0.04–0.06 mm thick and 0.03–0.10 mm above or outside main exowall and interwall layer. Cortex screen covers pores and interpore areas; with cortex pores 0.03–0.05 mm across, but most 0.04 mm, in diameter, separated by skeletal material mostly 0.04 mm across; cortex layer generally darker than main layer.

Discussion. Colospongia cortexifera Senowbari-Daryan and Rigby, 1988, is reported by them as separated from all other species of *Colospongia* by the development of a cortex, by branching of pores within the chamber exowalls, and by the occurrence of two-layered exowalls. The Chinese specimens described here have the general dimensions of chambers like that of the Tunisian species, and the same subglobose, relatively thick-walled chambers as well. As in the Tunisian species, our specimens are generally catenulate or beadlike of subspherical chambers, but rarely branch. Exopores and interpores, in our material, are somewhat smaller, but some of that size variation may be related to the intense recrystallization our materials have experienced. In some areas, the pores appear to be of the same general size of that reported by Senowbari-Daryan and Rigby (1988, p. 183) from the type material in Tunisia.

Deng (1982, p. 710, pl. 1, fig. 2) described *Colospongia*(?) *muliensis* from the Middle Permian Maokou Formation, and it has a double-layered interwall, similar to *Colospongia cortexifera.* Deng's species does not show pores within the chamber walls, and may not be a *Colospongia,* although Senowbari-Daryan (1990, p. 65) did include it in a list with other species of the genus.

Colospongia salinaria irregularis (Zhang 1983) has chambers that overlap in size with the *Colospongia cortexifera* described here, but in addition has chambers that are larger, as well. A suggestion of the cortex shows in one of the round chambers of *Colospongia salinaria irregularis* (Zhang 1983) shown by Fan and Zhang (1985, pl. 3, figure 2). This would suggest that at least some of the material included there might well be included in *Colospongia cortexifera,* but their material would have to be examined to be sure.

The other species listed by Senowbari-Daryan (1990, p. 65) have chamber or pore dimensions that would allow them to be separated from *Colospongia cortexifera.*

Material. Figured specimens JS0007, JS0072, and JS105 from uppermost Permian Changxing Formation, Jianshuigou, Huaying City, eastern Sichuan; and ZYD (1, 2,

18) and STZ 22-2, from Middle Permian Maokou Formation, Ziyun County, southern Guizhou. Reference specimens include JS0080 and JS106 from the Changxing Formation at Jianshuigou; ZS-9 and ZS-5-(10) and STZ-22-2 from the Upper Permian Shitouzai Member, Ziyun County, Guizhou; and B-29 from the Middle Permian Maokou Formation at Xiangbo, Longlin County, Guangxi.

Genus SUBASCOSYMPLEGMA Deng, 1981

Diagnosis. "Sponge body tubular or flabelliform, with a succession of segmental chambers with barrel vault-form superposed vertically as bedded structure occasionally shaped alternately. Each segmental chamber bounded by a strongly arched wall with convex shape toward the upper end. Walls penetrated by numerous small pores almost circular in section. Vesicular (filling) tissue occasionally visible in segmented chambers" (Deng 1981).

Discussion. The genus includes platelike sponges composed of stacked semicylindrical, tubelike, arched chambers with coarsely perforate walls. Such sponges are commonly identified as *"Ascosymplegma"* Rauff in the literature, according to Senowbari-Daryan and Rigby (1988, p. 187). *Subascosymplegma oussifensis* (Termier and Termier 1977a), redescribed and figured by Senowbari-Daryan and Rigby (1988), is seen as a platterlike or palmate form composed of long, semicylindrical to crescentic tubelike chambers. In a single section it is difficult to tell whether a catenulate-appearing linear series of chambers belongs to *Subascosymplegma* or to one of the other moniliform genera, unless the lateral bisymmetrical arrangement of the chambers can be demonstrated. However, the moderately annulate appearance of parts of the chambers in the Chinese form suggest that it should be included within that genus, even though the two surfaces have somewhat different sculpture.

Type species. Subascosymplegma guangxiensis Deng, 1981.

SUBASCOSYMPLEGMA sp.
pl. 3, fig. 5

Description. Sponge tabular or platterlike, skeletons of numerous superposed long subcylindrical chambers with curved rectangular to crescent cross sections. Chambers 6.1–8.0 mm wide or thick at widest near chamber bases, and 3.7–5.2 mm high, radially. Presumed lower or incurrent surface nearly smooth, but opposite surface undulating because of slightly offset (enlarged) base of upper or outer chamber beyond upper part of wall of previous chamber. Both walls 0.5–0.7 mm thick, but "upper" walls vary more in thickness and commonly thickest near basal junctions with earlier chambers; walls perforated with coarse pores 0.1–0.4 mm in diameter, but most approximately 0.2 mm across. Pores appear uniformly separated by about same distance as diameter of pores or slightly more. Interwalls generally somewhat thinner than other walls, usually about 0.3 mm thick, but may range to 0.5 mm thick and perforated by abundant coarse interpores, 0.2–0.4 mm in diameter, with most approximately 0.3 mm in diameter. Pores tube- or funnel-like and expand upward from base.

Discussion. The present form is probably a new species and differs from *Subascosymplegma paracatenulata* Rigby, Fan, and Zhang, 1989a, in having higher, more rectangular chambers. *S. paracatenulata* has chambers only 1.5–2.2 mm high, radially, and somewhat smaller coarsest pores. *Subascosymplegma guangxiansis* Deng, 1981, has chambers only 1–2 mm high, radially, but in a plate 10–20 mm thick, distinctly thicker than the species described here. The Tunisian species *Subascosymplegma oussifensis* (Termier and Termier 1977a) has chambers only 1–2 mm high, so it is easy to differentiate it from the coarser chambered species described here. Even though it is probably new, this species will not be named because we have such limited material.

Material. Figured specimen, ZS-19, from Upper Permian Shitouzai Member, Ziyun County, southern Guizhou; one reference specimen, ZS-5, also from the same formation and locality.

Subfamily CORYMBOSPONGIINAE
Senowbari-Daryan, 1990
Genus PARAUVANELLA Senowbari-Daryan
and di Stefano, 1988

Original diagnosis. "Nodular aggregates consisting of numerous small and irregular chambers. Central channel (tube) missing. Chamber walls sparitic to microsparitic (most probably primary aragonite?), imperforate to coarsely perforate without filling structures or vesiculae" (Senowbari-Daryan and di Stephano 1988, p. 18).

Type species. Parauvanella paronai Senowbari-Daryan and di Stefano, 1988.

PARAUVANELLA PARONAI Senowbari-Daryan
and di Stefano, 1988
pl. 4, figs. 1, 2; pl. 5, figs. 6, 8; pl. 7, figs. 1, 2;
pl. 11, fig. 1

Synonymy. Parauvanella paronai Senowbari-Daryan and di Stefano, 1988, p. 18–19, pl. 5, figs. 1–5; pl. 7, fig. 4.

Diagnosis. "Nodular aggregates consisting of numerous small and irregular chambers. Asiphonate. Glomerate chamber arrangement. Without filling tissue or vesiculae.

The primary composition of the skeleton was most probably aragonite" (from Senowbari-Daryan and di Stefano 1988, p. 19).

Description. Sponges consist of several loosely to superposed glomerate chambers; chambers spherical to hemispherical, and range 2.2–4.0 mm in diameter and height; usually appear round to elliptical in thin section. Chamber wall aporate, but penetrated by one to several ostia 0.2–0.5 mm in diameter. Walls may be smooth and even to irregular and slightly sagging or folded to uneven; range 0.2–1.0 mm thick in section, most 0.2–0.3 mm where not cut tangentially or diagonally. Chambers lack filling structures.

Discussion. The genus *Parauvanella* was proposed by Senowbari-Daryan and di Stefano (1988) for sponges that are a series of nodular aggregates of small irregular chambers. They noted that sections of walls of the type species, *Parauvanella paronai,* appear bright and transparent in transmitted light, in contrast to the dark chamber walls of *Uvanella* Ott, 1967. *Parauvanella paronai* was described by them as an encrusting sponge, with chambers that reach up to 4 mm wide and 2 mm long, with chamber walls 0.1–0.3 mm thick that may have up to four ostia in relatively little space.

The Chinese specimens appear to match well with dimensions and textures of *Parauvanella* and to be similar to the type species, *Parauvanella paronai.* For this reason the sponges are included there. The same sponge was recognized in samples of Permian beds from Djebel Tebaga, Tunisia, where some glomerate clumps may be up to 25 mm across. The present specimens are similar to those collected from Tunisia and Italy.

Material. Figured specimens, JS0068, JS0088, JS0090, and JS105, from Upper Permian Changxing Formation, Jianshuigou, Huaying City, eastern Sichuan.

PARAUVANELLA MINIMA
Senowbari-Daryan, 1990
pl. 5, figs. 1–5, 7

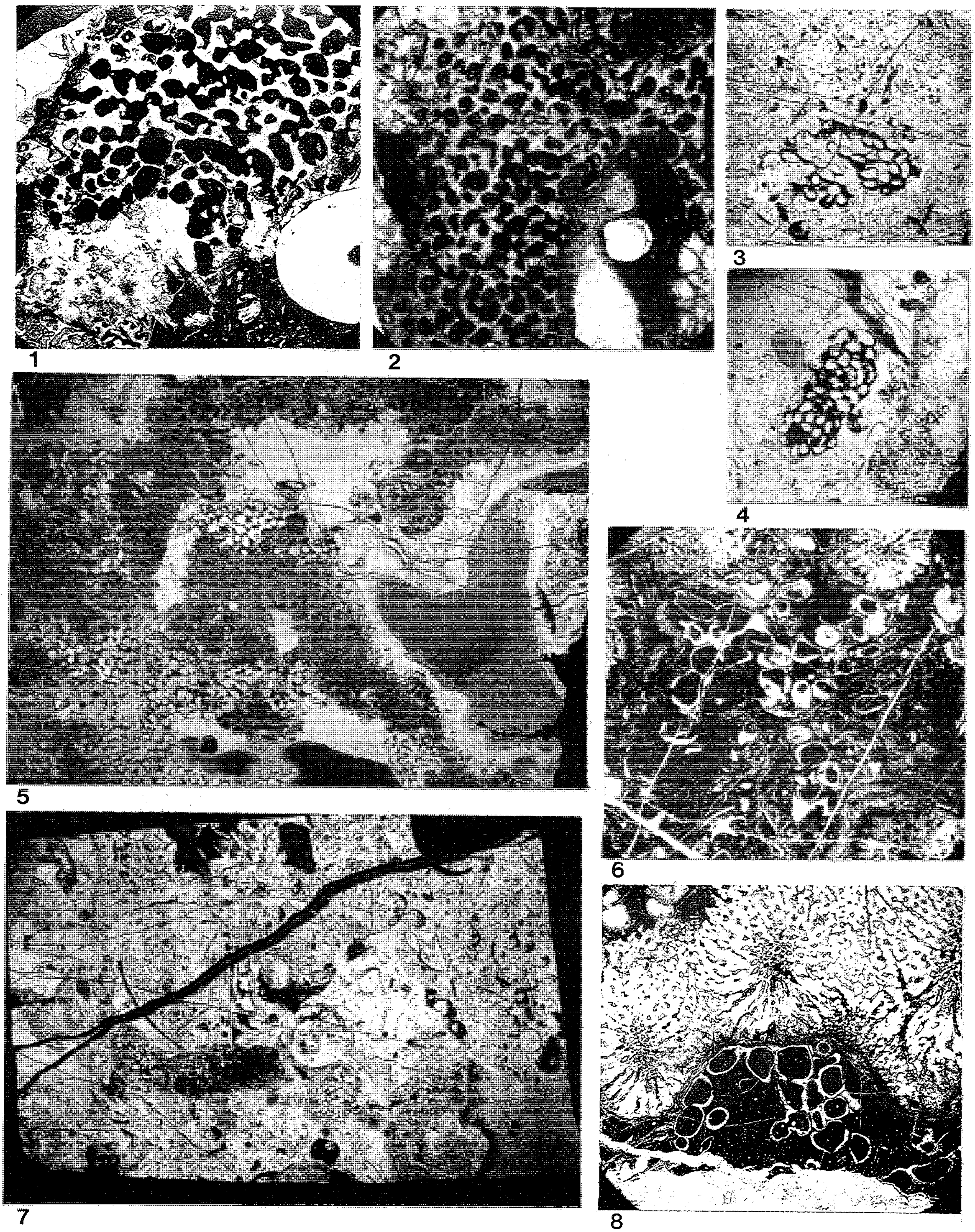
Synonymy. Uvanella sp. Fan and Zhang 1985, p. 21, pl. 8, fig. 10.
Parauvanella sp. Reinhardt, 1988, p. 258, pl. 33, fig. 6, pl. 35, fig. 1 (not pl. 34, fig. 6).
Paruvanella minima Senowbari-Daryan, Flügel and Reinhardt, 1989, p. 511, fig. 10A (nom. nud.); Senowbari-Daryan, 1990, p. 70–71, pl. 22, figs. 1, 2, 6, pl. 57, fig. 3, pl. 58, figs. 5–8, pl. 59, figs. 2, 3.

Original diagnosis. "Aggregate, bestehend aus kleinen und runden Kammern. Uviforme Anordnung der Segmente. Segment wände grob perforiert. Vesiculae kommen vor" (Senowbari-Daryan 1990, p. 70).

Description. Sponges of nodular aggregates of small, irregular subpolygonal, crescentic to globular, or hemispherical interconnected chambers. Clumps 2–4 cm across, of uniform-appearing chambers 0.5–1.2 mm

EXPLANATION OF PLATE 5

Parauvanella and *Subascosymplegma.* Figs. 1–5, 7.—*Parauvanella minima* Senowbari-Daryan, 1990; *1,* photomicrograph showing glomerately clustered small chambers with apparently imperforate walls, but with a few moderately coarse ostia that interconnect chambers; crinoid stem fragment in the lower right, specimen LRI-20, 4045, Upper Permian Changxing Formation, Beipei, Sichuan, X5; *2, 5,* glomerate clusters of characteristic small chambers with essentially imperforate walls, interrupted only by ostia that interconnect the chambers and produce almost spinose appearance to sections; *2,* photomicrograph of lower left part of *5,* X5; *5,* projection print of relatively massive, irregular, glomerate specimen of the species, specimen JS0039, Upper Permian Changxing Formation, Jianshuigou, Sichuan, X2; *3,* projection print of small cluster showing characteristic small chambers in glomerate specimen in wackestone matrix, specimen LRI-20, 4044, Changxing Formation, Beipei, Sichuan, X2; *4,* projection print of cylindrical-appearing specimen, with characteristic small, glomerately arranged chambers with walls perforated by only a few ostia, in general, but some walls appear almost porous, particularly in the upper center; inozoan fragment in the lower-right; in fine, wackestone matrix, specimen 4043, unit 20, Changxing Formation, Beipei, Sichuan, X2; *7,* projection print of wackestone that includes small examples of *Parauvanella minima* n. sp., particularly well shown in the lower part of the thin section as stemlike to irregular glomerate specimens, specimen JS0001, Changxing Formation, Jianshuigou, Sichuan, X2. Figs. 6, 8.—*Parauvanella paronai* Senowbari-Daryan and di Stefano, 1988; *6,* photomicrograph shows irregular chambers in isolated or loosely glomerate arrangement, with a few large ostia, generally 1–2 per chamber; transverse sections of rugose corals show in the upper part, specimen JS0068, Changxing Formation, Jianshuigou, Sichuan, X5; *8,* photomicrograph with cluster of irregular chambers of the species, with characteristic walls and ostia in glomerate arrangement, apparently irregularly overgrown by rugose dendroid coral in the upper part, specimen JS0068, Changxing Formation, Jianshuigou, Sichuan, X5.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across, with most 0.8–1.0 mm across, and generally less high; discontinuous curved central tube or canals may be locally developed and 0.8–1.5 mm in diameter; chambers with imperforate walls, but with common ostia 0.16–0.20 mm across that appear to interconnect chambers and chambers to exterior. Individual chamber walls 0.15–0.30 mm across, but with considerable irregularity, perhaps produced by some walls being cut tangentially or obliquely. Some walls appear ragged or spinose and angular; appear layered with main layer thick and usually bright, to 0.2–0.3 mm thick, inner and outer dark layer 0.10 mm thick or less; locally main layer darker and details obscured by diagenesis. Ostia may occur 3–4 per chamber as seen in thin section, but locally produce an almost beaded-appearing cross section of wall; most walls appear essentially imperforate in sections, but with ostia in both interwalls and exowalls at exterior of cluster. Thin vesiculae may be present but rare.

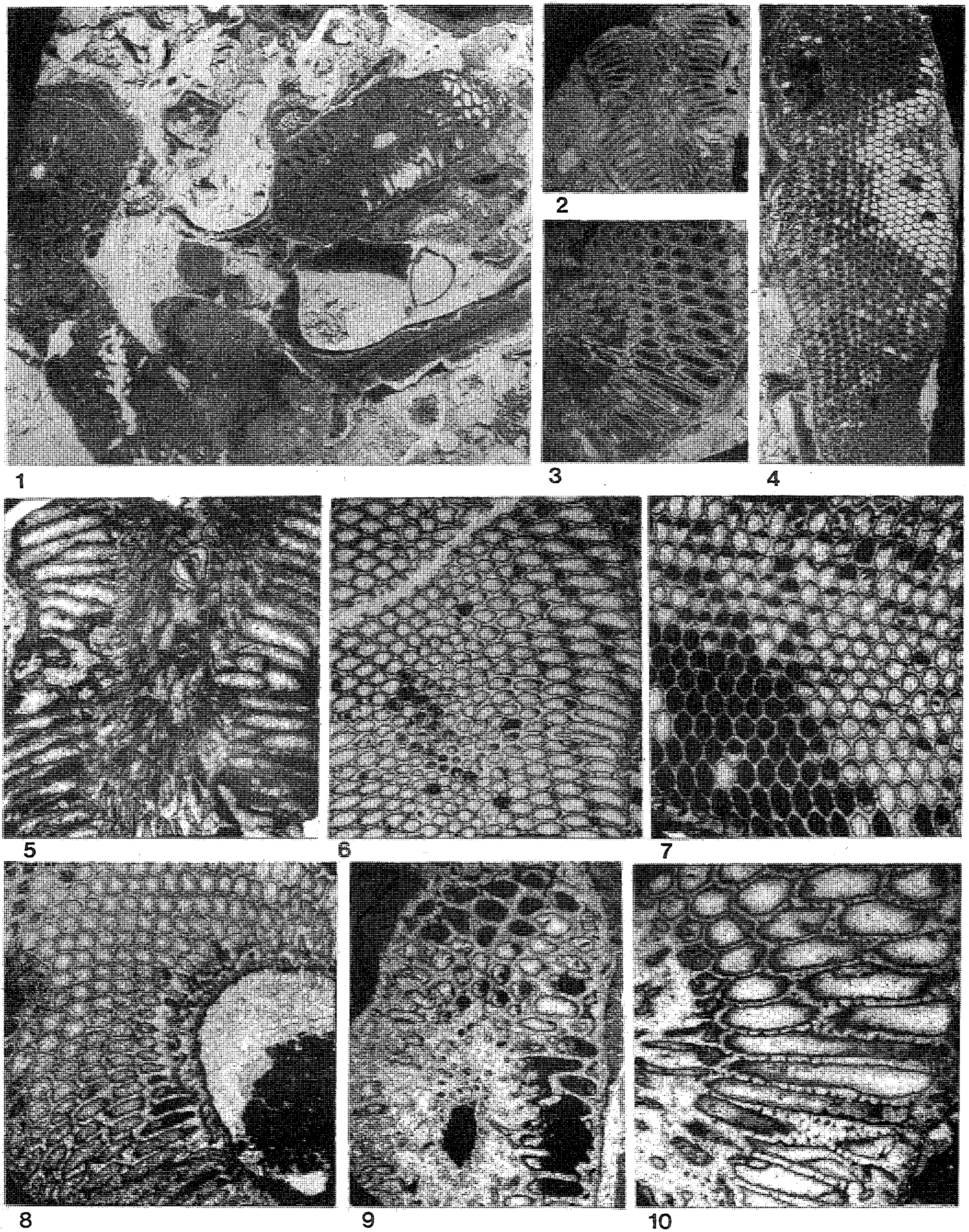
Discussion. The small-chambered species of the genus *Paruvanella* was described by Senowbari-Daryan (1990) from the Upper Capitan Limestone, near White City, New Mexico, in the Guadalupe Mountains. In general, dimensions of the clusters, individual chambers, and ostia in the Chinese specimen are the same as in the type material from the Permian of the Guadalupe Mountains. Senowbari-Daryan (1990, p. 71) noted that the species also occurs in the Upper Permian limestones on the island of Skyros, Greece, and was also described as *Uvanella* sp. by Fan and Zhang (1985, p. 21, pl. 8, fig. 10) from the Late Permian Changxing Formation of Huangnitang, western Hubei, in China. To these can now be added the occurrence in Sichuan.

Material. Figured specimens include 4043, 4044, and 4045, unit 20, from the Upper Permian Changxing Formation, at Beipei, eastern Sichuan, China, and JS0001 and JS0039, from the Changxing Formation at Jianshuigou, Huaying City, eastern Sichuan.

Reference specimens include: JS0002–0004, JS0010, JS0039, JS0040, JS0041, JS0044, JS0073, JS106, all from the Upper Permian Changxing Formation, Jianshuigou, Huaying City, eastern Sichuan.

EXPLANATION OF PLATE 6

Tebagathalamia cylindrica Senowbari-Daryan and Rigby, 1988. Fig. 1.—Projection print showing several crudely longitudinal to oblique and transverse sections, but each with characteristic, curved, honeycomb-like chambers of the walls around a moderately large, thick-walled, central spongocoel; structure perhaps best shown in transverse section in the upper left and in the high oblique section in the upper right, specimen ZYD16, Maokou Formation, Ziyundong, Ziyun County, Guizhou, X2. Fig. 2.—Projection print shows arcuate long chambers of walls connected to upward-curved tubules through the exowall, here cut in subtangential section, specimen H-28, Maokou Formation, Kefeng, Longlin County, northwestern Guangxi, X2. Fig. 3.—Projection print of oblique section through the wall showing the elongate chambers in the lower part, with perforate interwalls, with chambers connected to elongate tubes leading toward the spongocoel in the left center; chamber cross section and somewhat hexagonal packing characteristic of vertical sections through the chambers show in the upper center and upper right; porous exowalls show on the right, specimen KS-37, Maokou Formation, Kefeng, Longlin County, northwestern Guangxi, X2. Fig. 4.—Tangential longitudinal section through the wall showing the more or less hexagonal outlines of the stacked chambers producing a honeycomb-like cross section in projection print, specimen H-41, Maokou Formation, Kefeng, Longlin County, northwestern Guangxi. Fig. 5.—Photomicrograph of the middle part of 2 showing thin, porous chamber walls and upward-curved exhalant tubes, in tangential section, leading toward the spongocoel of the relatively narrow, partially debris-covered opening, in the upper center, X5. Fig. 6.—Photomicrograph showing subtangential section through the wall, with inner parts in the left center, as the narrow exhalant tubes, the small openings in the lower left center, and the more distal part near the exowall, along the right; pores through the interwalls show best in the lower right, specimen B-30, Maokou Formation, Xiangbo, Guangxi, X5. Fig. 7.—Photomicrograph showing hexagonal spacing of honeycomb-like chambers in the outerwall of the sponge, with interpores connecting chambers that are, in part, matrix filled (dark) and, in part, cement filled (light); shows the middle right part of *4*, rotated 90°, X5. Fig. 8.—Oblique view through the chamber wall and through the complex endowall into the large, circular, open spongocoel in the lower right; packing of chambers, as well as the tubular, very porous nature of the endowall, show in the center around the periphery of the spongocoel, specimen KS-87, Maokou Formation, Kefeng, Longlin County, northwestern Guangxi, X5. Fig. 9.—Photomicrograph through medial part of specimen shown in upper right of *1* showing subtangential view of thick endowall with small pores of exhalant tubes and with moderately thick chamber walls of the outer part of the sponge, Maokou Formation, Ziyundong, Ziyun County, Guizhou, X5. Fig. 10.—Photomicrograph showing the perforate nature of the interwalls and chambers in the lower center and upper right and their relationship to narrow exhalant tubes leading through the thick endowall in the left center; the exowall is shown, in part, in the lower right, but the spongocoel does not show in the left center, KS-37, Maokou Formation, Kefeng, Longlin County, northwestern Guangxi, X5.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Family IMBRICATOCOELIIDAE Wu, 1991
Genus IMBRICATOCOELIA Rigby, Fan, and Zhang, 1989a

Diagnosis. "Cylindrical to club-shaped or spheroidal sponges of overlapping scalelike chambers; chamber walls coarsely perforate, of multiple or single layers; lack small micromesh outer layer; central tubes may or may not be present" (Rigby and others 1989a, p. 419).

Discussion. Imbricatocoelia is a cylindrical form that in vertical cross sections appears distinctly similar to vertical sections of the platterlike, tabular sponge *Platythalamiella* Senowbari-Daryan and Rigby, 1988. If only single, vertical sections of the sponges were available, it might be very difficult to differentiate the two genera, but if the three-dimensional structure is known, they become immediately separated. Both are composed or overlapping crescentic chambers, with walls perforated by numerous pores, and in both a central tube, filling structures, and vesiculae are generally lacking. Sections of *Imbricatocoelia elongata* Rigby and others, 1989a, clearly show a cylindrical cross section to the stemlike form, which is composed of numerous, relatively small chambers arranged in several layers in the moderately solid, stemlike structure.

Platythalamiella newelli Senowbari-Daryan and Rigby, 1988, has interwalls that are two-layered, but with exowalls that have only one layer. The type species of that genus has chambers only 1 mm high, at a maximum, in contrast to the distinctly higher chambers in *Imbricatocoelia elongata* and in the only additional specimen available to us from Xiangbo. That thin section also shows several areas of tangential sections of the exowall surface where lateral chamber walls are almost straight. This would suggest a cylindrical form for the Chinese specimen described here.

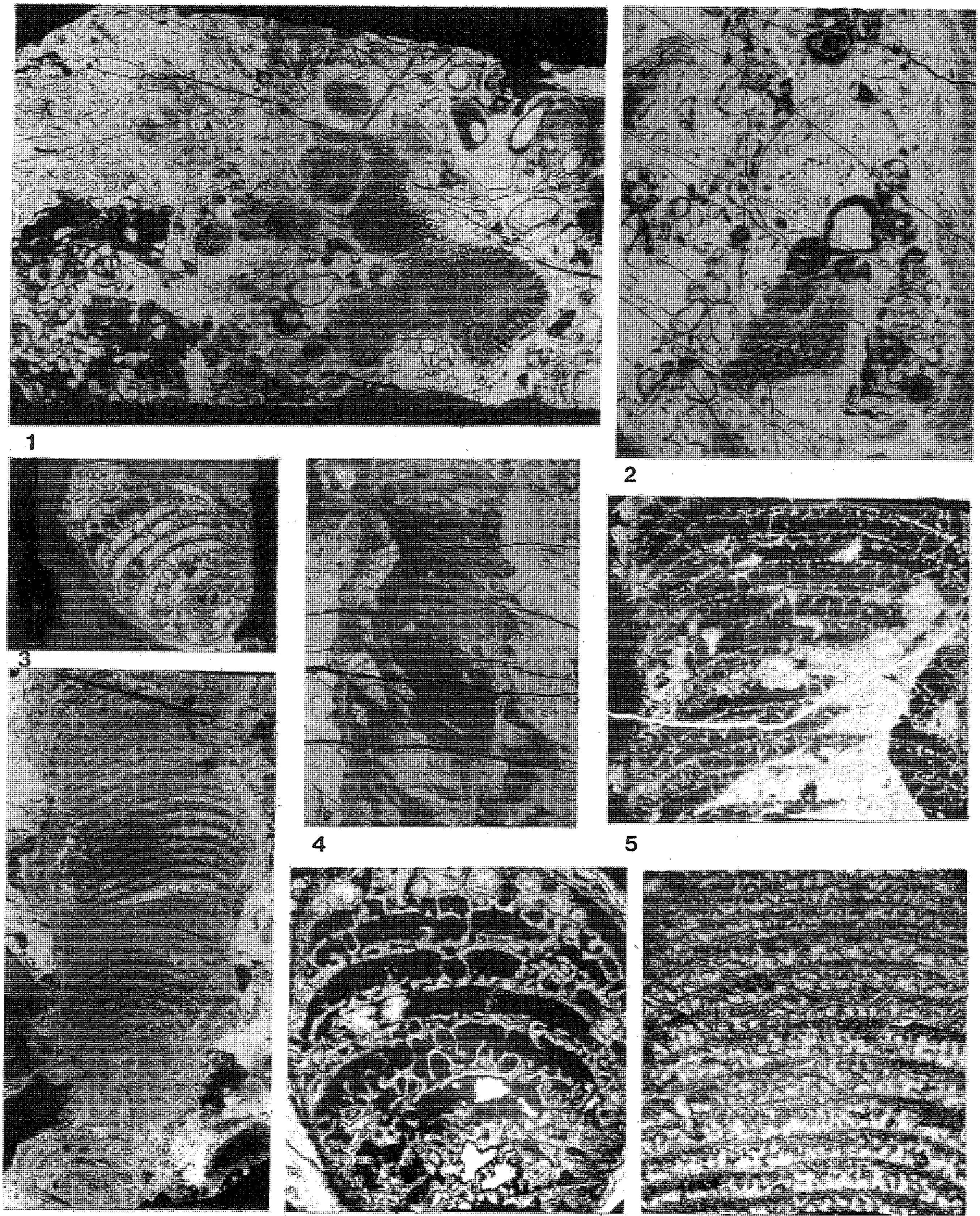
Neoguadalupia elegana Zhang, 1987, is the type species of the tabular *Neoguadalupia,* but could perhaps appear somewhat similar to *Imbricatocoelia,* but in general *Neoguadalupia* is composed of a single layer of globular to subspherical chambers, rather than the several layers of crescentic chambers seen here. The genus *Guadalupia* also may be a platelike form, but it is characterized by a single layer of tubular to crescentic chambers oriented perpendicular to the plates, according to Senowbari-Daryan (1990), and has a well-developed system of astrorhizal canals situated on one side of the plate. This asymmetry also would allow the cylindrical *Imbricatocoelia* to be differentiated from *Guadalupia* in even irregular sections.

Cystospongia Wu, 1991, is considered as a subjective synonym of *Imbricatocoelia.* The type and only described species, *C. guangxiensis* Wu, fits well within *Imbricatocoelia.* Their relationships are discussed below.

Type species. Imbricatocoelia paucipora Rigby, Fan, and Zhang, 1989a.

EXPLANATION OF PLATE 7

Parauvanella and *Preverticillites.* Fig. 1.—Projection print showing intermix of coarsely, irregularly glomerate chambers of *Parauvanella parona* Senowbari-Daryan and di Stefano, 1988, and rugose coral colonies in a micritic wackestone matrix; figure 8 of plate 5 shows in the lower right, below the prominent coral colony; irregular glomerate growth of somewhat thicker chambers shows in the lower left, JS0068, Changxing Formation, Jianshuigou, Sichuan, X2. Fig. 2.—Projection print that includes several isolated and loosely glomerate chambers of *Parauvanella paronai,* particularly well shown in the lower left; isolated chambers occur in the upper left and upper part, as well; associated inozoan sponge appears in the lower center, and algal crusts show in the right, JS0088, Changxing Formation, Jianshuigou, Sichuan, X2. Figs. 3, 7.—*Preverticillites* sp., specimen 5127, unit 34, Maokou Formation, Xiangbo, Guangxi; *3,* projection print of relatively coarse skeleton showing chambered nature and reticular-trabecular filling structures, with chamber walls porous and composed of netlike reticular fillings, X2; *7,* photomicrograph, X5. Figs. 4–6, 8.—*Preverticillites columnella* Parona, 1933; *4, 5,* specimen 5128, unit 54, Changxing Formation, Xiangbo, Guangxi; *4,* projection print of vertical section, possibly tangential through the wall, showing broad, shieldlike chambers and distinctive reticular-trabecular filling structures with prominent pillars, particularly prominent in the upper part, X2; *5,* photomicrograph of upper part of the sponge, orientation reversed from *4,* showing characteristic low chambers, complex reticulate netlike walls between chambers, and prominent pillars, particularly in the upper part, X5; *6, 8,* specimen 5129, Maokou Formation, Xiangbo, Guangxi; *6,* vertical section of characteristic specimen showing complex reticular filling structures, in vertical tangential(?) section through the wall, in the outerpart shows complex reticulate skeletal structure and only a few pillars tangential to the exterior; the lower part shows exopores in the outerwall, shown in more detail in plate 14, figure 1; reticular filling structure in the upper part is also shown in more detail in photomicrograph in plate 14, figure 3, X1.25; *8,* photomicrograph of the upper right center of *6* showing reticulate netlike walls and complex filling structures within the chambers, characteristic of the species, X5.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IMBRICATOCOELIA ELONGATA Rigby, Fan, and Zhang, 1989a
pl. 4, figs. 3, 6, 7

Synonymy. Imbricatocoelia elongata Rigby, Fan, and Zhang, 1989a, p. 420, figs. 15.7, 15.8, 16.4, 16.5.
Cystospongia quangxiensis Wu, 1991, p. 84, pl. 10, figs. 4, 7, 8.

Diagnosis. "Elongate, cylindrical, twiglike *Imbricatocoelia* lacking central tube; chambers overlapping, but low wide crescentic, 2–7 mm across, 0.06–1.5 mm high; interpores coarse, 0.2 mm across, expand to pits top and bottom of interwall" (Rigby and others 1989a, p. 420).

Description. Sponge elongate cylindrical, lacks central tube, composed of numerous, overlapping, low upward crescentic to elliptical chambers of varying widths; sponge relatively narrow and stemlike, about 8.0–8.5 mm in diameter; chambers generally 1.0–1.5 mm but range 0.8–2.0 mm high, and range 2–6 mm wide in thin section. Chamber walls may flex sharply to form elliptical chambers or arch gently to form crescentic ones; exterior knobby or lumpy, marked by inflated curved walls of individual chambers.

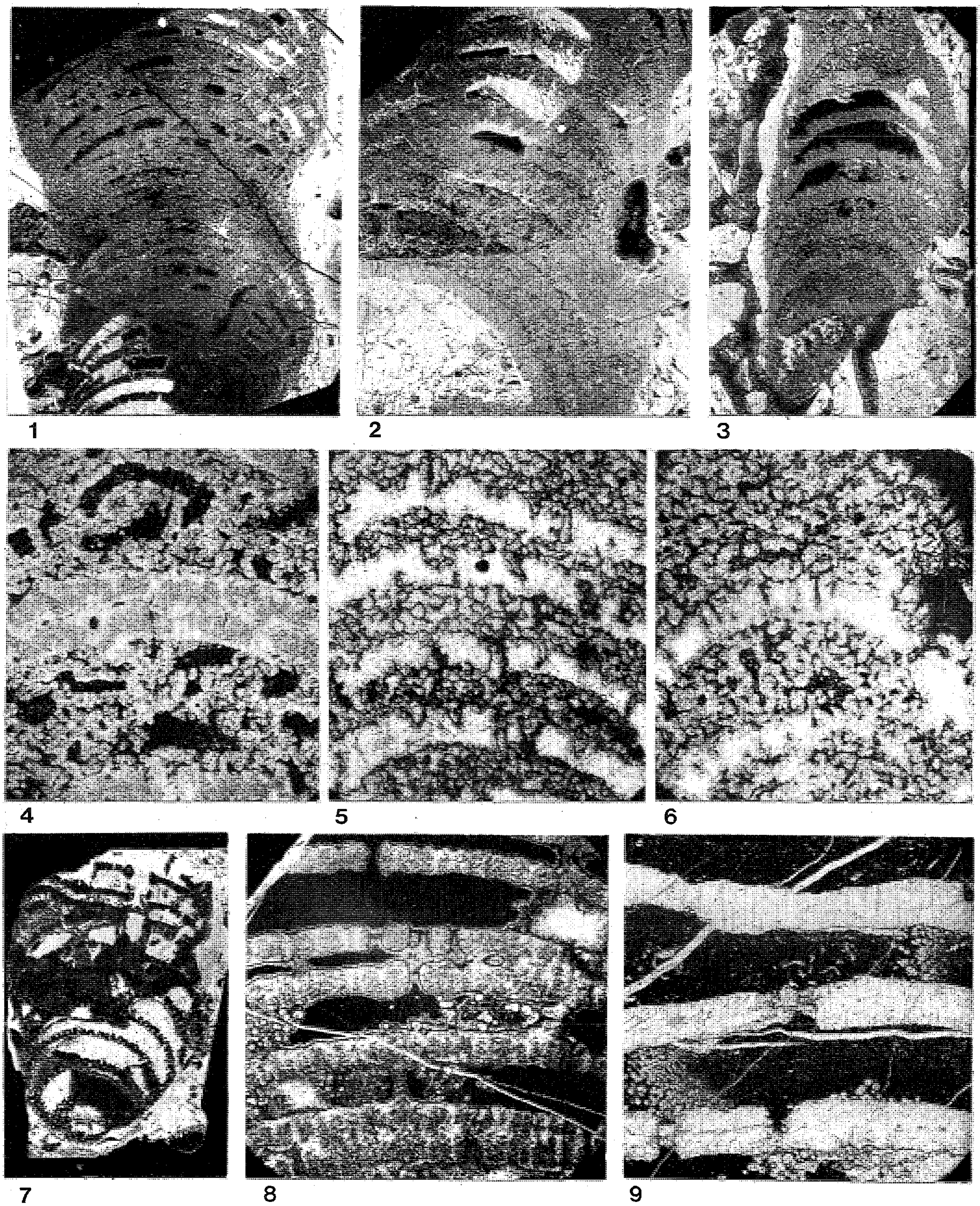
Interwalls range 0.3–0.5 mm thick, perforated by numerous, round coarse interpores that range 0.10–0.22 mm in diameter, with most approximately 0.2 mm across; pores expand slightly upward into shallow pits to produce skeletal elements with rounded elliptical cross sections between pores separated 0.3–0.5 mm, so 2–3 occur per millimeter; exopores of same general size and spacing.

Discussion. Imbricatocoelia elongata Rigby, Fan, and Zhang, 1989a, is characterized by its long, narrow growth form, the crescentic chambers with relatively coarse pores through the interwalls, and the lack of a central tube. This combination of characteristics occur in the present specimens, so we have placed them in *Imbricatocoelia elongata.*

Imbricatocoelia paucipora Rigby, Fan, and Zhang, 1989a, the type species of the genus, has a distinct central tube and contrasts in that major character with *Imbricatocoelia elongata* Rigby, Fan, and Zhang, 1989a, and the present material. *Imbricatocoelia irregulara* Rigby, Fan, and Zhang, 1989a, has prominent excurrent canals that may be

EXPLANATION OF PLATE 8

Intrasporeocoelia hubeiensis Fan and Zhang, 1985. Fig. 1.—Projection print shows general subcylindrical form of the species, with broad, relatively flat, overlapping chambers, and longitudinal exhalant tube in the lower right; chambers partially matrix and cement filled, with most showing isolated sporelike filling structures characteristic of the species and genus; skeleton recrystallized, but porous interwalls show particularly well in the upper right, specimen ZS-5 (10), Changxing Formation, Ziyun County, Guizhou, X1.25. Fig. 2.—Projection print of large specimen with thick interwalls and moderately high chambers, porous interwalls show well on the left and in the upper center; chamber and interwall boundaries vague because of complex filling of chambers by masses of sporelike filling structures, specimen ZYD (15), Maokou Formation, Ziyundong, Ziyun County, Guizhou, X1.25. Fig. 3.—Projection print of distinctly more cylindrical form with moderately high chambers; cement filled in the central part, but with prominent, massive fillings of sporelike filling structures in lower and upper few chambers, specimen ZYD (04), Maokou Formation, Ziyundong, Ziyun County, Guizhou, X1.25. Fig. 4.—Photomicrograph showing thick, recrystallized chamber walls in the center, but with sporelike filling structures occupying most of the chamber space above and below, with some open canals between filling structure now filled with dark matrix, specimen ZS-9, Changxing Formation, Ziyun County, Guizhou, X5. Fig. 5.—Photomicrograph of specimen with moderately low chambers and porous, moderately thin interwalls; chambers with abundant sporelike filling structures as isolated subspherical masses or glomerate stalagmite elements; most sporelike structures with dark outlines; some openings filled with dark matrix, specimen H-3, Maokou Formation, Houchang, Ziyun County, Guizhou, X5. Fig. 6.—Photomicrograph of specimen with abundant stalagmite-like sporelike filling structures in high chambers separated by moderately thin porous walls, interpores are connected to the thin, meandering canals between the sporelike filling structures, specimen STZ-A6-3, Shitouzai Member, Changxing Formation, Ziyun County, Guizhou, X5. Fig. 7.—Projection print of sponge with moderately high, mainly matrix-filled chambers defined by coarsely perforate interwalls; exhalant opening well preserved in upper part; sporelike filling structures extensive in the chamber to the upper right, but limited elsewhere, ZS-5 (03), Changxing Formation, Ziyun County, Guizhou, X1.25. Fig. 8.—Photomicrograph of the upper part of *1* showing relatively low chambers and thick perforated interwalls, with clusters of sporelike filling structures in some of the chambers, but most with dark matrix fill; unusual, pillarlike structures in lower center bridge interwalls, ZS-5 (10), Changxing Formation, Ziyun County, Guizhou, X5. Fig. 9.—Photomicrograph showing limited sporelike filling development in otherwise matrix-filled chambers; walls recrystallized so interpores moderately obscure, except for large openings, ZS-6 (1), Changxing Formation, Ziyun County, Guizhou, X5.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discontinuous, but do occur in the irregular sponge as asymmetric to the central tube. Multiple excurrent tubes are present in *Imbricatocoelia obconica* Rigby, Fan, and Zhang, 1989a, which is also a relatively upward-expanding form, in contrast to the more or less cylindrical-appearing *Imbricatocoelia elongata.*

Wu (1991, p. 84) described *Cystospongia guangxiensis* as the type species of the new genus. The growth form, chamber structure and dimensions, and pore dimensions fall within the range of *Imbricatocoelia elongata.* Wu's material apparently came from the same locality and stratigraphic unit as types of *I. elongata. C. guangxiensis* is considered as a junior synonym of *I. elongata.*

Material. Specimen 5058, unit 53, from the Upper Permian Changxing Formation, Xiangbo, Longlin County, northwestern Guangxi.

Family TEBAGATHALAMIIDAE Senowbari-Daryan and Rigby, 1988

Genus TEBAGATHALAMIA Senowbari-Daryan and Rigby, 1988

Diagnosis. "Porate and cylindrical stems with glomerate arrangements of the chambers, which are packed in only one layer around the spongocoel or central tube. The small chambers have polygonal cross sections, in longitudinal sections of the sponge, and are radially elongate and tubelike. Segmentation is ill defined to unrecognizable on the exterior. A very thick, porous, skeletal layer occurs around the spongocoel. Each chamber is connected to that exhalant opening with a separate tubular pore or opening, although these openings from the chambers may unite to form common tubes that empty into the spongocoel" (Senowbari-Daryan and Rigby 1988, p. 192).

Type species. Tebagathalamia cylindrica Senowbari-Daryan and Rigby, 1988.

TEBAGATHALAMIA CYLINDRICA
Senowbari-Daryan and Rigby, 1988
pl. 4, fig. 5; pl. 6, figs. 1–10

Synonymy. Paronaespongia adrianensis (Parona) Termier and Termier, 1977a, p. 29, pl. 5, fig. 7.
Paronaespongia sp. Termier and Termier, 1977b, pl. 9, fig. 5.
Guadalupia sp. Deng, 1982, p. 250, pl. 2, fig. 7.
Tebagathalamia cylindrica Senowbari-Daryan and Rigby, 1988, p. 193, pl. 34, figs. 1–9, text fig. 11.
Tebagathalamia lamella Wu, 1991, p. 89–90, pl. 11, figs. 3, 6.

Diagnosis. "Cylindrical stems with glomerated and finely perforate chambers. Chambers subhorizontal and radially, one layer deep, arranged around thick-walled central tube. Each chamber is connected by a separate tube to the spongocoel. Tubes from (adjacent) chambers may unite to form a single larger opening that opens into spongocoel. The chambers are elongate tubelike. Chambers lack vesicular or other filling structures" (Senowbari-Daryan and Rigby 1988, p. 193).

Description. Steeply conico-cylindrical sponges range in diameters to nearly 30 mm (KS-37), although some only 10 mm (ZYD) across. Outer segmentation poorly developed. Chambers numerous, small, tubelike subhorizontal, straight to low upward arcuate, and radially arranged in single honeycomb-like layer around central tube; tubular chambers range 3–10 mm long, and range curved hexagonal to spatulate in cross section, most evident in longitudinal and tangential sections of sponges. Chambers range 0.4–1.0 mm high and 0.6–1.4 mm wide, generally broader than high.

Interwalls thin, 0.12–0.14 mm thick in small specimens but thicken upward in single specimens; may be 0.3–0.4 mm thick in longest ones. Interpores connect neighboring chambers and 0.08–0.10 mm in diameter in smallest specimens, but to 0.14 mm in diameter in larger specimens.

Several exopores in each thickened outer wall, pores 0.20–0.28 mm in diameter. Endowall, or wall around central tube or spongocoel, complex and thick, composed of upflexed tubes of excurrent pores, one tube per chamber, chambers narrow on inner ends to almost one-half chamber height, lead to thin-walled tube that bends up sharply, through 70°–90°, tubes traceable for 4–5 mm to exit at spongocoel margin. Pores and tubes generally approximately 0.25–0.30 mm in diameter with thin dark walls 0.2–0.4 mm thick. Tubes may merge upward and expand to 0.3–0.4 mm in diameter before entering spongocoel. Spongocoels range 1.5–2.0 mm in diameter in small specimen only 10–12 mm in diameter, to openings 7.5 mm in diameter in sponge 20–30 mm across. Thin wall, approximately 0.7–0.9 mm thick, developed around central tube in larger specimen where upflexed excurrent tubes crowded together and shorter. Wall 1.5–2.0 mm thick in smaller and middle-sized specimens.

Discussion. The Chinese material has chambers of about the same dimensions and shapes as the type species from Tunisia, but the excurrent tubes in the type material were interpreted by Senowbari-Daryan and Rigby as horizontal and straight. Their material includes complete specimens and a few diagonal sections. We would interpret the excurrent tubes of the Tunisian material as bent upward too. Except for the variation in interpretation, measurements of chambers, interwalls, tubes, and pores are like those of *Tebagathalamia cylindrica* Senowbari-Daryan and Rigby, 1988, so we include the present specimens studied in that species. Comparisons to other forms were discussed by them, but table 2 compares the named species of the genus from Tunisia and China.

Wu (1991, p. 89) concluded that the tiny sponge *Graminospongia girtyi* (Parona), as described by Senowbari-Daryan and Rigby (1988, pl. 35, figs. 1–10, and pl. 34, figs. 12, 13) should be included in the large *Tebagathalamia*. *Graminospongia* has a thin endowall and an exhalant canal pattern markedly different than the complex thick endowall structure in *Tebagathalamia*, and it has a dense exowall with marked pustules, a structure not developed in the porous outer walls of chambers in *Tebagathalamia*. *Graminospongia* is not a *Tebagathalamia*.

Wu (1991, p. 89–91) proposed two new species of *Tebagathalamia* from the Middle Permian of Xiangbo, Guangxi. *T. lamella* Wu falls within the general range of sizes of features reported by Senowbari-Daryan and Rigby (1988, p. 193) for the type species *T. cylindrata* and is considered a junior synonym of that species. The lamellar encrustation noted by Wu is probably a foreign organism. *T. diagonalis* has a more delicate structure and is considered as a distinct species. The lack of pores, however, suggests that it has lost much structural detail by secondary processes. Some pores are suggested in walls of the specimen shown in pl. 12, figs. 1 and 2 (Wu 1991), but it is impossible to be certain without examining the thin sections. The reported granular secondary deposits around the exterior likely have no taxonomic significance.

Material. Specimen B30, from Xiangbo, and specimens KS-37, and KS-87, H28, and H41 are from the Middle Permian Maokou Formation, from Kefeng, Longlin County, northwestern Guangxi. Specimen ZYD(6) is from the Middle Permian Maokou Formation, and ZS-5 (08) is from the Shitouzai Member of the Upper Permian Changxing Formation, both from Ziyun County, southern Guizhou.

Reference specimens include STZ-22-2, from the Upper Permian Changxing Formation at Shitouzai, Ziyun County, southern Guizhou.

Family SOLENOLMIIDAE Engeser, 1986
Subfamily SOLENOLMIINAE
Senowbari-Daryan, 1990
Genus PREVERTICILLITES Parona, 1933

Original diagnosis. "Zylindrische, äusserliche kaum segmenterte Stämmchen mit niedringen Segmenten. Zentralrohr pseudosiphonate. Füllskelett reticulär-trabeculär. Segmentdecken sehr dünn und als Punktreihen erscheinens" (Senowbari-Daryan 1990, p. 96).

(Cylindrical, outer surface of stems obscure with segmentation. Central tube pseudosiphonate. Filling structure reticular-trabecular [pillarlike]. Chamber interwalls very thin and appear as points in a line.)

Type species. Preverticillites columnella Parona, 1933.

PREVERTICILLITES COLUMNELLA
Parona, 1933
pl. 7, figs 4–6, 8; pl. 14, figs, 1, 3

Synonomy. Preverticillites columnella Parona, 1933, p. 46, pl. 9, figs. 1–4; Senowbari-Daryan and Rigby, 1988, p. 195, pl. 36, figs. 1, 2, 4, 5, 7; Senowbari-Daryan, 1990, p. 97, pl. 31, figs. 4–6.
Verticillites columnella Seilacher, 1962, pl. 2, fig. 2; Aleotti, Dieci, and Russo, 1986, p. 20, pl. 7, fig. 1–4; [non *Preverticillites columnella* Termier and Termier, 1977a, p. 44, pl. 11, fig. 3; Termier and Termier, 1977b, fig. 13, pl. 10, fig. 1(?)].

Emended diagnosis. Sponge cylindrical to 85 mm high and 50 mm in diameter, with low chambers 1–2 mm high; chambers crescent-shaped and filled with reticular-

Table 2.—Comparisons of dimensions of features in named species of Tebathalamia *from Tunisia and China. Measurements are in millimeters.*

Species	Sponge Diameter	Spongocoel Diameter	Chamber Dimensions	Interpore Diameter	Exopore Diameter	Endopore Diameter	Interwall Thickness
T. cylindrata (Tunisia)	8–12	2.0	~ 1 high, broader	0.07	0.07	0.3	~ 0.1
T. cylindrata (China)	10–30	1.5–2.0 to 7.5 largest	0.4–1.0 high 0.6–1.4 wide	0.08–0.10 smallest to 0.14 in largest	0.20–0.28	0.25–0.30	0.12–0.14 (most) but to 0.4
T. lamella Wu, 1991	10–12	1.5	0.5–1.0 high	0.05–0.07	—	0.15–0.37	—
T. diagonalis Wu, 1991	to 22	5.5	0.75 high	reported to be imperforate	—	0.25–0.50	0.05

trabecular filling structure. Interwalls of chambers thin and netlike, with numerous interpores to 0.15 mm in diameter, all forming complicated, intricate screenlike layer. Chambers with reticular trabecular filling structure, with prominent pillars in most chambers and more complex reticulate structure in upper part of each chamber. Vesiculae do not occur.

Description. Sponge body steeply obconical to cylindrical club-shaped, composed of low chambers. Chambers crescent-shaped, overlapping and only 1.0–1.4 mm high. Interwalls of chambers thin, 0.1–0.3 mm thick, dense, and irregularly perforated, with interpores 0.08–0.15 mm in diameter separated by netlike elements that range 0.08–0.14 mm, but commonly 0.10 mm across, forming complicated and intricate reticulate to screenlike layer.

Chambers filled with reticular-trabecular filling structures. Pillars and reticulate segments range 0.04–0.12 mm in diameter, with most 0.08 mm in diameter. Segments commonly only 0.3–0.4 mm long, essentially one-half chamber high, usually with Y-shaped junctions, but irregular; forming triangular to polygonal openings in net 0.2–0.4 mm across within chambers. Vesiculae do not occur.

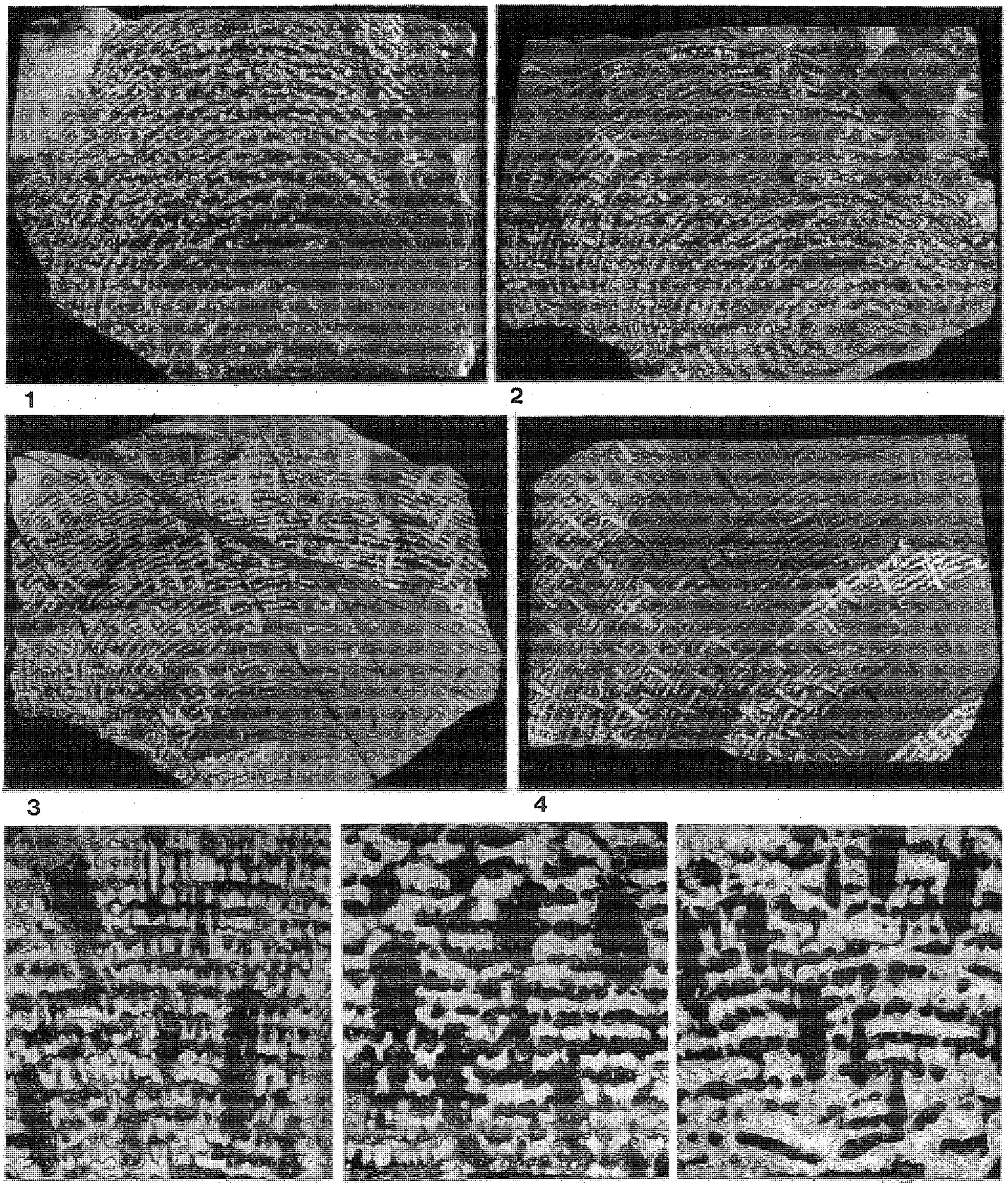
Exowalls vary in thickness because of merging of sloping outer interwalls, may range 0.3–1.0 mm thick as regular screenlike net, with exopores 0.08–0.40 mm across, but most 0.10 mm in diameter, separated by net segments with circular sections 0.04–0.12 across; exowall net may range 1–5 segments thick, but usually only 1–2 thick.

Discussion. The specimens in our sections are similar to *Preverticillites columnella* Parona, 1933, described from the Permian of Sicily, and specimens of the same species described by Senowbari-Daryan and Rigby (1988, p. 195) from Tunisia. All of them show a reticulate skeletal filling structure in low chambers that are only 1–2 mm high, and in complete specimens, chambers extend around the retrosiphonate central tube. That central tube is not cut in our probably tangential sections in the Chinese material. The structure of the skeleton and the dimensions of the pores are well shown in the moderately well preserved material collected at Xiangbo from both the Maokou and Changxing Formations.

Reitner and Engesser (1985) concluded that *Verticillites* has a pillarlike filling tissue and an irregularly aragonite crystal microstructure, whereas *Preverticillites* has a reticulate, pillarlike structure and a sphaerolitic microstructure, supporting the early separation of the genera as proposed by Parona (1933). Our specimens show a decidedly more reticulate structure than pillarlike trabecular structure

EXPLANATION OF PLATE 9

Rhabdactinia columnaria Yabe and Sugiyama, 1934, all from the Shitouzai Member of the Changxing Formation from Ziyun County, Guizhou. Figs. 1–4, projection prints, X1.25; figs. 5–7, photomicrographs, X5. Fig. 1.—Essentially horizontal section through the skeleton with interwalls shown almost tangentially in the lower center, where interpores and circular longitudinal exhalant openings are clearly defined; tones are reversed in projection prints so recrystallized calcite skeletons appear dark, and the dark matrix appears light; moderately uniform spacing of the coarse exhalant openings shows throughout the section, specimen Z-1 (6). Fig. 2.—Horizontal or transverse section in which porous interwalls show particularly well in the lower right; radial arrangement of coarser exhalant openings is prominent in the upper and left parts of the section, which also shows the spinose or columnlike ragged nature of the interwalls, particularly prominent in the upper center, specimen Z-1 (5). Fig. 3.—Vertical oblique section showing porous, ragged, spinose-appearing interwalls, particularly prominent in the upper chambers, the relatively low chambers, and the abundant, moderately uniformly placed, coarse exhalant canals, which interrupt the skeleton; these canals generally increase in diameter, radially. They are small where they begin, but increase in size to become essentially subcylindrical in the middle and outer parts of the sponge skeleton, specimen Z-1 (3). Fig. 4.—Radial oblique section nearly parallel to some of the subcylindrical, radial exhalant openings, shows the low chambers, characteristic of the species, and the moderately ragged interwalls, moderately well preserved in the left, but coarsely replaced in the upper and lower right, specimen Z-1 (2). Fig. 5.—Radial oblique sections showing relatively massive, horizontal, coarsely perforate and spinose walls as light recrystallized calcite, separated by dark matrix that fills chambers, interpores, and the coarser longitudinal or exhalant openings; regular spacing of interpores and intervening spines produce almost reticulate appearance, and is more regular here than normal, specimen Z-1 (9), X5. Fig. 6.—Oblique section showing moderately thick irregular spinose chamber walls separated by dark gray matrix that fills the chambers and the coarser exhalant tubes, which here are characteristically unwalled, as is typical of the species; the range in diameters of these longitudinal radial openings is also shown by variations in interruptions of the wall structure, specimen Z-1 (4), X5. Fig. 7.—Oblique radial section showing dark matrix-filled canals and chambers defined by replaced calcareous walls and by interruptions in those walls; ragged spinose sculpture of the interwalls shows in characteristic fashion in the central part, where some spines also merge to form pillars within the chambers; section is of the lower left center of *3*, specimen Z-1 (3), X5.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and would have been fairly easily put into the genus *Preverticillites* on that basis alone.

Material. Figured specimens; 5129 from the Middle Permian Maokou Formation, at the secondary stratigraphic section, Xiangbo, and specimen 5128, unit 54, from the Upper Permian Changxing Formation, Xiangbo, Longlin County, northwestern Guangxi.

PREVERTICILLITES sp. A
pl. 7, figs. 3, 7

Description. Single specimen of moderately coarse *Preverticillites* occurs in collection. Orientation of section somewhat questionable, but appears oblique and in part tangential. Sponge appears steeply conico-cylindrical, and at least 21 mm high, with width of at least 12–13 mm, composed of prominent, coarse, upward-arcuate, and shield-shaped chambers, 1.0–1.5 mm high in center, but become lower in zone of prominent downcurving along margin.

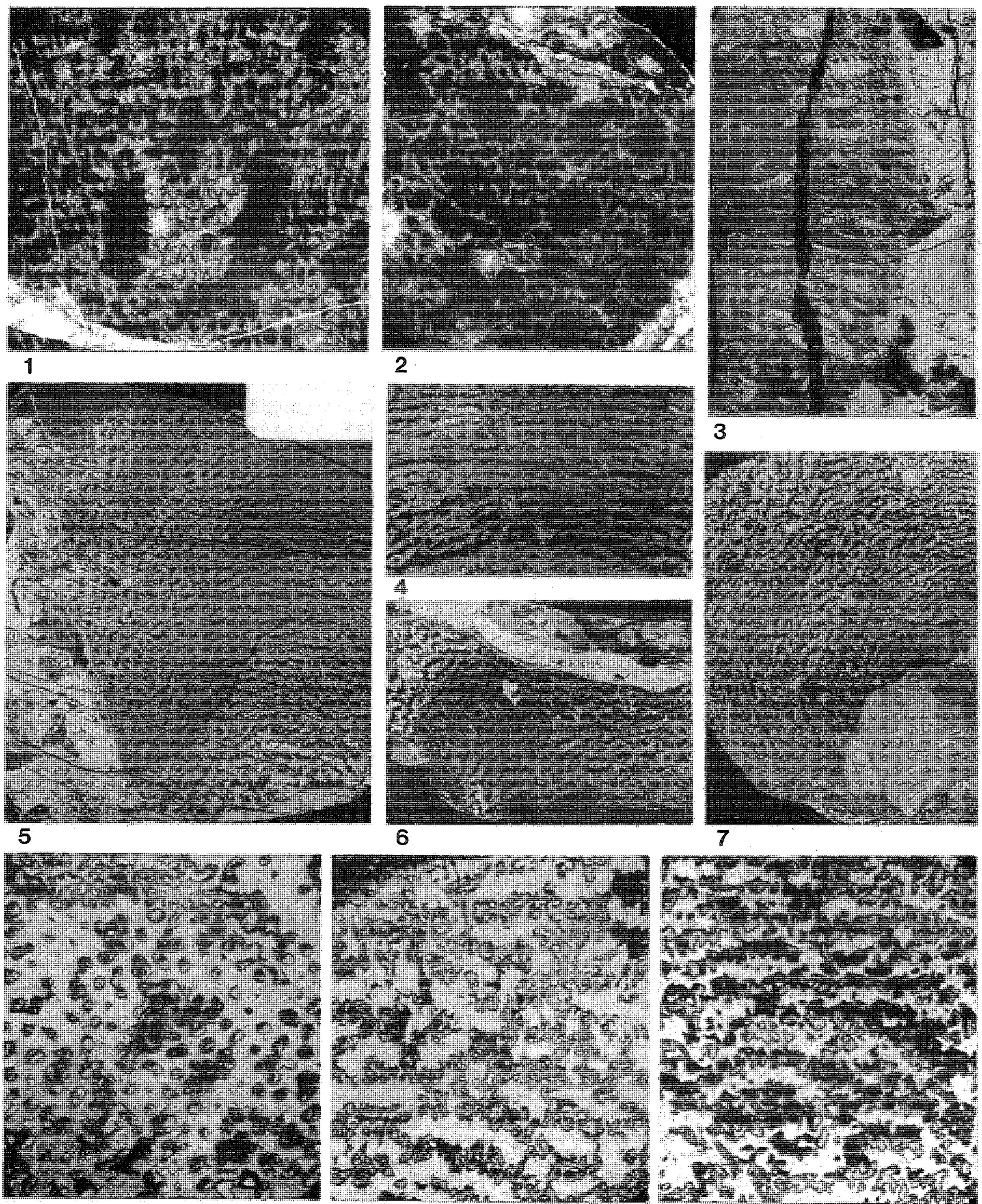
Chambers separated by prominent inner walls that combine with reticular filling structures to produce double-layered wall at base of each of chamber. Interwalls prominently porous and 0.10–0.30 mm thick, overlain by prominent, regular, rectangular reticulate net that fills lower 0.3–0.5 mm of each chamber, to produce near double-wall appearance. Pores between porous layers range 0.10–0.30 mm in diameter and cross-connect fairly straight tubelike openings to produce rectangular reticulation. Reticular segments tend to be somewhat uneven, swelling to spherical intersections but thinning in areas between; where 0.08–0.12 mm wide, or in diameter, with most approximately 0.10 mm across, so of essentially same dimensions as interwall segments below.

Interpores lead through both interwalls and reticular filling structure or interwalls into pores of reticulate filling structure. Interpores range 0.08–0.20 mm in diameter, with most approximately 0.10–0.12 mm in diameter, and combine to produce rather robust porous wall and net. Trabeculae extend upward from reticular net essentially same dimensions as segments in reticulation below to slightly thinner; appear as essentially vertical, reedlike rods that extend across much of chamber; may expand slightly in upper part, where merge with interwalls that separate next chamber.

Exowalls irregular and range 0.5–0.8 mm thick, combine to produce relatively smooth exterior, because of

EXPLANATION OF PLATE 10

Rhabdactinia regulara n. sp., *Rhabdactinia complexa* n. sp., and *Intrasporeocoelia hubeiensis* Fan and Zhang, 1985. Figs. 1–3.—*Rhabdactinia regulara* n. sp., sections of holotype STZ21-1, Shitouzai Member, Changxing Formation, Ziyun County, Guizhou; *1,* photomicrograph of oblique radial section showing relatively delicate, netlike, spinose, porous interwalls and low chambers interrupted by moderately coarse and common longitudinal exhalant tubes; figure is from upper central part of figure 3, section A, X5; *2,* photomicrograph of transverse section showing reticulate, netlike nature of the very porous interwalls and circular interruptions of the interwalls by the coarse, radial, longitudinal, exhalant openings, section C, X5; *3,* projection print showing the relatively regularly spinose, but reticulate, netlike nature of the interwalls interrupted by coarse, matrix-filled exhalant tubes; top of the sponge is toward the right, section A, X1.25. Figs. 5–7, 9, 10.—*Rhabdactinia complexa* n. sp.; figs. 4–7, projection prints, X1.25; figs. 8–10, photomicrographs, X5; *5,* paratype shows relatively massive structure of the skeleton with thick, irregular interwalls separating ill-defined chambers, which may be relatively narrow or broad and interrupted by pillarlike structures that bridge between interwalls, as in the upper center; preservation best in the lower right where coarse matrix-filled pores show in the interwalls, specimen KS-100, Maokou Formation, Kefeng, Guangxi; *4,* paratype shows irregular nature of the chambers defined by cement fill, which here appears dark; minor coarse pillarlike structures characteristic of the species show in the left center as extensions of the interwalls, specimen 5158, unit 69, Changxing Formation, Xiangbo, Guangxi; *6,* paratype, small specimen showing characteristic irregular interwalls and chamber development with limited radial excurrent openings in the upper left, specimen 5168, unit 37, Maokou Formation, Xiangbo, Guangxi; *7,* holotype showing massive hemispherical growth form and irregular chamber and interwall structure, with chambers cement filled and here shown as dark gray, sponge apparently overgrown, well-preserved specimen of *Precorynella* sp. in the lower right; specimen 5159, Maokou Formation, Kefeng, Guangxi; *9, 10,* oblique radial sections showing the irregular discontinuous chamber walls and chambers that characterize the form; some walls interrupted by coarse matrix-filled interpores; *9,* paratype, specimen 5168, unit 37, Maokou Formation, Xiangbo, Guangxi; *10,* holotype, section is part of the lower center of figure 7, specimen 5159, Maokou Formation, Kefeng, Guangxi, X5. Fig. 8.—*Intrasporeocoelia hubeiensis* Fan and Zhang, 1985, tangential section showing relatively uniform, continuous massive interwalls interrupted only by circular, coarse interpores; wall grades up to sporelike filling structures of the chambers, seen in tangential view in the uppermost part, specimen 5193, unit 35, Middle Permian Maokou Formation, Xiangbo, X5.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crescent shape of chamber and downward overlap of walls; exowalls pierced by pores 0.08–0.20 mm in diameter, with most 0.12–0.15 mm across, with circular cross sections, and may be straight and arranged essentially at right angles to exowalls and adjacent parts of interwalls, or may slope slightly downward and curve somewhat into adjacent chambers. Pores may be separated only 0.15 mm apart or may be as much as 0.4 mm apart and with essentially same range of occurrences seen in interwalls and interpores.

Vesiculae and central tube not evident although lack may be related to somewhat tangential or oblique section available.

Microstructure clearly sphaerolitic, with sphaerolites 0.05–0.06 mm in diameter, and clearly defined in what appears to be part of exowall. In vertical sections of interwalls and filling structures, sphaerolites appear to be 0.08 mm in diameter and occur side-by-side.

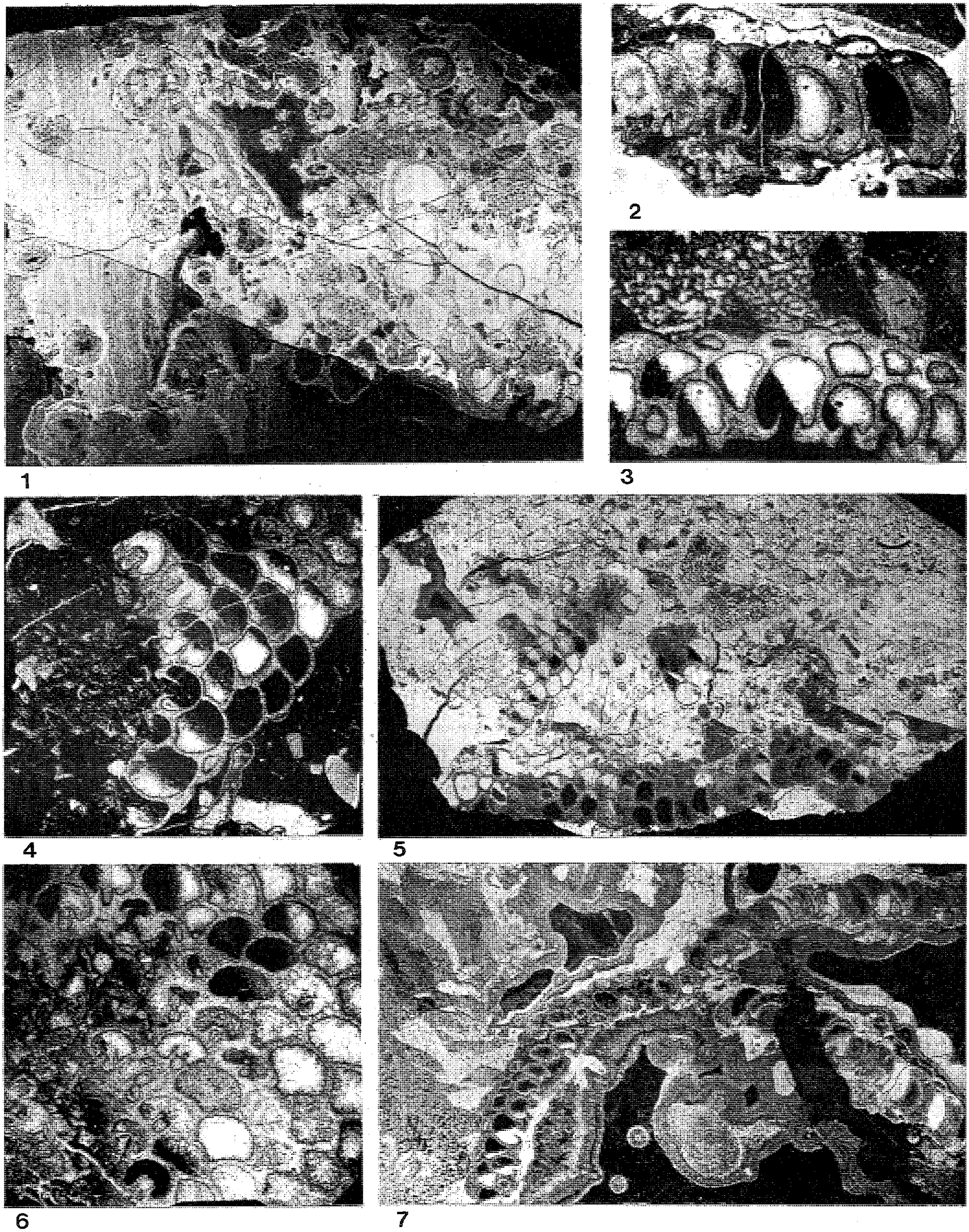
Discussion. This species of *Preverticillites* is one of the coarsest-textured forms in the collection, contrasting sharply with *Preverticillites columnella* Parona, 1933, which has a delicate skeletal net and has filling structures that are principally thin, isolated trabeculae. Chamber heights are similar, but *Preverticillites columnella* has thin trabeculae, in sharp contrast to the robust dimension of the species described here. These differences clearly separate the forms.

Stylothalamia elegante n. sp. is also a thin-walled, cylindrical sponge, but it is even more delicate in skeletal structure than *Preverticillites columnella,* and in addition *Stylothalamia* has a retosiphonate central tube. The thin, reedlike trabeculae, as thin pillarlike rods in *S. elegante,* contrast sharply to the more or less reticulate filling structure seen in the specimen here.

Material. Single figured thin section, 5127, unit 35, from the Middle Permian Maokou Formation, at Xiangbo, Longlin County, northwestern Guangxi.

EXPLANATION OF PLATE 11

Sollasia, Parauvanella, and *Huayingia.* Fig. 1.—*Sollasia ostiolata* Steinmann, 1882, *Parauvanella minima* Senowbari-Daryan, 1990, and *Colospongia*(?) *cortexifera* Senowbari-Daryan and Rigby, 1988; projection print, *Sollasia ostiolata* Steinmann, 1882 (S), shows characteristic, hemispherical, globular chambers, with single cryptosiphonate opening between chambers in upper part; lower part of sponge cut tangentially through imperforate exowalls; *Parauvanella minima* (M) occurs as small glomerate clusters in several isolated specimens, as the most common form here; *Parauvanella paronai* Senowbari-Daryan and di Stefano, 1988, (P) occurs as several isolated to attached, irregular chambers, particularly evident in the lower right; a replaced *Colospongia cortexifera* (C) shows in the left center; vesiculae show in the lower chamber, but the rest of the internal structure is not well preserved; an additional transverse section of a chamber of *Colospongia* shows in the lower left; other problematica, such as *Radiomura* Senowbari-Daryan and Schäfer (R), also occur with the encrusting algae *Tubiphytes*, etc., in the complex association, specimen JS105, Changxing Formation, Jianshuigou, Sichuan, X2. Figs. 2–7.—*Huayingia glomerata* n. sp., holotype and paratypes from the Upper Permian Changxing Formation at Jianshuigou, Huaying City, eastern Sichuan; *2, 3, 7,* paratype, specimen JS0056; *2,* vertical section through the explanate form showing the arcuate chambers and the coarse reflexed ostial tube, in what is interpreted as the basal part of the sponge; some chambers filled with dark matrix, others with light calcite cement, X5; *3,* vertical to slightly oblique section showing spatulate insertion of chambers and prominent, coarse, reflexed ostial tubes at the base; chambers partially filled with dark sediments, with apparent upper parts filled with calcite cement in geopetal structures; absence of a cribibulla is well documented in the lower chambers, where the ostial tubes appear to empty directly into the chambers or to lead around them, X5; *7,* projection print of the thin section, including the paratype, with more or less vertical sections of the platelike form, figure 2 is on the plate in the lower right and figure 3 is an enlargement of part of the plate in the lower left, X2; *4, 5,* holotype, specimen JS0055; *4,* photomicrograph of oblique, subhorizontal section through part of the plate showing the spatulate addition of chambers, toward the right, and the prominent coarse, reflexed tubes characteristic of the genus and species in chambers in the center; some show as merely simple reflexed straight tubes, but others with a constriction at about midtube; walls recrystallized, but apparently imperforate; geopetal structure of sediment and cement fill produces the layered chamber fillings, X5; *5,* projection print of holotype showing platelike form, as cut in near horizontal section, although upturned edges of the triangular cluster of chambers in the left center appears to have been cut essentially vertical to the tubes in the basal part, as though sharply upflexed along the margin; associated *Peronidella* sp. occurs in the upper right center, X2; *6,* paratype cut in low-angle oblique section, so parts of tube walls in the presumed lower part of the sponge show in the left and upper parts of the spatulate chambers on the right; some of the tubes appear to be essentially cylindrical, but others show a marked construction at midlength, so that in diagonal sections they may produce eight-shaped openings, like in the center, specimen JS0054, X5.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PREVERTICILLITES sp. B
pl. 14, fig. 5

Description. Sponges cylindrical, relatively large to 26 mm in diameter although smaller one in section only 13 mm in diameter, as cut in oblique-transverse section; large simple spongocoel, about 11 mm wide, located eccentrically near one side of cylindrical sponge and in central position in largest sponge.

Skeletal fibers irregularly arranged, sinuous, and generally variable in thickness as though section cut through layer of dense and coarse net and layer of open, relatively fine net. Coarse fibers 0.3–0.5 mm across, commonly merge to produce nearly solid "interwall" with only minor pores in dense part of skeleton. Finer fibers 0.08–0.20 mm in diameter produce much more open reticulate net of curved, sinuously interconnected segments around larger circular pores, 0.3–0.6 mm in diameter, to irregularly compound pores over 1 mm in diameter. Some skeletal canals in net exhibit straight canal segments 2.0–4.0 mm long and 0.4–0.5 mm across. Pores in dense areas mostly circular and 0.3–0.5 mm across.

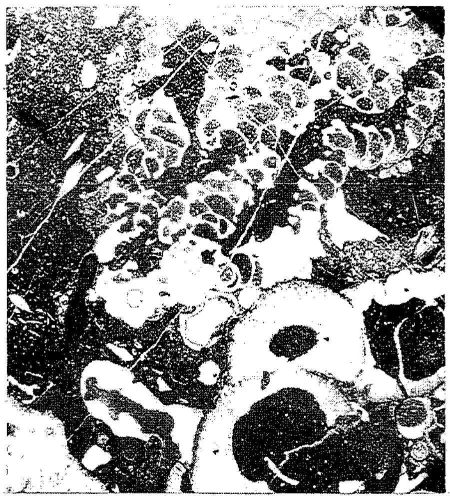
Smaller specimen with less differentiated areas in net, more commonly fibers 0.2–0.4 mm across, but some irregularly only 0.05 mm across and others much coarser. Pores mostly 0.3–0.5 mm across, but some much larger where net finest and most sinuously irregular around possibly larger subcentral opening 1.5–2.0 mm across.

Discussion. Two transverse sections occur on thin section XII-Ch, 5304, that are somewhat difficult to classify to genus and species. They appear to be most closely related to *Preverticillites* sp. A in terms of textures of the reticulate nets that appear to compose the interwalls of a cylindrical form. The relatively thin elements in part of the transverse sections appear to be part of reticular filling structure, but others may be somewhat expanded elements that make up the interwalls. These coarse elements appear to grade laterally into moderately coarse textured exowalls, as well, in both the large form, where the central

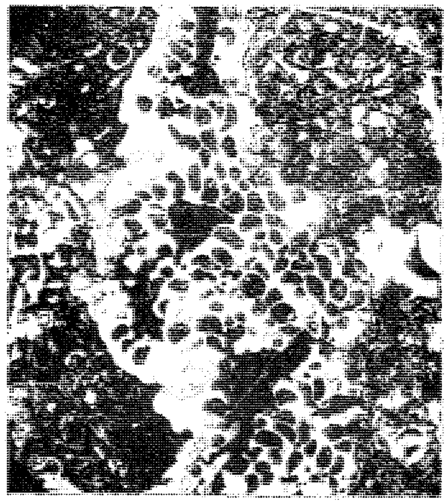
EXPLANATION OF PLATE 12

Sollasia, Glomocystospongia, Stylothalamia, Peronidella, Colospongia, and *Imperatoria*(?). Fig. 1.—*Sollasia ostiolata* Steinmann, 1882, photomicrograph showing globular chambers connected with a cryptosiphonate central opening in the otherwise generally imperforate wall, which is interrupted only locally by ostia, as for example in the second chamber on the left; the sponge is overgrown in the upper part by *Parauvanella minima* Senowbari-Daryan, 1990; dark micritic matrix fills the chambers, specimen JS105, Changxing Formation, Jianshuigou, Huaying City, Sichuan, X5. Figs. 2, 3.—*Glomocystospongia gracilis* Rigby, Fan, and Zhang, 1989a; 2, photomicrograph of glomerately arranged small chambers, characteristic of the species, in irregular, subcylindrical columns around what appears to be a central tube, into which ostia of the chambers open in characteristic fashion in the upper right; sponge overgrows a *Radiomura*(?) sp., a microproblematica like that described by Senowbari-Daryan and Schäfer (1979) from the Triassic near Salzburg in Austria, specimen JS0080, Changxing Formation, Jianshuigou, Huaying City, Sichuan, X5; 3, somewhat oblique section through glomerately arranged, irregular stems of bubblelike small chambers, with moderately large ostia that open into central tubes in the axial part of the chambers, as for example in the lower center, specimen JS0072, Changxing Formation, Jianshuigou, Huaying City, Sichuan, X5. Figs. 4, 6, 7.—*Stylothalamia eleganta* n. sp., holotype and paratype, ZYD-17, Maokou Formation, Ziyundong, Ziyun County, Guizhou; 4, projection print of holotype (right) and paratype (left) in high-oblique section showing cylindrical, stemlike growth, with prominent central spongocoel and upward-arcuate chambers that contain reedlike or pillarlike trabecular filling structures that interconnect the distinctly porous interwalls, X2; 6, photomicrograph of paratype showing prominent, thin, coarsely perforate interwalls defining upward-arcuate chambers that contain common, pillarlike trabecular filling structures; exowall on the right appears merely as a continuation of the interwalls; endowall on the left less clearly defined, X5; 7, photomicrograph of the upper part of the holotype section, showing characteristic interwalls and trabecular filling structures within the chambers and the uniformly, fine, perforate, relatively thin endowall around the debris-filled spongocoel; porous nature of the endowall shows particularly well in the upper left center, X5. Fig. 5.—Projection print of thin section that includes moderately large colony of *Glomocystospongia gracilis* Rigby, Fan, and Zhang 1989a, in the lower left, part of which is shown in figure 3, above; transverse sections of stems of *Peronidella regulara* Rigby, Fan, and Zhang, 1989b, in the upper and upper right center, do not show the rectangular arrangement of canals and skeletal tracts, but dimensions of those elements are essentially like the type specimens; transverse section through a chamber of *Colospongia cortexifera* Senowbari-Daryan and Rigby, 1988, in the upper left; that section shows characteristic vesicular development in the chambers and the moderately thick exowall of the species; specimen JS0072, Changxing Formation, Jianshuigou, Huaying City, Sichuan, X2. Fig. 8.—Projection print of *Imperatoria*(?) sp. shows the upperward-convergent axial cluster of exhalant canals and the moderately regular interruptions of the skeleton shown as discontinuities in the skeletal structure, although the axial canals pierce those surfaces of interruption, specimen 5314, unit 32, Maokou Formation, Xiangbo, Guangxi, X2.

1



2



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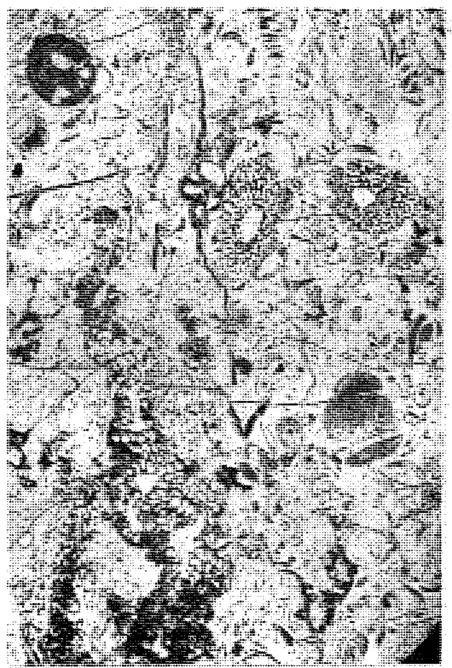

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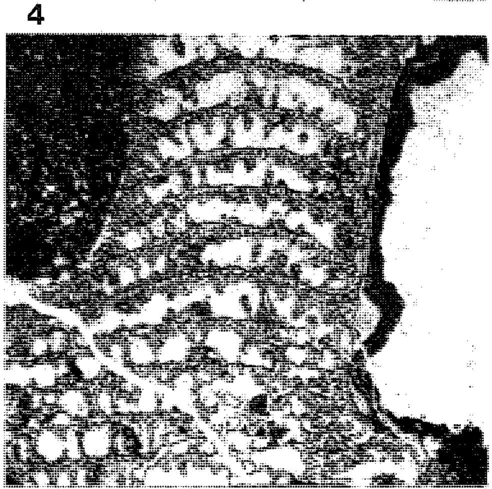

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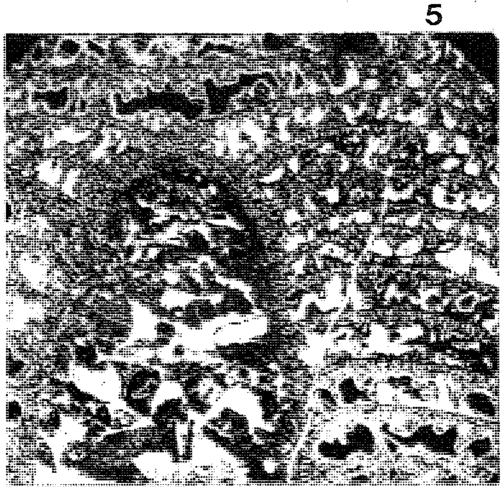


7

8

spongocoel or central tube is clearly defined, and in the smaller transverse section. The latter may be from a lower, more immature part of the sponge, before the spongocoel became established.

Because we are uncertain of the structural relationship, we have listed the fossil tentatively within *Preverticillites* but have made no attempt to identify species, although some of the elements appear to be essentially the same size as those in the longitudinal section identified as *Preverticillites* sp. A. Until additional material can be examined, however, the form must remain poorly identified.

Material. Figured specimens are on thin section 5304, from the Upper Permian Changxing Formation, at the secondary stratigraphic section, Xiangbo, Longlin County, northwestern Guangxi.

Family INTRASPOREOCOELIIDAE
Fan and Zhang, 1985
Genus INTRASPOREOCOELIA
Fan and Zhang, 1985

Original diagnosis. "Cylindrical to steeply obconical sphinctozoans composed of vertically stacked, overlapping chambers that may be relatively flat to highly arched and extend completely across cylindrical sponge, superimposed one above the other, with minor overlap; without central tube, but may have several longitudinal exhalant tubes in irregular positions; tubes may be discontinuous or long; numerous exopores and interpores pierce relatively thick walls; interiors of the chambers filled with sporelike filling structure" (Rigby and others 1989a).

Type species. Intrasporeocoelia hubeiensis Fan and Zhang, 1985.

INTRASPOREOCOELIA HUBEIENSIS
Fan and Zhang, 1985
pl. 8, figs. 1–9

Synonymy. Intrasporeocoelia hubeiensis Fan and Zhang, 1985, p. 18–19, pl. 7, figs. 4, 6, 8; Fan and Zhang, 1986, p. 154, pl. 1, figs. 1–4, pl. 2, figs. 6, 7; Fan and Zhang, 1987, p. 55, pl. 1, figs. 6, 7, pl. 3, fig. 5; Rigby, Fan, and Zhang, 1988, p. 747–53, figs. 4–6; Rigby, Fan, and Zhang, 1989a; p. 426–27, figs. 13.5, 14.8, 14.9; Senowbari-Daryan, 1990, p. 101–02, pl. 33, figs. 3–5; Wu, 1991, p. 82, pl. 10, fig. 13, pl. 13, fig. 1.
Intrasporeocoelia aff. *hubeiensis* Fan and Zhang, 1985, p. 19, pl. 7, figs. 4, 6, 8.
Intrasporeocoelia laxa Wu, 1991, p. 82–83, pl. 11, figs. 2, 5.

Emended diagnosis. Steeply obconical to cylindrical, curved to straight to branching sponges of superposed chambers 1.0–4.0 mm high, with most 3.0–3.5 mm high; chambers contain sporelike filling structures that range from spherical isolated to beaded, stalactite-like, or columnar. Interpores and exopores numerous and generally 0.15–0.20 mm in diameter, separated 0.2–0.4 mm. Vesicular plates may occur with attached filling structures in chambers; longitudinal excurrent tubes may occur.

Description. Straight to curved, or branching sponges, cylindrical to obconical with considerable variability; largest form 7 cm tall and 4.2 cm wide; crescentric flattened chambers vertically stacked, superimposed one above the other. Height of chambers variable, range 1.0–4.0 mm, but generally 3.0–3.5 mm. Thicknesses of interwalls range 1.0–2.0 mm, but generally 1.3–1.4 mm. Numerous interpores pierce thick walls in regular close fashion, and range 0.1–0.5 mm, with most 0.15–0.20 mm.

Exowalls spinose or pitted, 0.8–1.5 mm thick, thinnest near midheight, thickest in upper interwall and in zone of overlap of exowalls at base of chambers. Exopores locally smaller in diameter than interpores. Exopores 0.15–0.25 mm in diameter, sometimes funnel-like and 0.5–0.6 mm in diameter at outside of wall, pores numerous and uniformly spaced 0.2–0.4 mm apart.

Chambers filled with sporelike filling tissue that consists of isolated subspherical masses, beaded pendants, or stalactite-like columns of various diameters that extend downward from bases of interwalls and connect with columns growing upward from upper surface of lower interwalls or bottom of chambers. Sometimes sporelike masses appear as isolated subspherical beads irregularly distributed in lime mud matrix. In some chambers, spherical masses fill only part of chambers; remaining open spaces filled laterally by fibrous calcite cement at their margins and lime mud in centers, or may be totally filled with sparry calcite mosaics. In another specimen, spore-filling structures define irregular spaces rimmed by equant fibrous calcite at margins and lime mud in center or totally filled with sparry calcite mosaic; and in another, the spore-filling structure defines irregular space rimmed by equant fibrous calcite cement; remaining cavities laterally filled by micrite.

Ziyun specimen ZS-5-10 with chambers filled by abundant vesicular filling structures on which irregularly distributed sporelike structures occur, which suggests that spore-filling structures may be related to vesicular plates and formed at same time as when chambers were rimmed and filled by short fibrous calcite cement in the specimen. These evidences document that spore-filling structures represent primary structures of sponge.

Several longitudinal excurrent tubes occur within interiors of type specimens from western Hubei, but such structures are generally not developed in present specimens, for a few tubes with elliptical cross sections present only in thin section GD-A. These tubes might have been essentially horizontal lateral openings perpendicular to growth direction of sponge or essentially longitudinal excurrent tubes, for they are diagonal to plane of oblique section. They range 1.2 X 3.0 mm and 2.8 X 3.6 mm in section.

Discussion. It is interesting to note that rims of short fibrous calcite cement usually have variable thicknesses within single openings (pl. 8, fig. 8). This indicates that some solution may have occurred after their deposition and prior to burial by next generations of filling. Distinct dark lines of possible algal origin generally underlie the short fibrous calcite cement layers.

Intrasporeocoelia laxa Wu, 1991, is considered as a junior synonym of *I. hubeiensis* Fan and Zhang, 1985. The development of tubes between the sporelike filling tissues and the walls and the local sparsity of such filling structures fall well within the development seen in the type sections of *I. hubeiensis*, for example, compare figures 13.5, 14.8, and 14.5 of Rigby and others (1989a) for developments of ranges in filling structure packing and development of small tubules.

In thin section 15 (ZDY), some chambers are filled with lime muds, fine bioclasts, micritic peloids, and some ostracod shells. They exhibit distinct graded structure, with peloids at the bottom and lime mud toward the top.

Materials. Figured specimens: ZS-5 (2, 3, 10), ZS-6 (1), ZS-9, and STZA6-3, from the Changxing Formation, at Ziyun County, southern Guizhou; ZYD (04, 15) from the Maokou Formation, Ziyundong, Ziyun County; H-3 from the Maokou Formation, at Houchang, about 30 km south of the town of Ziyun County.

An additional 15 reference specimens from the Maokou and Changxing Formations were collected mainly from Ziyun County, at Shitouzai and Ziyundong. Only one specimen was collected from Ceyang, a village about 4 km west of Ceheng County, in southern Guizhou.

Genus RHABDACTINIA Yabe and Sugiyama, 1934

Original diagnosis. "Columnar sponges with numerous pores, broad superimposed low concentric chambers (with porous walls); chambers hollow or perhaps with scattered sporelike filling structures; vertical exhalant tubes well developed, widely distributed; prominent central tube or spongocoel not developed" (Rigby and others 1989a, p. 427).

Discussion. The genus was first described, without a formal diagnosis, by Yabe and Sugiyama (1934) and included by them in the class Hydrozoa, within the Coelenterata. Later, Fan and Zhang (1985) included *Rhabdactinia* within the sphinctozoan sponges and utilized the sporelike filling structures to relate *Rhabdactinia* with *Intrasporeocoelia.* They included those two genera within the family Intrasporeocoeliidae Fan and Zhang (1985, p. 17–18). In addition to the type species, *Rhabdactinia columnaria,* three species found in the Middle Permian Maokou Formation and Upper Permian Changxing Formation, at Xiangbo, Longlin County, northwestern Guangxi, were described by Rigby and others (1989a).

Wu (1991, p. 83) proposed the new genus and species *Guangxispongia spinalis,* but these are considered as a synonym of *Rhabdactinia depressa* Rigby and others, 1989a, which was described earlier from the same unit in the Maokou Formation at Xiangbo, Guangxi.

Occurrence. Middle Permian Maokou Formation and Upper Permian Changxing Formation, Xiangbo, Longlin County, southwestern Guangxi, as well as from the Changxing Formation at Huangnitang, Lichuan, western Hubei.

Type species. Rhabdactinia columnaria Yabe and Sugiyama, 1934.

RHABDACTINIA COLUMNARIA Yabe and Sugiyama, 1934
pl. 9, figs. 1–7

Synonymy. Rhabdactinia columnaria Yabe and Sugiyama, 1934, p. 179–80, pl. 20, figs. 5, 6, pl. 21, figs. 4, 5, pl. 22, fig. 4; Fan and Zhang, 1985, p. 20, pl. 8, figs. 1–3; Rigby, Fan, and Zhang, 1989a, p. 427, figs. 11.1, 17.1.

Emended diagnosis. Broadly obconical hemispherical sponges of relatively low, broad, overlapping chambers in early stages; later chambers arched nearly completely across skeleton; may be large structures to 20 cm or more high and across. Chambers approximately 1 mm high and range 0.4–1.5 mm, with interwalls generally 0.3–0.8, but up to 1.2 mm thick, as moderately continuous, relatively massive elements; pierced by common, large, exhalant tubes, 0.8–2.0 mm in diameter, generally approximately 1.0–1.5 mm across; tubes expand in diameters slightly radially; spaced 1.5–4.0 mm apart; walls pierced with common interpores, generally approximately 0.10 mm in diameter, but with funnel-like tips to 0.5 mm across. Walls spinose, commonly connect interwalls as columnlike structures 0.1–0.2 mm in diameter.

Description. Relatively large, broadly obconical to hemispherical and laterally extensive sponges composed of relatively highly arched superimposed chambers that extend across whole sponge body to form cabbagelike structures; exowalls and interwalls densely perforated; numerous longitudinal excurrent canals moderately regularly distributed, particularly in upper and outer part of skeleton; entire sponge bodies may be 20 cm high and across.

Chambers generally 0.4–0.5 mm high; interwalls very irregular and generally 0.3–0.5 mm thick, but locally may range to 1.2 mm thick. Small spines extend upward and downward from interwalls to merge as columns. Spines usually about 0.1 mm across. Longitudinal exhalant tubes common, cylindrical, and range 0.8–2.0 mm in diameter with most 1.0–1.5 mm across. Tubes increase in diameter, slightly, radially so largest tubes in outer parts. Such tubes range 1.4–2.5 mm apart in moderately aligned patterns from regular moderate geometric pattern, so 3–4 occur per cm. Interpores irregular, usually funnel-like openings 0.04–0.06 mm across in basal part, but expand upward to as much as 0.4 mm across. Some interpores tubelike, generally about 0.1–0.2 mm wide, but range up to 0.5 mm across. Chamber heights less than those of Xiangbo specimens, which are 0.5–1.2 mm.

In specimen Z-1 (no. 11), chambers relatively low, less than 0.5 mm high; interpores irregular, funnel-like or irregularly curved tubes about 0.2 mm across; funnel-like openings widen to 0.5 mm across. Longitudinal exhalant tubes commonly cylindrical, range 0.7–1.1 mm in diameter.

Discussion. Large massive specimens of *Rhabdactinia columnaria* Yabe and Sugiyama, 1934, are among the largest individual elements within the reef frameworks of Permian reefs of southern China. Steeply obconical to broadly hemispherical sponges range up to 20 mm across and high and commonly occur as domelike elements in the fabric. Specimens from Ziyun have a somewhat finer skeletal texture than those reported from Middle and Upper Permian outcrops at Xiangbo in northwestern Guangxi, but the spinose and continuous nature of the walls, and dimensions of the moderately common exhalant tubes fall within the general range of forms previously included in the species by Fan and Zhang (1985, p. 20–21) and Rigby and others (1989a, p. 427). The broad continuous chambers, relative uniform wall, and common cylindrical exhalant tubes as vertical or radial structures are considered as characteristic elements of the skeleton of the species.

Rhabdactinia regulara n. sp. is known from smaller forms, but has wall and chamber dimensions and exhalant tube dimensions essentially like that of *Rhabdactinia columnaria,* and the forms appear closely related. However, the delicate, netlike skeleton in *Rhabdactinia regulara* contrasts with the more or less massive continuous interwalls in *Rhabdactinia columnaria.* Both have spines on interwalls, but those in *Rhabdactinia columnaria* are more massive. Table 3 shows comparisons of species of *Rhabdactinia* described from the Permian of China.

Rhabdactinia depressa Rigby and others, 1989a, has relatively thick walls, pierced by numerous tubular interpores and only scattered exhalant tubes. The thick walls in *Rhabdactinia depressa* and the relatively low chambers combine to produce a massive-appearing species. *Rhabdactinia squamata* Rigby and others, 1989a, has relatively narrow, ovate chambers, rather than broad chambers, and has only poorly developed, discontinuous radial exhalant tubes, in contrast to the well-defined structures in *Rhabdactinia columnaria. Rhabdactinia irregulara* has chambers that are somewhat intermediate in dimensions between *Rhabdactinia columnaria* and *Rhabdactinia squamata,* but they are far less evident and discontinuous than in the moderately uniform *Rhabdactinia columnaria.* The regularity of *Rhabdactinia columnaria* also contrasts sharply to the irregular skeleton of *Rhabdactinia complexa* n. sp., which also appears to have only rare exhalant tubes in the massive skeleton.

Material. Figured sections are Z-1 (2, 3, 4, 5, 6, 9), sections 3 and 4 are of a single specimen, all are from the Upper Permian Shitouzai Member, Ziyun County, southern Guizhou. In addition, reference specimens include Z-1 (1, 7, 8, 10, 11), ZS-20 (8, 9), TLZS-3-2A and 3-2B, QCC5B from the Upper Permian Shitouzai Member, Ziyun County, and 5157 and 5307, unit 69, from the Upper Permian Changxing Formation, Xiangbo, Longlin County, northwestern Guangxi.

RHABDACTINA REGULARA n. sp.
pl. 10, figs. 1–3

Diagnosis. Broad, irregular to low-mounded *Rhabdactinia,* with relatively delicate netlike walls and complex spines. Chambers low to 1 mm high; moderately ill defined in reticulate delicate skeleton. Interwalls to 0.5 mm thick, with numerous interpores, making very porous structure in walls and between spines. Exhalant tubes common, cylindrical, mostly 1.5 mm across, and 1.0–2.0 mm apart.

Description. Sponge hemispherical to subcylindrical to laterally expanded; exterior rounded, moderately smooth; chambers low to 1 mm high, ill defined; interwalls distinctly perforated and netlike chamber walls irregular and chamber limits obscure.

Complex spines dominate skeletal structure, extend upward and downward from interwalls to produce columnar fillings within chambers and make chambers appear irregular. Spines and columns relatively coarse, 0.1–0.4 mm in diameter, with most approximately 0.2 mm across. Interwalls in interior of sponge about 0.3–0.5 mm thick. Interpores 0.15–0.20 mm across at base and, where cylindrical, expand upward to as much as 0.4–0.5 mm across funnel-like tops between spines. Interwalls reticulate and irregularly netlike in tangential sections. Exhalant tubes common, cylindrical, unwalled with rough edges, range 0.8–2.0 mm in diameter with most 1.5 mm across, separated 1–2 mm with netlike interwalls and coarse spines.

Table 3.—Characteristics of species of Rhabdactinia *described from the Permian of China. Measurements are in millimeters. Numbers in parentheses indicate most common dimensions.*

Species	Shape of Sponge	Chamber Height	Interwall Thickness	Interpore Diameter	Diameter of Exhalant Tubes	Spacing of Tubes	Other Characteristics
R. columnaria Yabe and Sugiyama, 1934	Obconical-massive	0.4–1.5 (1.0)	0.3–1.2 (0.8)	0.10	0.8–2.0 (1.0–1.5)	1.4–4.0 Regular common	Low continuous chambers, exhalent tubes large
R. depressa Rigby, Fan, and Zhang, 1989	Obconical-massive	0.5–3.0 (0.8–1.0)	0.3–2.0	0.1–0.2	0.8–1.6	Irregular scattered	Discontinuous spinose walls
R. irregulara Rigby, Fan, and Zhang, 1989	Hemispherical-subcylindrical branching	3.0	0.35–5.0	0.10	0.5–0.8	Irregular common	Discontinuous irregular interwall and chambers
R. squamata Rigby, Fan, and Zhang, 1989	Hemispherical-massive	1.0	0.4–0.5	0.08–0.1	Poorly defined	Rare	Scalelike chambers
R. regulara n. sp.	Broad massive mounds	1.0	0.3–0.5	0.15–0.20	0.8–2.0	1–2 Regular common	Delicate netlike skeleton with coarse spines
R. complexa n. sp.	Subcylindrical hemispherical	0.4–0.5	0.6–1.0	0.3–0.5	1.2	Rare	Complex irregular skeleton, obscure chambers

Discussion. This new species of *Rhabdactinia* is characterized a delicate reticulate netlike skeleton, with numerous columns that subdivide the chambers into regular rectangular openings. It is differentiated from all other species in the genus *Rhabdactina* by the delicate skeleton. The species is most similar to *Rhabdactinia columnaria* Yabe and Sugiyama, 1934, in gross dimensions of chambers and openings, but it is principally the distinctive delicate reticulate skeletal net in *Rhabdactinia regulara* n. sp. that differentiates the species from *Rhabdactinia columnaria,* which has a relatively massive-appearing skeleton, in sharp contrast.

In the type specimens, skeletal elements are rimmed with an early thin fibrous calcite cement. The remaining space was later filled with lime mud matrix in the holotype.

Material. Holotype, sections STZ21-1A and 1C from single specimen, at right angles to each other, from Upper Permian Shitouzai Member, Ziyun County, southern Guizhou.

RHABDACTINIA COMPLEXA n. sp.
pl. 10, figs. 4–10

Diagnosis. Broad, subcylindrical to hemispherical *Rhabdactinia* with low chambers irregularly defined between undulating walls. Chambers generally 0.4–0.5 mm high with interwalls 0.6–1.0 mm thick. Interpores common and range 0.3–0.5 mm in diameter through thick walls. Longitudinal or radial exhalant tubes rare.

Description. Relatively large, broad, subcylindrical to hemispherical, and laterally extensive, composed of numerous low chambers not well defined in irregular structure. Interwalls coarsely perforated. Small spines extend downward and upward from interwalls to form columns, giving chambers more irregular appearance. Chambers generally low, about 0.2–1.0 mm high but most variable and about 0.4 mm high, separated by irregular interwalls 0.6–1.0 mm thick. Interpores irregular, round and oval, range 0.3–0.5 mm across, funnel-like, tubelike, or curved tubelike openings.

Longitudinal exhalant tubes rare, cylindrical, and not well defined, with margins irregular or uneven, some tubes bent or curved, range to 1.2 mm in diameter.

Discussion. The new species *Rhabdactinia complexa* is characterized by its complex and irregular skeletal structure, obscurely defined chambers, and rare exhalant tubes. It is most similar to *Rhabdactinia irregulara* Rigby and others, 1989a (p. 429), but *Rhabdactinia irregulara* has moderately common, though irregular and somewhat discontinuous exhalant tubes that are clearly evident in the relatively massive skeleton. In addition, individual chambers appear to be laterally more continuous and more clearly defined in *Rhabdactinia irregulara* than in *Rhabdactinia complexa*. *Rhabdactinia complexa* also has relatively more massive interwalls and somewhat coarser interpores, but it is principally the moderately common exhalant tubes in *Rhabdactinia irregulara* that separate the forms.

Rhabdactinia squamata Rigby and others, 1989a, has relatively narrow ovate chambers, but is considerably more regular in skeletal structure and definition of chambers than is *Rhabdactinia complexa*. *Rhabdactinia squamata* is characterized by relatively small scalelike chambers, regularity of the skeletal structure, moderately thick walls, and numerous interpores. Walls tend to be moderately smooth and continuous, laterally, rather than the undulating irregular structures seen in *Rhabdactinia complexa*, where limits of individual chambers are sometimes difficult to establish.

Material. Holotype, Km-V, 5159, and paratypes include KS-100, from the Middle Permian Maokou Formation, Kefeng: 5167 and 5168, unit 37, from the Middle Permian Maokou Formation, and 5158, unit 69, from the Upper Permian Changxing Formation at Xiangbo, all from Longlin County, northwestern Guangxi.

Suborder APORATA Seilacher, 1962
Family THAUMASTOCOELIIDAE Ott, 1967
Genus SOLLASIA Steinmann, 1882

Original diagnosis. "Aporate moniliform stems with a single large cryptosiphonate opening in the chamber interwalls; without a central tube. Chamber exowalls contain one or more ostia. Interwalls normally two-layered. Vesiculae may occur. The skeleton was composed of aragonite with sphaerolitic microstructure" (Senowbari-Daryan and Rigby 1988, p. 197).

Type species. Sollasia ostiolata Steinmann, 1882.

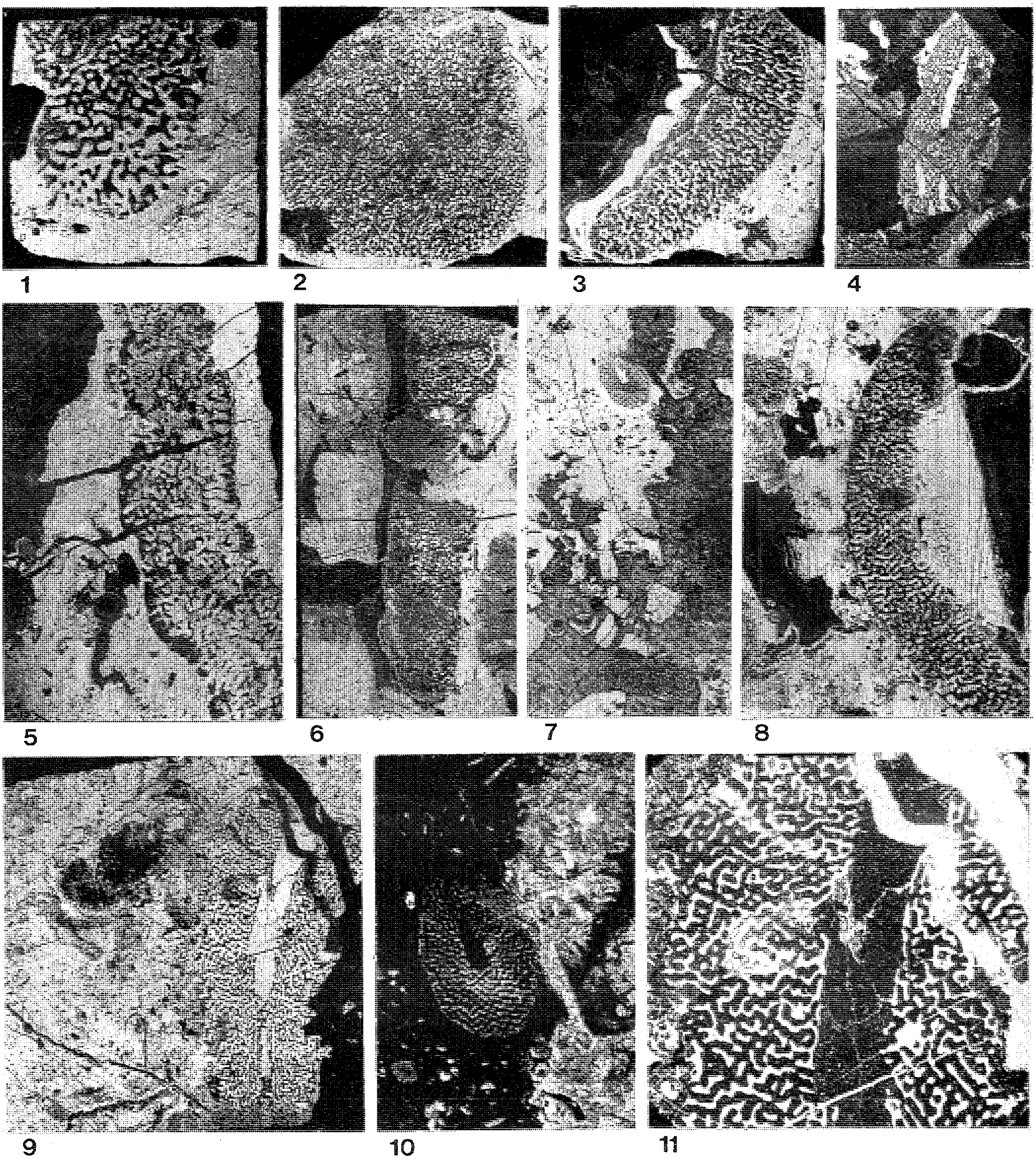
SOLLASIA OSTIOLATA Steinmann, 1882
pl. 8, fig. 1; pl. 11, fig. 1; pl. 12, fig. 1

Synonymy. Sollasia ostiolata Steinmann, 1882, p. 151–52, pl. 7, fig. 3; Senowbari-Daryan, 1990, p. 128–29, pl. 43, fig. 7, pl. 45, figs, 4, 8, pl. 56, fig. 9, text fig. 47. For a complete synonymy see Senowbari-Daryan (1990).

Emended diagnosis. Moniliform stems of stacked aporate chambers that may range from small subspherical chambers less than 1 mm in diameter to large chambers to

EXPLANATION OF PLATE 13

Species of *Peronidella*. Fig. 1.—*Peronidella*(?) sp., coarsely textured, possibly tangential section, projection print of one of the coarsest textured inozoans in the collection, specimen 5223, Maokou Formation, Kefeng, Guangxi, X2. Fig. 2.—Projection print of moderately fine textured, irregular, platelike *Peronidella* sp. of intermediate texture, but specifically unidentifiable, specimen 5229, unit 35, Maokou Formation, Xiangbo, Sichuan, X2. Fig. 3.—*Peronidella* sp., projection print of sponge with intermediate texture, perhaps a transverse section of part of a palmate or bladelike form, or margin of a cup, but specifically unidentifiable, specimen 5226, unit 27, Maokou Formation, Xiangbo, Sichuan, X2. Fig. 4—*Peronidella cylindrata* (Wu 1991), irregular subaxial longitudinal section showing 2–3 irregular canals in the lower part of the figure and single larger exhalant axial canal or central tube in the upper part in the moderately fine textured skeleton, specimen 5288, unit 31, Maokou Formation, Xiangbo, Guangxi, X2. Fig. 5.—Vertical tangential section, projection print of irregular columnar, moderately coarsely textured form, may be part of a vertical section of a platelike sponge; interior skeletal structure finer textured than exterior, and exterior may be of essentially the same general dimensions as the form shown in tangential section in figure 1, specimen 5227, Maokou Formation, Xiangbo, Guangxi, X2. Fig. 6.—Projection print of intermediate textured form, possible tangential view of columnar or platelike form, like shown in figure 2; exhalant structure or orientation of the slide unknown, specimen Z-1 (20), Shitouzai Member, Changxing Formation, Formation, Ziyun County, Guizhou, X2. Fig. 7, 10.—*Peronidella parva* Rigby, Fan, and Zhang, 1989b; specimen STZ10-1, Shitouzai Limestone, Changxing Formation, Shitouzai, Ziyun County, Guizhou, X2; *7*, projection print showing a diagonal, essentially transverse section of a small branch of the fine-textured skeleton in which tracts are subrectangularly arranged; section of a poorly preserved, coarse-textured *Peronidella*(?) occurs near the base, X2; *10*, photomicrograph showing the prominent rectangular arrangement of skeletal tracts and the uniform nature of the skeleton, X5. Fig. 8.—*Peronidella* sp., possible transverse section through curved plate showing skeleton of intermediate texture in projection print, not specifically identifiable, specimen 5221, unit 34, Maokou Formation, Xiangbo, Guangxi, X2. Figs. 9, 11.—*Peronidella regulara* Rigby, Fan, and Zhang, 1989b, specimen JS0071, Changxing Formation, Jianshuigou, Sichuan; *8*, projection print of essentially vertical section showing the regular, uniform, subrectangular arrangement of the moderately coarse skeletal fibers and canals around a prominent axial spongocoel or central tube, X2; *11*, photomicrograph of the upper part of the fractured specimen showing the prominent, uniform, subrectangular arrangement of the skeletal fibers as they define uniformly wide, rectangularly arranged canals in the skeleton, around the dark, matrix-filled spongocoel, X5.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15 mm across. Chamber heights increase upward and may range as high as 10 mm. Central cryptosiphonate opening may also increase in diameter upward to 2 mm across. Imperforate wall with moderately large ostia also increases in thickness as chamber size increases, and may range to 0.8 mm across. Ostia generally 5–6 or fewer per chamber, and commonly at midwall; may be rimmed but lack exaules.

Description. Sponge body composed of moniliform stems, chambers enlarge upward during growth and stems may branch; each stem in our sections consists of 5–6 chambers that range subspherical to barrel-shaped. Exowalls 0.6–0.8 mm thick at chamber base, thin to more or less uniform 0.5 mm thick in upper parts and as outer or early layer in interwalls. Second lining layer wedge-shaped to 0.2–0.3 mm thick at outer edge, thins to feather edge near center; may have dense outer layer irregularly present and 0.02–0.04 mm thick, not screenlike cortex. Main walls faintly radially fibrous, in part, though sphaerolitic elsewhere. Typical cryptosiphonate opening between chambers well developed, approximately 0.5 mm in diameter. Ostia few in one-layered exowalls of each chamber, generally 0.3–0.5 mm diameter, not limited but most in shallow "dimple" in dense exowalls. Interwalls two-layered because of floorlike lining of younger chamber over interwall "roof" of porous chambers. Lining thickest near exowall junction and overlap, decreases toward wall oscular opening. Vesiculae common in early chambers as curved plates 0.2–0.5 mm thick.

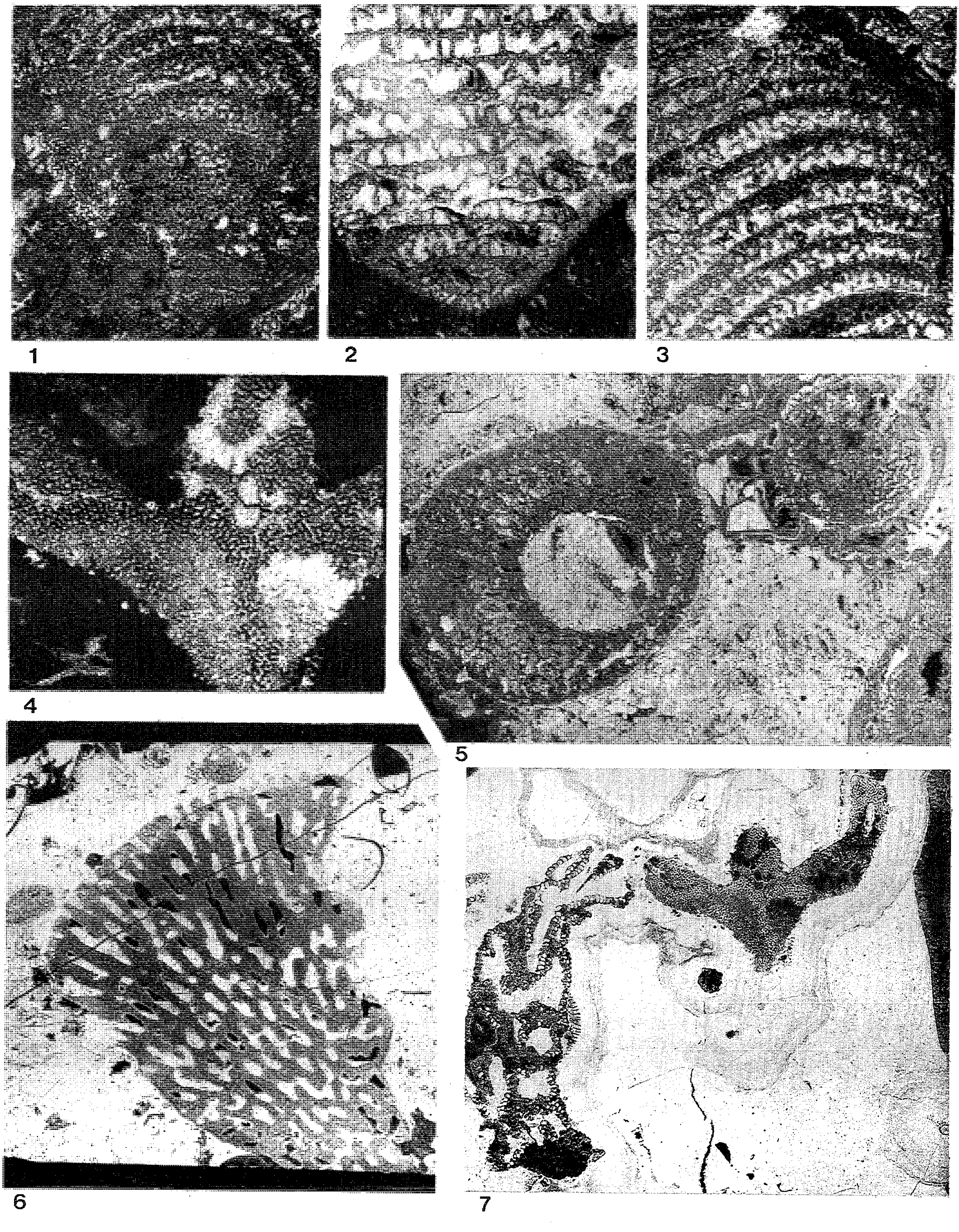
Discussion. The available specimens fit within parameters of the variable type specimens, as interpreted by Senowbari-Daryan and Rigby (1988) and Senowbari-Daryan (1990). A typical cryptosiphonate opening is present in specimen JS105, which can be included in *Sollasia* without doubt.

Material. Figured specimen JS105 from Upper Permian Changxing Formation, Jianshuigou, Huaying City, eastern Sichuan. Specimen STZ22-2 is from the Upper Permian Shitouzai Member, Ziyun County, southern Guizhou.

Reference specimens also occur on ZS-5 (02) from the Changxing Formation at Ziyun, on TLZ5-3-2B from the Shitouzai Member at Tanluzai near Ziyun, and STZ-10-8

EXPLANATION OF PLATE 14

Preverticillites, Stylothalamia, Grossotubenella, Glomocystospongia, and *Peronidella.* Figs. 1, 3.—*Preverticillites columnella* Parona, 1933, specimen 5129, Maokou Formation, Xiangbo, Guangxi; *1,* photomicrograph of tangential view of the central part of one of the interwalls showing its netlike nature, in the center, and lack of a central tube in the sponge; reticulate trabecular filling shows in the upper center and the porous exowall shows on the right; this is the lower central part of specimen shown in plate 7, figure 6, X5; *3,* near-vertical section through the wall showing the thin, very porous, arcuate interwalls and the reticular trabecular structure within the low arcuate chambers; figure is enlarged part of the upper right of the specimen shown in plate 7, figure 6, X5. Fig. 2.—*Stylothalamia eleganta* n. sp., lower part of the paratype, showing the porous exowall, near the base, and pillarlike filling structures extending between porous interwalls in the middle and upper part; this is an enlargement of the lower central part of specimen shown in plate 11, figure 4, specimen ZYD (17), Middle Permian Maokou Formation, Ziyundong Member, Ziyundong, Ziyun County, Guizhou, X5. Figs. 4, 7.—*Peronidella minima* n. sp., specimen STZ-17-1, holotype, Shitouzai Member, Changxing Formation, Shitouzai, Ziyun County, Guizhou, X5; *4,* photomicrograph of the junction area of the three branches, showing the general dimensions of the skeletal net and an axial central tube in the subvertical branch, above the junction; generalized rectangular arrangement of the skeletal tracts shows in the right center, as well as in the uniform spacing of the tracts in the branch on the left, X5; *7,* projection print shows the branched specimen in the upper right, associated with a moderately open textured specimen of *Glomocystospongia gracilis* Rigby, Fan, and Zhang, 1989a, on the left; the latter branching form has an axial spongocoel or central tube in each of the branches and shows the uniform fine texture of the species, which shows essentially imperforate chambers one-layer deep and with ostia that open into the more or less completely matrix-filled central tubes in an unusually open-textured specimen of the species; much of the rest of the section is composed of various types of calcareous cement; X2. Fig. 5.—Transverse section of *Preverticillites*(?) sp. showing a large axial spongocoel in the specimen on the left, but poorly developed central canal in specimen on the right; texture variations within the specimen on the left suggest it cut through interwalls of varying texture and suggests it may be related to *Preverticillites,* but relationships are uncertain, specimen 5304, Changxing Formation, projection print, X2. Fig. 6.—*Grossotubenella parallela* Rigby, Fan, and Zhang, 1989b, projection print of vertical section showing the very porous, open-textured skeleton, with gross canals separated by skeletal tracts of only essentially the same width; skeleton generally recrystallized, but details show in the better-preserved, uppermost part of the sponge, specimen ZYD (22), Maokou Formation, Ziyundong, Ziyun County, Guizhou, X2.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from the Shitouzai Member at Shitouzai, near Ziyun, all in southern Guizhou.

Family GLOMOCYSTOSPONGIIDAE Rigby, Fan, and Zhang, 1989a

Genus GLOMOCYSTOSPONGIA Rigby, Fan, and Zhang, 1989a

Original diagnosis. "Sponge of glomerate chambers in compact hemispherical to subspherical masses, slender, cylindrical branching stems, or cylindrical columns; individual chambers small, of variable shape of overlapping crescentic to subspherical or hemispherical; chamber walls aporous, uniformly thin; chambers generally with one large ostium, which commonly connects to slits or subcylindrical tubelike openings in massive sponge; ostia generally do not connect chambers but open to exterior; chambers commonly one layer deep around openings" (Rigby and others 1989a, p. 436).

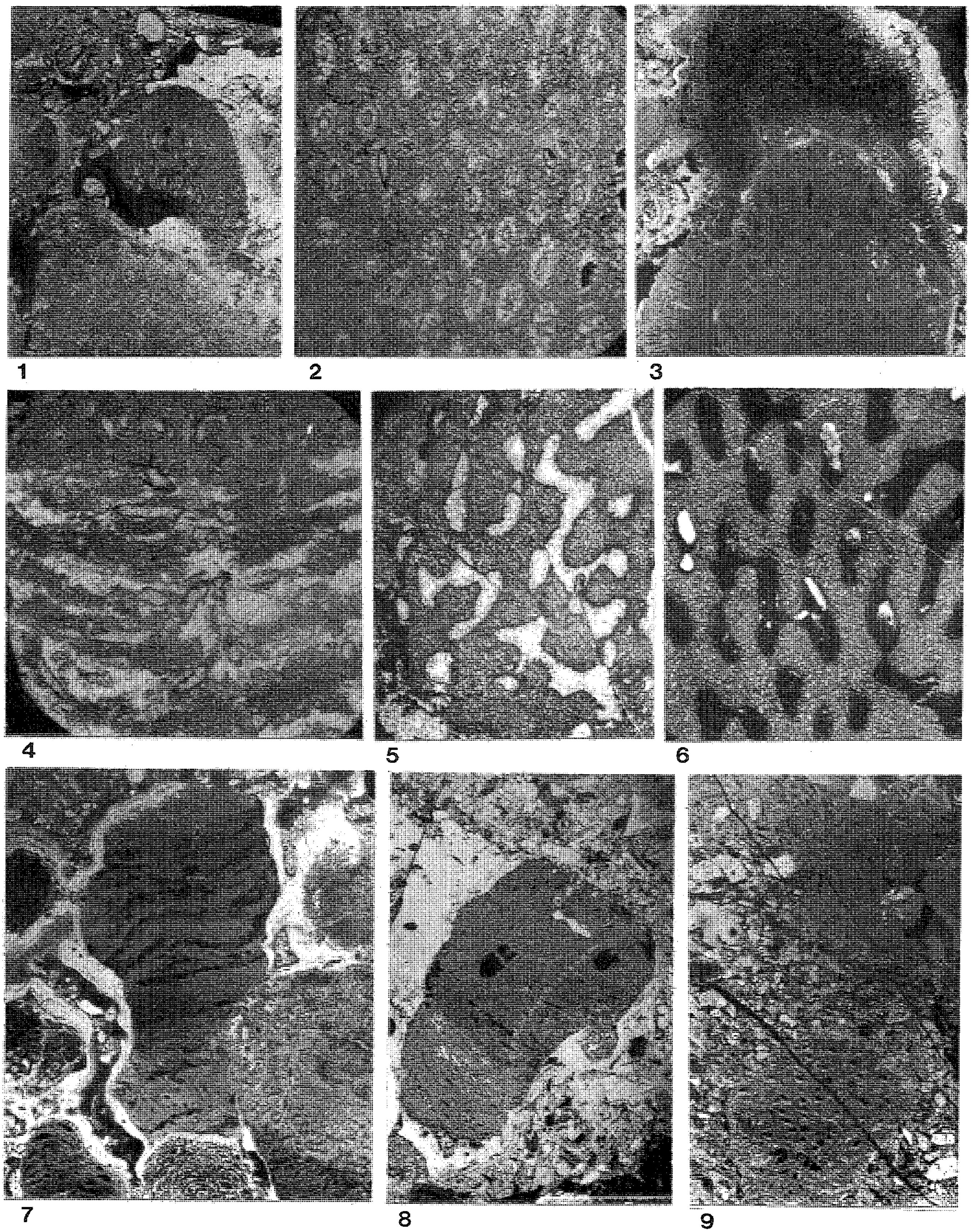
Type species. Glomocystospongia gracilis Rigby, Fan, and Zhang, 1989a.

GLOMOCYSTOSPONGIA GRACILIS Rigby, Fan, and Zhang, 1989a
pl. 12, figs. 2, 3, 5; pl. 14, fig. 7

Synonymy. Glomocystospongia gracilis Rigby, Fan, and Zhang, 1989a, p. 436–37, figs. 13.1, 18.7–18.9, 19.5; Senowbari-Daryan, 1990, p. 135; Senowbari-Daryan and Rigby, 1991, p. 627, figs. 4.1, 4.2, 12.5.

EXPLANATION OF PLATE 15

Intratubospongia, Stellispongia, and *Imbricatocoelia.* Figs. 1, 8, 9.—*Intratubospongia typica*(?) Rigby, Fan, and Zhang, 1989b, *1,* sponge in center attached to a colony of tabulozoans at the base; oblique section shows several exhalant canals of the center in the moderately, coarsely recrystallized skeleton, specimen 5199, unit 27, Maokou Formation, Xiangbo, Guangxi, X2; *8,* projection print of moderately well preserved specimen showing the normal coarse canals within a recrystallized skeletal net; the sponge has grown around some unidentified soft-bodied organism, now removed, which produced the two large crystalline calcite-filled openings in the upper part of the sponge; skeleton in wackestone-grainstone, specimen B-34-1, Maokou Formation, Xiangbo, Guangxi, X2; 9, projection print of transverse section of moderately well preserved specimen in the lower part, and less well preserved specimen, in the upper part, in coarse grainstone; geopetal structures mark the canals where sediment filled the lower part and crystalline calcite the upper part of the canals, specimen B-38-3, Maokou Formation, Xiangbo, Guangxi, X2. Figs. 2, 3.—*Intratubospongia tenuiperforata* Rigby, Fan, and Zhang, 1989b, specimen 5236, unit 32, Maokou Formation, Xiangbo, Guangxi; 2, photomicrograph showing characteristic skeletal structure and perforated, lined, exhalant tubes characteristic of the species; perforations show well in the lower center as dark pore fillings in the light-colored tube linings, X5; *3,* projection print shows upper part of the sponge with uniformly spaced, moderately coarse canals interrupting the fine-textured skeletal net; figure 2 is of the lower part of the section; sponge overgrown by massive, fine tabulozoan, X2. Figs. 4, 7.—*Stellispongia* sp., specimen 5272, unit 36, Maokou Formation, Xiangbo, Guangxi; *4,* photomicrograph showing the essentially horizontal, proximally gently upward-convergent exhalant canals that empty into short exhalant canals of osculum, not well shown here, but related to an ill-defined axial cluster in the lower center; smaller vertical canals pierce the regular skeleton in the upper part, where the fine fibers form a regular reticulate network—these smaller regular spaced canals are probably downward-convergent inhalant openings oriented generally normal to former positions of the upper domed surface of the sponge, such canals are common in areas between the radial canals of the exhalant system, X5; *7,* projection print of a more or less complete sponge showing general, irregularly laminate nature of the fine skeletal structure, perforated by more or less horizontal and upward-convergent, moderately coarse exhalant canals, best shown in the upper center, and more regular, downward-convergent inhalant canals that occur throughout the skeleton, but show best in the upper part; figure 4 is of the upper central part of the sponge; a very coarsely preserved specimen of probably the same species shows in the lower right, sections of *Imbricatocoelia elongata* Rigby, Fan, and Zhang, 1989a, occur in the lower left, and coarse tabulozoans occur on the left, near the margin; clear calcite replacements show as the dark, subhorizontal laminae in the central part of the sponge, where the fine-textured skeletal structure has been destroyed by recrystallization, X2. Figs. 5, 6.—*Grossotubenella parallela* Rigby, Fan, and Zhang, 1989b; *5,* photomicrograph showing fine-textured skeletal tracts of moderately uniform dimensions separated by calcite cement-filled canals; section is probably oblique transverse, because the prominent elongate nature of the canals is obscured, specimen B-29, Maokou Formation, Xiangbo, Guangxi, X5; *6,* photomicrograph of more nearly vertical section showing elongation of the upward-divergent, now dark, matrix-filled canals separated by fine-textured skeletal tracts, characteristic of the species and genus; more or less vertical canals interconnected by somewhat smaller subhorizontal elements in the open porous sponge; view is of the central part of the specimen shown in plate 14, figure 6, specimen ZYD (22), Maokou Formation, Ziyundong, Ziyun County, Guizhou.



Original diagnosis. "Irregular subspherical to explanate sponges or clusters of closely branching cylindrical columns; chambers small, spherical to subspherical crescentic, 0.5–0.7 mm across, 0.3–0.5 mm high; interpores lacking, each chamber generally with single ostium 0.2–0.3 mm wide on chamber exterior; chambers arranged in single layer around incurrent-excurrent slits or irregular openings" (Rigby and others 1989a, p. 436).

Description. Sponges composed of clusters of closely branched cylindrical columns or slender branching stems of glomerate aporate chambers; chambers small, spherical to flattened spherical or bubble-shaped, and overlapping with new chambers added distally in direction of growth.

Exowalls and interwalls thin, generally uniform in thickness but range 0.04–0.12 mm thick, may thicken or thin toward large pore commonly present in each chamber; openings do not develop into exaules or major tubes.

Individual chambers range moderately uniformly 0.4–0.5 mm across and 0.3–0.4 mm high, but may range to 0.8 mm across and 0.6 mm high; ostia 0.08–0.10 mm wide, connect to adjacent chambers or open to exterior, may have a few pores or ostia per chamber as both incurrent and excurrent openings; long subcylindrical curved openings or central tube 0.05 mm in diameter, must have functioned as incurrent and excurrent connections in branching forms.

Discussion. The present specimens are similar to *Glomocystospongia gracilus* in general growth form and size of chambers, but some have more than one ostium within each chamber and into the long central tube within the sponge body. Only in STZ17-1 are the chambers smaller than those in type specimens of the species.

Material. Figured specimens include JS0001, JS0072, JS0080, and JS105 from the Upper Permian Changxing Formation, Jianshuigou, Huaying City, eastern Sichuan; and STZ 17-1 from the uppermost Permian Shitouzai Member of the Changxing Formation at Shitouzai, Ziyun County, southern Guizhou. Reference specimens include JS0005, from the Chiangxiang Formation at Jianshuigou, Sichuan; and LD-6 from the Changxing Formation from Luodian County in southern Guizhou.

Genus HUAYINGIA n. gen.

Diagnosis. Sponge body nodular aggregate, foliate to irregularly tabular, consists of numerous small crescentic chambers in vertical section and arched triangular to spatulate or crescentic in horizontal section. Chamber walls imperforate, with single large "retrosiphonate"-appearing tubular ostium; lacks cribribulla; vesicular filling tissue rare within chambers.

Discussion. This new genus is characterized by glomerate superposed or laterally added chambers in tabular forms, which are several centimeters across, and by the distinctive inflexed tubular openings for each ostium. The new genus is similar in general growth form to *Guadalupia zitteli* Girty, 1908, or *Neoguadalupia* Zhang, 1987, but it has imperforate walls, and is thus clearly separated. The new genus has wide chambers up to 5 mm in diameter and chamber walls that are coarsely perforate. *Huayingia* is also quite different from the perforate *Platythalamiella* Senowbari-Daryan and Rigby, 1988, although it may have a superficially similar gross form. *Subascosymplegma* Deng, 1981, has a tabular growth form, but it has long, almost annular chambers and numerous small pores in the chamber walls.

Cribrothalamia madoniensis (Senowbari-Daryan 1980) has chambers that look remarkably similar to those in *Huayingia*, but *Cribrothalamia* is a cylindrical form in which the chambers are arranged around a retrosiphonate central tube. *Cribrothalamia* also has well-developed cribribullae over the coarse tubular openings in the wall. Senowbari-Daryan (1990, p. 79), in an emended diagnosis, noted that a double wall is developed in the contact zone between chambers, because each chamber has its own wall. This is a development not seen in the Chinese genus. *Cribrothalamia gulloae* Senowbari-Daryan, 1990, has even more complex cribribullar structures in the large tubular openings to the chambers. These types of structures are not developed in *Huayingia glomerata* n. sp., and the two genera contrast sharply in growth form as well, although the reflexed, relatively massive tubules in individual chambers do appear similar. *Huayingia* may be ancestral to the somewhat more complex *Cribrothalamia* from the Triassic of Sicily.

Pamirocoelia sphaerica Boiko, 1991, is a superficially similar sponge but appears to be less tabular or foliate and to have more complex ostia, and more ostia per globular chamber than in *Huayingia. Pamirocoelia* has at least two or three ostia per chamber, and these ostia commonly have screened outer ends (Boiko and others 1991, pl. 31, figs. 3, 4). The ostia lack the reflexed tubular structure so typical of *Huayingia*, as well.

These sponges seem to fit well in the Glomocystospongiidae in terms of growth form, wall structure, and lack of filling structure. The genus is included in the family with *Glomocystospongia* from the Permian of China. *Henricellum* was initially included in the family by Rigby and others (1989a), but that sponge was placed in the Celyphiidae de Laubenfels, 1955, by Senowbari-Daryan (1990, p. 117).

Type species. Huayingia glomerata n. sp.

Etymology. Huayingia, named for Huaying City, eastern Sichuan, where the sponge was discovered.

HUAYINGIA GLOMERATA n. sp.
pl. 11, figs. 2–7

Diagnosis. Irregular aggregates or tabular to foliate sponges several cm across, extends laterally for some distance. Chambers crescentic or arched triangular to 4 mm high and 3 mm wide, distal surface arched in *en echelon* structure; walls imperforate with only single large tubular ostium with thick wall reflexed into chambers, tubes to 0.5 mm wide and up to 1 mm long.

Description. Nodular aggregates or tabular to several centimeters across; sponge body composed of numerous high, crescent-shaped chambers to 4 mm high and 1.5–2.4 mm wide, in vertical sections, chambers spatulate to globular in horizontal section; spatulate chambers with pointed proximal junctions, inserted between arched interwalls of diagonally subjacent chambers and with high arched distal walls; small chambers superposed one above other radially.

Chamber walls about 0.2 mm thick, imperforate, flex sharply inward to form single large tubular ostium, 0.3–0.5 mm wide, in each chamber. Tube may be cylindrical to long nipple-shaped and may be simple opening or 8-shaped with sharp midlength constriction; cribribulla not developed; tube may be to 1 mm long; walls of tube 0.1–0.2 mm thick at base, thin abruptly to approximately 0.1 mm thick, then to less than 0.05 mm thick at curved to inflexed narrowed tips. Chambers generally lack filling structures, but locally, simple arched vesicular plates, 0.05–0.10 mm thick, may occur.

Discussion. Relationships and comparisons to similar forms have been treated in discussion of the genus above.

Material. Holotype JS0054, and paratypes JS0055 and JS0056, all from the Upper Permian Changxing Formation, Jianshuigou, Huaying City, eastern Sichuan. Reference specimens include JS0068 and JS0070 from the Changxing Formation at Jianshuigou; and Z-1 (7) from the Shitouzai Member of the Changxing Formation, at Ziyun in southern Guizhou.

Class CALCAREA Bowerbank, 1864
Order PHARETRONIDA Zittel, 1878
Suborder INOZOA Steinmann, 1882
Family PERONIDELLIDAE Wu, 1991
Genus PERONIDELLA Hinde, 1893

Original diagnosis. "Einfach oder durch Knospong ästig; Eizel-Individuen cylindrisch dickwandig; Scheitel gewölbt, seltewer eben, in der Mitte engem, Kreisrundem Osculum der röhrenförmigen Magenhöhle, welche welde uit nahezu gleichbleibendem durchmesser die gauze lange des Schwammenkörpers bis in die Nähe der Basis durchbohrt. Einströmungskanäle fehlen. Wand der Magenhöhle und Oberfläche porös. Aussenseite entweder nackt oder an der Basis, zweilen auch bis in die Nähe des Scheitel nit dichter, concentrisch runzeliger Epidermis überzogen.

Das Skelet besteht aus uneist groben, wurmförmig gekrümmten, anastomosirenden Fasern, die ein wirres Gewebe bilden" (Zittel 1878, p. 30, 120).

(Single to branching through buds; individual cylindrical thick walled; summit arched rarely flat, with a central circular osculum of the tubular spongocoel, which extends nearly the full length of the sponge body to near the base. Inhalant canals absent. Walls of the spongocoel and upper surface porous. Exterior either naked or covered by a thick concentrically wrinkled epidermis from near the base to the vicinity of the summit.

The skeleton composed of uncoated large, vermiform anastomosing fibers that build an irregular web.)

Type species. Spongia pistilliformis Lamaroux, 1821 (subsequent designation by de Laubenfels [1955, p. E99]).

PERONIDELLA REGULARA Rigby, Fan, and Zhang, 1989b
pl. 12, fig. 5; pl. 13, figs. 9, 11

Synonymy. Peronidella regulara Rigby, Fan, and Zhang 1989b, p. 787–89, figs 10.1–10.4.

Original diagnosis. "Cylindrical sponges with relatively large and deep axial spongocoel; skeletal fibers regularly arranged in subrectangular meshwork oriented approximately 45° to principal axis of sponge; skeletal canals 0.12–0.18 mm across and relatively delicate fibers 0.12–0.15 mm in diameter" (Rigby and others 1989b, p. 787).

Description. Cylindrical, thick-walled sponge at least 30 mm high, expands upward from 10–12 mm in diameter; central spongocoel generally along entire axis, widens somewhat irregularly upward from approximately 1 mm wide to 2.5 mm wide in upper part; gastral margin of spongocoel moderately smooth and may be lined by fiber set parallel to axis or may show abrupt truncation of skeletal fibers. Wall 4–5 mm thick, becoming slightly thicker upward.

Skeletal fibers regularly arranged, often form regular subrectangular meshwork at least 45°–60° to axis of sponge, with some irregularity; meshwork fibers round to oval in cross section and most 0.10–0.12 mm in diameter; become swollen in tract junctions to 0.22 mm across. Microstructure not preserved but replaced by sparry calcite mosaics.

Walls pierced by numerous meandering serpentine to rectangular-appearing skeletal canals that branch and reconnect at regular intervals to produce even-textured skeleton; skeletal canals generally 0.18–0.22 mm across; straight canal segments parallel fiber segments, and moderately uniform, 1.2–1.4-mm-long canals may widen in junction areas to 0.4 mm across, but elsewhere of remarkable uniform width.

Discussion. The present specimens are similar to types of *Peronidella regulara* Rigby, Fan, and Zhang, 1989b, in having relatively delicate fibers that are arranged in a regular subrectangular meshwork. The type specimens largely came from the Middle Permian Maokou Formation from the Xiangbo area, northwestern Guangxi. Small specimens from the uppermost Permian Shitouzai Limestone from Ziyun County show some of the distinctive regular skeletal network characteristic of *Peronidella regulara* but are smaller and have a slightly finer textured skeletal net. Table 4 shows comparisons with other Permian species of *Peronidella.*

Material. Figured specimens JS0071 and JS0072 from the uppermost Permian Changxing Formation, at Jianshuigou, Huaying City, eastern Sichuan.

PERONIDELLA MINIMA n. sp.
pl. 13, figs. 7, 10; pl. 14, figs. 4, 7

Diagnosis. Small, branching cylindrical *Peronidella* with stems generally 4–5 mm across, pierced by central axial spongocoel, generally 0.8–1.0 mm in diameter and with fine, regular skeletal net composed of segments generally 0.10 mm across, defining canals essentially 0.10 mm in diameter. Skeletal net rectangular and at angles to axes of branches.

Description. Holotype is small branched form, trident-like growth form, as seen in sections, composed of three subcylindrical branches and somewhat more massive stem. Branches 4–5 mm across with moderately smooth exteriors perforated only by very regularly placed and sized pores that lead to uniform-size canals of interior. Walls generally 1.0–1.5 mm thick, but locally to 2 mm thick in central branch. Each branch perforated with axial central spongocoel that ranges 0.6–1.0 mm across with moderately smooth, distinctly walled gastral margin.

Skeletal tracts generally with rounded cross section, 0.08–0.12 mm in diameter, but most uniformly approximately 0.10 mm across. Tracts expand to circular or subspherical junctions that may be 0.15 mm across and remarkably rectangularly arranged at 45°–60° to principal axis. Net interrupted in rectangular, three-dimensional pattern by uniformly spaced canals that have narrowed sections 0.08–0.10 mm across, where interconnected between swollen sections of net, and expand into subspherical openings in centers of rectangles up to approximately 0.15 mm across; entire sections have remarkable rectangular patterns.

Pores in outside wall, as seen in tangential section, 0.14–0.18 mm in diameter, separated by skeletal tracts generally of same general dimensions, in regular uniform, almost geometrically predictable patterns, so that approximately three pores occur per millimeter in linear series. In interior, 4–5 expanded canal openings in rectangular net occur per millimeter, where structure most distinct and regular.

Discussion. The small, branching, new species *Peronidella minima* appears to be similar to *Peronidella rigbyi* Senowbari-Daryan, 1991, in terms of dimensions of the stem and the branching habit, but the specimens included in this species, here, have a distinctly finer and more uniformly textured skeletal net than that in *Peronidella rigbyi.* In the new species described here, skeletal elements are approximately 0.1 mm in diameter and are separated by canals of essentially the same dimensions. This is approximately one-half the size of skeletal fibers and canals in the type specimens of *Peronidella rigbyi.* In addition, the skeletal net of *Peronidella rigbyi* has skeletal fibers that join in a somewhat serpentine pattern, rather than the distinctly rectangular, uniform pattern seen here.

Of the four species of *Peronidella* described by Wu (1991, p. 61–64), *P. labiaformis* Wu is perhaps the most similar in overall dimensions and in texture of the skeletal net, but Wu noted that *P. labiaformis* has the skeleton as an "irregular lattice" rather than the sinuous pattern of fibers and canals seen here. *P. minima* described here is a branched form, but *P. labiaformis* was described as conical.

Peronidella nana Hinde, 1884b, and *Peronidella recta* Hinde, 1893, are both small species with fine-textured skeletons with tracts of the general size of the Chinese species described here. These European Jurassic species have different growth forms and are also unlikely the same species because of their great stratigraphic separation from the Permian. They also contain spicule elements not known to be present in the Permian inozoans.

The sponges described as *P. recta* Hinde, 1893, by Wu are also small, possibly branched sponges with thin cylindrical stems and with fiber and pore dimensions like the new species described here. The sponge described and figured as *P. recta* should be included in the new species *P. minima* described here. Chinese specimens of *P. nana* Hinde, as described by Wu (1991), may represent a new species.

The other species described by Wu appear to be coarser and larger species.

In the regularity of the skeleton, the small species, *P. minima,* is like *Peronidella regulara* Rigby, Fan, and Zhang, 1989b, but dimensions of that species are considerably coarser than the small branching form described here. That contrast is most apparent in the skeletal canals,

Table 4.—Characteristics of species of Peronidella *described from the Permian of China. Measurements are in millimeters. Numbers in parentheses indicate most common dimensions.*

Species	Form	Diameter of Sponge	Diameter of Spongocoel	Diameter of Skeletal Pores	Diameter of Fibers	Other Characteristics
P. beipeiensis Rigby, Fan, and Zhang, 1989	Cylindrical to branched	16–20	5–9	0.25–0.45 (0.25–0.30)	0.25–0.50 (0.25–0.30)	Coarse sinuous fibers, gastral layer
P. regulara Rigby, Fan, and Zhang, 1989	Cylindrical	6.8–38.0 (12–18)	2–10 (2–6)	0.12–0.18	0.12–0.15	Subrectangular mesh, straight delicate fibers diagonal
P. rigbyi Senowbari-Daryan, 1992	Cylindrical to branched	4–6	1.2–2.0	0.20–0.25	1.18–0.50 (0.20)	Gastral and dermal layers
P. gravida Wu, 1991	Pear- or eggplant-like	8.5+	2.3–5.0	0.18–0.40	0.05–0.08	Gastral pores in rows, diagonal sections only
P. labiaformis Wu, 1991	Conical	4–10	1.0–2.8 oval	—	0.05–0.10	Liplike diagonal cross section
P. minicoeliaca Wu, 1991	Columnar	13–21	3.75	0.15	0.13–0.20	Relatively thick fibers, large form
P. recta Hinde, 1893, per Wu, 1991	Cylindrical	4.7–6.9	0.9–2.3	0.25	0.05–0.12	Fibers in irregular lattice
P. minima n. sp.	Cylindrical to branched	4–5	0.6–1.0	0.08–0.15	0.08–0.12 (0.10)	Small fibers and canals, sinuous

which are approximately 0.2 mm across in *Peronidella regulara,* but only 0.1 mm across in the small branching species. When *Peronidella parva* (now *P. rigbyi* Senowbari-Daryan, 1991) was described by Rigby, Fan, and Zhang (1989b, p. 789–90), it was considered to be the smallest representative of the genus known from the Permian of China, in terms of size and textures of fibers; however, the forms described here are of still finer texture and are now the smallest species of the genus known from the Upper Permian of China.

Material. Holotype, STZ17-1, and paratype, STZ10-1, both from the uppermost Permian Shitouzai Member of the Changxing Formation, Ziyun County, southern Guizhou. Reference specimens include sections on 5031, unit 53, Changxing Formation, at Xiangbo.

Etymology. Minima, L., least, in reference to the small size and fine skeletal texture of the species.

PERONIDELLA(?) spp.
pl. 13, figs. 1–3, 5, 6, 8

Several different species of what may be *Peronidella* occur as small fragments in the collection (pl. 13, figs. 1–3, 5, 6, 8). These range from a coarse-textured specimen (Km-1, 5223) to a fine-textured, platelike form (Xm-31, 5229), both from the Maokou Formation, from the Xiangbo area. Both appear to be sections through platelike forms, but dimensions of their entire skeletons are unknown.

Curved segments in what may be transverse sections of parts of funnel-like forms also occur (pl. 13, figs. 3, 8), but again these fragments are too small to be generically or specifically identified. These two figured sponges do have the general texture and branching skeletal pattern of a form differentiated as *Peronidella* sp. A by Rigby and others (1989b, p. 790, figure 10.8).

Fragments of what appear to be tangential sections of subcylindrical sponges also occur in the collections (pl. 13, figs. 5, 6). These specimens also have inadequate morphologic data to characterize them as of a particular genus and species, but, like the others, are included here to document the occurrence of various other peronidellid inozoan sponges in the collection. The later forms may be only tangential sections of otherwise cylindrical forms like *Peronidella regulara* Rigby, Fan, and Zhang, 1989b, but until more adequate samples are collected and sectioned in critical directions, these species must remain in uncertain positions.

Wu (1991, p. 59) interpreted similar plate-, ear-shaped, or cuplike forms as belonging to the genus *Elasmostoma* Fromentel, 1860. He named the species *Elasmostoma aperien* Wu, 1991, for sponges with the general skeletal appearance of the fragments shown in figures 3 and 8 of plate 13. His sponges, like those shown here, came from the Maokou Formation at Xiangbo.

The nature of *Acoelia ruida* Wu, 1991 (p. 58, pl. 8, fig. 7) is also uncertain. It may be only a fragment or a tangential section of another inozoan sponge. The name should be limited to this specimen until the genus and species can be more fully documented.

BISIPHONELLA CYLINDRATA(?) Wu, 1991
pl. 13, fig. 4

Synonymy. Bisiphonella cylindrata Wu, 1991, p. 60–61, pl. 7, figs. 4, 5; pl. 9, fig. 11.

Original diagnosis. "Skeletons columnar in form. The canal systems consist of two excurrent tubes vertically running through the axial region of skeletons. Fibers arranged into regular or irregular lattice. Skeleton with or without cortex" (Wu 1991, p. 60).

Description. Single thin section in our collection of subcylindrical sponge, approximately 17 mm long and ranging 6–8 mm in diameter. Lower part pierced with central simple tubular spongocoel, up to 0.8–0.9 mm in diameter, but upper part with two and possibly three similar exhalant tube or spongocoels 0.6–0.8 mm in diameter. Two of exhalant tubes appear to have origins in outer part of wall, where inhalant canals sweep in almost horizontally and then curve abruptly upward. The inner parts curve 20°–30° from axis and rise upward, to become parallel and vertical in upper part of interior. Diameters seem to increase from only 0.3–0.4 mm, where first differentiated from normal small skeletal pores or canals, to where they become identifiable as exhalant openings. Walls of spongocoel moderately well defined with more or less continuous, but porous, skeletal tracts 0.20–0.25 mm thick.

Skeleton pierced by upward-curved skeletal pores or canals 0.10–0.15 mm in diameter, like those in interior of skeletal wall, although some pores appear to curve downward through walls as well. Pores in lower part with distinct upward and inward trend as elongate more than uniform openings in a reticular net, although cross-connected to form a complexly interconnected network of canals. These pores range 0.10–0.18 mm across, but most approximately 0.12–0.15 mm in diameter, enter wall essentially horizontally in outer part, but curve upward through 50°–60° to inner half of wall with dominant trend 30°–40° to axis and spongocoel wall; spaced 3–4 tracts and 3–4 canals per one millimeter, measured across elongation.

Most skeletal tracts appear with circular cross sections, and 0.15–0.20 mm in diameter in midsection, but swell to as much as 0.3 mm across, where tracts join to produce somewhat aligned reticular network. Skeleton interrupted only by incurrent openings and skeletal pores or canals of interior wall between excurrent openings.

Skeletal microstructure appears sphaerolitic and moderately well preserved in upper and lower left and upper center of sponge. Sphaerolites 0.04–0.05 mm in diameter in moderately well preserved, but somewhat recrystallized, skeletal structure of tracts.

Neither bottom nor top of sponge preserved.

Discussion. Wu (1991, p. 60) defined a new genus *Bisiphonella* for columnar inozoans in which there are two vertical excurrent tubes in the general axial region of the skeleton, and in which the skeleton is made of fibers in a regular lattice. He included two sponges of vastly different textures within the new and type species *Bisiphonella cylindrata* Wu, 1991. The holotype is the coarser textured of the two and has skeletal dimensions essentially matching that of the sponge in our thin section, except the specimen from the Maokou Formation may have more than two cylindrical excurrent tubes. The holotype of *Bisiphonella cylindrata* has excurrent tubes that are 0.75–0.90 mm across, and skeletal fibers that range 0.10–0.18 mm thick, with the interfiber spaces, or skeletal pores, 0.18–0.20 mm wide. The finer-textured form, which appears to be a transverse section but was referred to as a longitudinal section by Wu (1991, p. 154, pl. 7, fig. 4), has a skeletal net with fibers that range 0.10–0.15 mm thick and with tubes 0.20–0.25 mm in diameter. The figures show considerable more difference in fiber dimensions and canal dimensions than that. The consistency of skeletal dimensions in the holotype, and in the form described here from the Maokou Formation, suggest that the two specimens, included in the same species by Wu, should be separated.

Material. Single figured specimen on 5288, unit 31, from the Middle Permian Maokou Formation at Xiangbo.

Genus GROSSOTUBENELLA Rigby, Fan, and Zhang, 1989b

Original diagnosis. "Cylindrical to subcylindrical sponges without a spongocoel but with a weakly annulate exterior; interior pierced by many coarse, nearly equally spaced, subvertical, subparallel to sinuous exhalant canals that branch upward infrequently; incurrent canals not evident; skeleton even textured, composed of fine vermiform fibers, pierced throughout by small irregular skeletal pores; spicules unknown" (Rigby and others 1989b, p. 794).

Type species. Grossotubenella parallela Rigby, Fan, and Zhang, 1989b.

GROSSOTUBENELLA PARALLELA Rigby, Fan, and Zhang, 1989b
pl. 14, fig. 6; pl. 15, figs. 5, 6

Synonymy. Grossotubenella parallela Rigby, Fan, and Zhang, 1989b, p. 796, figs. 12.4, 12.5, 12.8; Wu, 1991, p. 67, pl. 7, fig. 10, pl. 8, fig. 9; pl. 9, fig. 4.

Original diagnosis. "Cylindrical to subcylindrical sponges, weakly annulate, coarse excurrent canals 1–2 mm apart and generally 1.0–1.2 mm in diameter, each with thin fibrous porous layer, skeletal fibers irregular, approximately 0.10 mm in diameter, between skeletal pores 0.15–0.20 mm across" (Rigby and others 1989b, p. 796).

Description. Sponges obconical to club-shaped; abundant coarse, generally longitudinal exhalant canals moderately regularly spaced and subparallel to each other to gently upward divergent, most straight, although some may be irregularly sinuous and anastomosing, generally 0.6–0.8 mm in diameter, but range to 1.2–1.3 mm across near where branch upward, intervening skeletal tracts of same general dimensions. Horizontal incurrent canals 0.5–0.8 mm in diameter but swell where joined with vertical canals, internally short and discontinuous, generally connect two adjacent longitudinal canals and do not form prominent porous zones.

Skeletal tracts moderately regular reticulation of fine fibers of uniform net between longitudinal canals. Fibers within thick tracts range 0.04–0.12 mm in diameter between junctions, with most 0.06–0.08 mm in diameter, but swell at junctions to 0.10–0.12 mm across and may range to 0.15 mm across. Skeletal pores within tracts range 0.06–0.14 mm across, but most are 0.08–0.10 mm across as uniform-appearing interconnected openings.

Discussion. The present specimens are very similar to the type specimens of *Grossotubenella parallela* Rigby, Fan, and Zhang, 1989b, in their general skeletal characteristics and in dimensions of longitudinal exhalant canals. The skeletal tracts composed of a fine uniform reticular net are also similar in dimensions to the type species.

Material. Figured specimens include ZYD (22) from the Middle Permian Maokou Formation, at Ziyundong, Ziyun County, southern Guizhou; and B-29, from unit 31, Middle Permian Maokou Formation at Xiangbo, Longlin County, northwestern Guangxi.

Genus INTRATUBOSPONGIA Rigby, Fan, and Zhang, 1989b

Diagnosis. "Cylindrical to club-shaped sponges that lack a spongocoel but with many large, longitudinal exhalant tubes of various diameters, irregularly distributed; inhalant canals essentially horizontal; skeleton of fine fibers; lacks axial cluster of exhalant canals" (Rigby and others 1989b, p. 790).

Type species. Intratubospongia typica Rigby, Fan, and Zhang, 1989b.

INTRATUBOSPONGIA TYPICA(?) Rigby, Fan, and Zhang, 1989b
pl. 15, figs. 1, 8, 9

Synonymy. Intratubospongia typica Rigby, Fan, and Zhang, 1989b, p. 790–92, figs. 11.1–11.3, 11.5, 11.7.

Original diagnosis. "Cylindrical to club-shaped sponges with irregularly spaced longitudinal exhalant canals, generally 0.8–0.9 mm in diameter; inhalant canals average 0.5 mm in diameter, rise obliquely inward from pores in thin dermal layer; skeletal fibers 0.04–0.08 mm in diameter and skeletal pores 0.06–0.14 mm across; irregular lenticular to bulbous chamberlike interruptions throughout, defined by relatively impervious layers 0.10–0.15 mm thick" (Rigby and others 1989b, p. 790).

Description. Sponges steeply obconical to club-shaped with abundant longitudinal to upward-divergent exhalant canals generally regularly spaced and parallel to each other, most straight and range 0.4–1.0 mm in diameter but generally 0.6–0.8 mm in diameter, larger where branched upward. Horizontal incurrent canals 0.5–0.8 mm in diameter but swell where joined with vertical canals, generally connect two adjacent longitudinal canals but locally form irregular porous zones. Longitudinal canals may contain horizontal to upward-flexed vesiculae or diaphragm-like nonporous vesicular plates generally 0.02–0.09 mm thick, laterally equivalent to skeletal interruption surfaces that range from prominent to obscure.

Skeleton moderately regular reticulation of fine fibers of uniform net between longitudinal canals. Fibers range 0.04–0.22 mm in diameter with most 0.08–0.10 mm in diameter between junctions, but swell at junctions. Skeletal pores range 0.14–0.30 mm across, with most 0.08–0.10 mm across as uniform-appearing interconnected openings in tracts.

Discussion. The present specimens are similar to the type specimens of *Intratubospongia typica* Rigby, Fan, and Zhang, 1989b, in their general canal and skeletal characteristics but are only locally well preserved. The skeleton of a fine uniform reticular net is also similar in dimensions to that of the type *Intratubospongia typica.* Our generally oblique sections make specific identification difficult, and hence questionable.

Material. Figured specimens include section 5199 from unit 27 of the Maokou Formation and B38-8 and B34-1, also from the Middle Permian Maokou Formation, all from Xiangbo, Longlin County, northwestern Guangxi. Less certainly identified reference specimens include ZYD (2) from the Maokou Formation at Ziyundong, southern Guizhou; KM-V-5129 from the Maokou Formation at Kefeng, near Xiangbo, northwestern Guangxi; and Z-1 (27) from the Changxing Formation at Ziyun, from southern Guizhou.

INTRATUBOSPONGIA TENUIPERFORATA
Rigby, Fan, and Zhang, 1989b
pl. 15, figs. 2, 3

Synonymy. Intratubospongia tenuiperforata Rigby, Fan, and Zhang, 1989b, p. 792, figs. 10.5, 10.6, 11.4, 11.8.
Dendrosclera irregularis Wu, 1991, p. 46, pl. 3, fig. 7, pl. 4, figs. 1, 3, pl. 5, fig. 7, pl. 6, fig. 1.

Diagnosis. "Cylindrical to subcylindrical to club-shaped sponges with many parallel longitudinal, walled, exhalant canals 0.5–0.6 mm across; canal walls 0.1–0.2 mm thick and coarsely perforate with pores 0.1 mm across that are openings of fine inhalant canals 0.12–0.15 mm across; skeletal fibers generally 0.05–0.07 mm across" (Rigby and others 1989b).

Description. Cylindrical to subcylindrical sponges with fine-textured skeletal interiors pierced by many longitudinal, distinctly walled, parallel exhalant canals 0.6–1.0 mm in outer diameter and 0.2–0.6 in inner diameter; canals 0.3–1.5 mm apart fairly uniformly. Walls of exhalant canals prominent and 0.2–0.4 mm thick with distinctly inner and outer edges; walls now generally sparry calcite, pierced by numerous small pores 0.10–0.18 mm in diameter; transverse section of canals round to elliptical.

Skeletal pores between fibers irregularly rounded to rounded polygonal and variously interconnected, range 0.08–0.20 mm in diameter. Skeletal fibers 0.08–0.12 mm in diameter, united in fused fine-textured networks, with segments about 0.2–0.4 mm long; fibers may expand to 0.16 mm across at junctions.

Discussion. Intratubospongia tenuiperforata Rigby, Fan, and Zhang, 1989b, is characterized by thick-walled exhalant canals that are perforated by small pores. The present specimen is very similar to the types of *Intratubospongia tenuiperforata* in having a fine-textured skeleton and thick-walled exhalant canals of the same general texture and dimensions. The walls in this specimen are thicker than those in the types of *Intratubospongia tenuiperforata.*

Dendrosclera irregularis Wu, 1991, the genotype species, is considered to be a junior synonym to *Intratubospongia tenuiperforata,* for it has the same skeletal structure perforated by the numerous longitudinal widespread canals, and those canals have the typical thick perforate walls so distinctive of the species (see Rigby and others 1989b, pl. 11, figs. 4, 5). *Dendrosclera,* thus, become a junior synonym of *Intratubospongia.* Both the material described by Rigby and others (1989b, p. 792) and Wu (1991, p. 46) came from virtually the same part of the Maokou Formation from Xiangbo, Longlin County, Guangxi. Sections available to Rigby and others (1989b, figs. 10.5 and 10.6) were oblique sections, as are sections of Wu (1991), but one of the latter (pl. 3, fig. 7) does show some canals converging to an oscular area and is probably closer to the top of the sponge than other sections. The presence of this structure should probably be added to observations on canal development of the species.

Material. Figured specimens, 5236, unit 32, at Xiangbo, and 5159, at Kefeng, Longlin County, northwestern Guangxi, from the Middle Permian Maokou Formation, from which the types were collected. The new sections represent new specimens of the moderately rare species.

Family STELLISPONGIIDAE de Laubenfels, 1955
Genus STELLISPONGIA d'Orbigny, 1849

Emended diagnosis. Polymorphic sponges ranging from irregularly hemispherical, with a colonial appearance, to branched or single sponges that are subcylindrical to steeply obconical; upper surface marked with one or numerous small oscula to which converge several horizontal exhalant canals in small, starlike patterns; oscula may have several short, vertical exhalant openings that are the inner terminations of earlier interior horizontal canals; skeleton between exhalant systems interrupted by more or less continuous, small tubelike canals that radiate upward and outward and oriented essentially normal to the upper surface; skeletal structure fine and moderately regular, appearing to be in layers parallel to the upper surface; exterior may have dense, basal cortex or epitheca-like layer.

Type species. Cnemidium variabilis Münster, 1841.

Discussion. Inozoans with exhalant systems that consist of several convergent canals which lead to a series of axially clustered, coarse exhalant canals contrast with those that have a deep, simple, single spongocoel. Among those Permian-Triassic genera with axial clusters, *Precorynella* and *Sestrostemella* appear to be most common.

Sestrostemella has a distinctive axial cluster of long continuous elements that appear to terminate essentially at the edge of the cluster. Other strong vertical elements or canals are essentially wanting in the irregular skeleton, although some short inhalant canals are evident in the outer part. This structure significantly differs from the sponges here identified as *Stellispongia*(?) sp.

Precorynella has an axial cluster of moderately coarse canals in most of the species described thus far. It also has a strong upward-arched and inward-convergent transverse series of inhalant canals that essentially mark former positions of the rounded upper margins of the walls. Canals of third series are somewhat smaller, perhaps less continuous, and diverge upward and outward, essentially normal to the upper rounded edges of the walls. *Precorynella* is characterized by a single cluster in each of the pyriform sponges, or in each of the branching tubular parts of the sponge, in a structure somewhat similar to that in the Chinese species described here. Our sponges, however, lack the prominent, upward-arched, inhalant series, although they do have some horizontal canals that may be downward arched and that connect to the axial clusters. Inner tips of those essentially horizontal canals arch upward to merge with the short(?) exhalant openings. Only one exhalant cluster, however, is evident in the best preserved and largest specimen. Other exhalant openings or clusters such as characterize *Stellispongia* are not evident, but this could be an artifact of the placement of the section through the sponge.

Stellispongia, as the genus is commonly used, has one to several clusters of convergent exhalant canals that are essentially radial and tangential. They converge to form coarse exhalant canals in oscula at several points on the surface of the skeleton. The genus also has a fairly regular placed, upward and outward, radiating series of smaller canals that are normal to the upper surface of the sponge. Somewhat less clearly defined horizontal canals also occur within the sponge and are arranged approximately horizontal to the upward- and outward-diverging series. These are earlier tangential canals that converged to earlier, now overgrown, exhalant ostia. In general, the canal structure in our Chinese specimens is most similar to that within *Stellispongia,* but only a single exhalant structure of short vertical canals is evident. In lacking multiple oscula, the specimen is most like *Precorynella,* but in other aspects of the canal and skeletal structure, it appears to be more like *Stellispongia* and is tentatively included there.

D'Orbigny (1849) proposed the genus for those polymorphic sponges that have several oscula surrounded by radial convergent canals that combine to produce starlike patterns. Dieci and others (1968, p. 112–13) noted that some species do not have the colonial form of *Stellispongia variabilis* (Münster 1841), the type species, but are like individuals with only a single ostium. For example, *Stellispongia manon* (Münster 1841) may be hemispherical or steeply obconical and have only a single small osculum with convergent radial canals, as seen on the exterior, but in the interior has the general canal pattern characteristic of the genus. This structure shows well in a vertical section of *Stellispongia manon* (Münster 1841) figured by Dieci and others (1968, pl. 18, fig. 6). That section is the one which appears most similar to the figured specimen from China.

Several species of *Stellispongia* were reported by Termier and Termier (1977a) from the Permian of Tunisia. Among those, only the species *Stellispongia permica* Parona, 1933, is a relatively simple form with a single, central, osculum surrounded by a convergent exhalant canals. The others are colonial-appearing twiglike or lobate forms. These species are currently under investigation and analysis by Rigby and Senowbari-Daryan. *Stellispongia permica* Parona, 1933, does not appear to be the Chinese species described here. These species of *Stellispongia* previously reported from the Permian of China by Rigby and others (1989b) are also forms with several oscula and contrast sharply to the relatively simple skeletal structure of the species described here.

STELLISPONGIA(?) sp.
pl. 15, figs. 4, 7

Description. Sponges cylindrical to club-shaped or irregularly encrusting, largest and best preserved is steeply and irregularly obconical and about 30 mm high and 19 mm wide, with irregular outer surface. Lacks spongocoel, but interior of sponge with irregularly spaced and perhaps discontinuous exhalant canals that converge upward in axial area where most continuous in central part, but present elsewhere as well as canals 0.4–0.5 mm in diameter. Well-developed, obliquely inclined, and downward-convergent inhalant canals, 0.2–0.5 mm in diameter, common in parts of skeleton outer margin. They meet subhorizontal inhalant canals that occur moderately regularly in skeletal net as convex or concave upward openings in regular skeletal net. These openings occur 1–3 mm apart, but usually about 1 mm apart, and produce layered-appearing skeletons; inner ends flex upward to produce or merge with central excurrent canals.

Skeletons of fine fibers usually well developed between canals and forms regular reticulate network that appears with uniform layers about 0.10 mm apart and supported by vertical fibers somewhat more irregularly, 0.10–0.15 mm apart. Fibers 0.04–0.08 mm in diameter between junctions, but at junctions may be 0.1 mm in diameter. Skeletal pores 0.08–0.10 mm across, vertically and to 0.14 mm across horizontally.

Discussion. Among the species of *Stellispongia* described to date, *Stellispongia manon* (Münster 1841) is the most similar. It is an obconical form that has only a single osculum in the very shallow spongocoel on the surface, with small convergent exhalant canals that extend only a short distance away from the osculum. The upward radial system of canals appears to be like that in the Permian species here. Dimensions of canal openings and of the convergent exhalant cluster may fall within the general range of that seen in the Chinese species, but measurements were not given, either in the original definition nor in the redescription by Dieci and others (1968) when they redescribed and refigured the excellent material from the Triassic of Italy.

Other species of *Stellispongia* described to date are easily differentiated because of their general colonial-appearance and their growth forms. The Chinese material may well represent a new species, but it certainly is a form closely related to *Stellispongia manon* (Münster).

Material. Figured specimen, Xm-36, 5272, from Middle Permian Maokou Formation, Xiangbo, Longlin County, northwestern Guangxi. Reference specimens also occur on sections ZYD (1, 4, 14, 16) from the Maokou Formation at Ziyun County; on Z-1 (4, 7, 18, 19) from Shitouzai Member at Ziyun County; STZ-10-1, from the Shitouzai Member at Shitouzai, Ziyun County, QCC-5B, Shitouzai Member at Qincaichong near Ziyun, Southern Guizhou; on JS0071, 0072, 0080, from the Permian Changxing Formation at Jianshuigou, Huaying City, eastern Sichuan; on 5165, unit 30, Maokou Formation, Xiangbo, and on KS-87 (Q1159) from the Maokou Formation at Kefeng, both from northwestern Guangxi.

Uncertain Taxonomic Position

Genus IMPERATORIA de Gregorio, 1903

IMPERATORIA(?) sp.

pl. 12, fig. 8

Description. Conico-cylindrical sponges appear segmented in crude fashion in units 1.0–3.5 mm high, with several closely spaced, walled, longitudinal axial exhalant tubes that range 0.4–0.8 mm across, but mostly approximately 0.5 mm across; canals converge upward into central cluster; numerous irregular inhalant canals, 0.1–0.3 mm in diameter in outer part, converge laterally toward center and enlarge into interior and merge with upward-curved exhalant canals; relatively impervious subhorizontal to upward-concave dark skeletal layers separate sponges into chamberlike units generally 2.5–3.5 mm high, but with some irregularity, such layers most pronounced in outer parts of sponge where they range to 0.02 mm thick and essentially seal off early parts of sponge. Impervious layers bound inhalant sections but are perforated in axial region by exhalant canals. Skeletal fibers 0.14–0.20 mm wide, not well preserved, outline irregular subrectangular skeletal pores 0.3 mm across.

Dense outer wall about 0.5 mm thick, dimpled, at least in outer part, by numerous small pores 0.04–0.10 mm in diameter; larger openings 0.10–0.15 in diameter less common and pierce walls as inhalant openings. Many may have been obscured by secondary infilling.

Discussion. The specimen is characterized by its segmented appearance, by inward- and outward-convergent, narrow, slender longitudinal exhalant canals that are usually 0.4 mm across and usually in an axial cluster, although others do occur.

At first glance, the small form appears similar to *Diecithalamia* Senowbari-Daryan, 1990, in having an axial cluster of exhalant canals and an irregular skeletal net, but *Diecithalamia* has an outer part of the sponge composed of crescentic isolated chambers and is not the irregularly segmented form, even across the axial area, that we see in this Chinese specimen. *Diecithalamia* was proposed by Senowbari-Daryan (1990, p. 58–59) for a form called *Cystothalamia* by Dieci, Antonacci, and Zardini (1968). The form appears similar to *Imperatoria marconii* de Gregorio, 1903, in general canal structure and the irregular, somewhat defined, crude segmentation in the skeletal structure.

The small inhalant canals that converge inward and upward to the coarser axial cluster of exhalant canals is distinctively similar to specimens figured by Senowbari-Daryan (1990, pl. 33, figs. 6–7) for the Permian *Imperatoria marconii* from the Sosio Beds of Sicily, and more particularly like the form Senowbari-Daryan (1990, pl. 33, fig. 8) shows as *Imperatoria* sp. from the Upper Permian from Djebel Tebaga of southern Tunisia. He noted that even though the segmentation is evident in the turriculate exterior, nonetheless, these sponges are not part of the thalamiid sphinctozoan sponges, which was also earlier pointed out by Senowbari-Daryan and Rigby (1988) when they proposed term *Pseudoimperatoria* to cover these kinds of sponges.

The Chinese specimen does not have the markedly turriculate exterior seen in other *Imperatoria* and *Pseudoimperatoria* species, but it does have the segmentation and a very weak irregular indentation at what would be the shoulders of the turriculate structure. It is here tentatively included in *Imperatoria,* with question, because of the canal structure, skeletal structure, and the irregular apparent segmentation, but it does not have the cleanly defined, chambered, development seen in the sphinctozoans.

Pseudoimperatoria was limited by Senowbari-Daryan and Rigby (1988, p. 195–96) to the species described by Rigby and Potter (1986) from the Ordovician out of the eastern Klamath Mountains of northern California, for those sponges appear to be sphinctozoans that belong to the family Sebargassiidae Girty and are not related to the form described as *Imperatoria* by de Gregorio (1903). Senowbari-Daryan and Rigby (1988, p. 195) discussed the usage of the term "*Imperatoria*" by earlier workers.

Material. Figured specimen, 5314, unit 32, from the Middle Permian Maokou Formation, Xiangbo, Longlin County, northwestern Guangxi.

ACKNOWLEDGMENTS

We appreciate the support for fieldwork and study of the sponges provided by the National Natural Science Foundation of China. The Department of Geology, through a grant to Rigby, covered local costs of international visitors to Brigham Young University. We appreciate the continued support of our home institutions. Baba Senowbari-Daryan and an unknown reviewer provided critical and very helpful reviews of the manuscript and illustrations. L. T. Bird helped with preparation of the manuscript and some figures.

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