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ORDOVICIAN ALGAE FROM SPITI, INDIA

by

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(with 3 text-figures and 2 plates)

Abstract

Two algae, *Apidium indicum* and *Coeloshaeridium shianense*, are described and illustrated from the Ordovician of Spiti, India. Their internal features are made known for the first time and their stratigraphic horizon and geological age are discussed.

Introduction

The classic Pin-Parahio river sections in Spiti were reexamined and sampled at close intervcals in late July 1985 as part of a D.S.T. (Department of Science and Technology, Government of India) sponsored project "Biostratigraphy of Cambro-Triassic sequences of Tethys Himalaya", run by the Department of Earth Sciences, University of Roorkee, Roorkee, India. The primary objective of this investigation was to collect from seemingly continuous carbonate lithologies of the Lower Palaeozoic sequences in Spiti for acid leaching and recovery of conodonts and other acid-insoluble micro-organic remains that are still so poorly known from this part of the column in the Indian subcontinent.

The collection included a black limestone slab on the surface of which two kinds of macrofossils, beautifully weathered out. They proved to be identical with *Apidium indium* and *Pasceolus? shianensis* (Reed, 1912), forms for which no internal features have yet been documented. The purpose of the present note is to provide morphological and stratigraphical data on these forms.

Stratigraphy

The collection came from the 'Shaly Limestone', sample M28, near Muth on the right bank of Pin river in Spiti (Text-fig. 1), 58.7 metres below the base of Muth Quartzite. It most probably belongs to the uppermost Shaly Limestone (Unit 4) of the Pin Limestone of Goel and Nair (1977). The fossils weather out prominently from the matrix.

Goel and Nair (1977) presented the following sequence of beds along the Pin river, units being considered in decending order;

Muth Quartzite ..... 110—245 metres

passing down gradually into:

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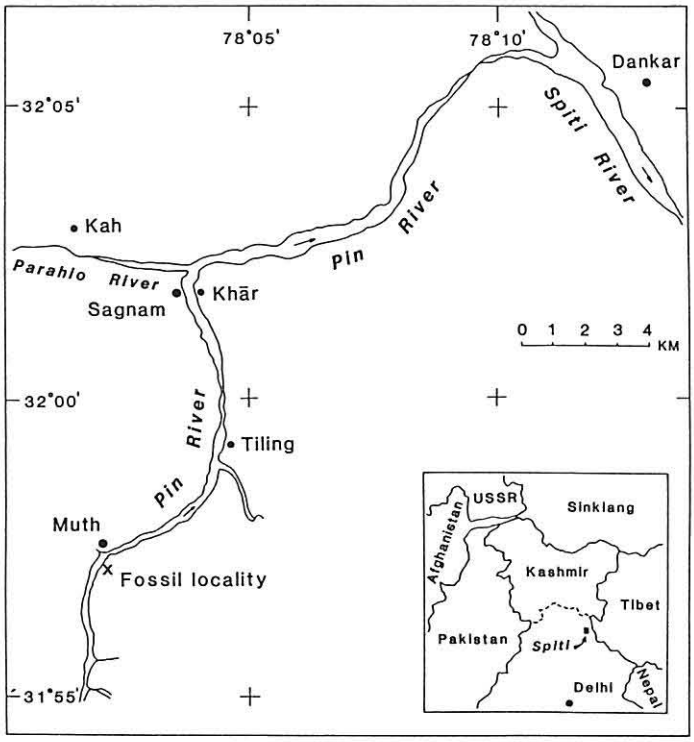
Unnamed Quartzites	..... 25 metres
transitional to:	
Unnamed siliceous and flaggy limestone — Llandovery	..... 20 metres
Thanam Limestone with halysitid and other corals — Late Ashgill or Early Llandovery	..... 15 metres
Pin Limestone — Ordovician	
Unit 4 shaly limestone with algae	..... 10 metres
Unit 3 dolomitic and siliceous limestones with shales	..... 12 metres
Unit 2 limestone weathering brown	..... 10 metres
Unit 1 dark foetid limestone with shaly limestone and shale bands containing brachiopods and trilobites	..... 60 metres
Shian Quartzite — Ordovician	..... Approx. 550 metres
- - - - - Unconformity - - - - -	
Parahio Formation — Cambrian	..... 390 metres

Hayden (1904) recognized eight horizons in the Spiti Ordovician-Silurian succession but objects, similar to ones described herein, according to him (1904, p.26) occur in a band near the top of his dark grey limestone bed, his Horizon 3, near Shian. Our material on the other hand seems to be derived from Unit 4 (= Hayden's Horizon 5) of the Pin Limestone of Goel and Nair (1977). There is thus no doubt that our material came from a higher horizon of younger age than Hayden's collections studied by Reed (1912). According to Gupta (1973) the exact line of demarcation between the Ordovician and Silurian systems has yet to be drawn in Spiti and Hayden (1904, p.32) himself has doubtfully drawn the boundary between these two systems against Horizon No.5 (= Unit 4 of Goel and Nair) and Reed (1912) has therefore included Hayden's Horizon No.5 in his Ordovician System. Gupta (1973) however, believes that boundary between these two systems should have been drawn on top of Horizon No.4 of Hayden on palaeontologic grounds.

Fossil Algae

Reed (1912) condidered these objects curious and somewhat problematical in nature and so described them as 'Incertae sedis', referable to genera allied to *Pasceolus* or *Mastopora* and *Apidium*. Das Gupta (1929) and Gupta (1973) while proposing a subdivision of the Ordovician rocks on palaeontological grounds have also admitted the utility of retaining an Upper Ordovician *Apidium indicum* zone for the Spiti/Kinnaur regions without probing too much into the nature and origin of these forms or even mentioning them in the check list of Ordovician fossils reported from this region (Gupta, 1973, pp.104-105). The true biological affinity of these was not understood until these objects were definitely proved to be plant remains of marine Dasycladacean algae by Pia (1927) and Johnson (1952, 1961a). They are being described as such from Ordovician of India for the first time in this paper. Descriptive terminology is after Johnson (1961a).



Text-fig. 1 Outline map showing locality of Ordovician algae.

Systematic Description*

Phylum Chlorophycophyta Papenfuss, 1946

Class Chlorophyceae Kützing, 1843

Order Dasycladales Pascher, 1931

Family Dasycladaceae Kützing, orth. mut. Stizenberger, 1860

Genus *Coelosphaeridium* Roemer, 1883

Coeloshaeridium Roemer, 1883 (not seen).
Coelosphaeridium, Stolley, 1896, S.177.
Coelosphaeridium, Pia, 1927, S.63.
Coelosphaeridium, Johnson, 1952, P.40.
Coelosphaeridium, Johnson, 1961a, p.40
Coelosphaeridium, Johnson, 1961b, p.125.
Coelosphaeridium, Maslov (ed.), 1963, p.212.
Type species: *Coelosphaeridium cyclocrinophilum* Roemer, 1883
Generic diagnosis: "Thallus spherical, with a spherical central stem on a long slender stem. Primary branches radiate out from the central stem and end in a wide bowl-like

* Suprageneric classification is after Johnson (1961b).

extension, which forms a terminal plate. These plates are calcified and form a dermal layer (Johnson, 1961b)"

*Included species***:

Chaetetes? *sphaericus* Kjerulf, 1865.
Coelosphaeridium cyclocrinophilum Roemer, 1883.
Coelosphaeridium conwentzianum Kiesow, 1893.
Coelosphaeridium excavatum Stolley, 1898.
Coelosphaeridium wesenbergense Stolley, 1898.
Pasceolus ? *shianensis* Reed, 1912.

Remarks: Genera *Cyclorinites* (=*Cyclocrinus*) and *Coelosphaeridium* are very much alike (Stolley, 1896, Pia, 1927; Johnson, 1952, 1961a). Although *Cyclocrinites* was reinvestigated in detail by Nitecki (1970) he did not compare it with *Coelosphaeridium* at all. According to Johnson (1961a), however, *Cyclocrinites (Cyclocrinus auctt.)* is distinguished from *Coelosphaeridium* in having a larger "drumstick-shaped" central stem and large and more slender primary branches with wider bowlshaped tips. He further mentions that *Cyclocrinites* is more weakly calcified. We follow Johnson in the recognition of *Cyclocrinites* and *Coelosphaeridium*.

So far *Coelosphaeridium* has been known from peri-Baltic countries, as well as Great Britain and India. Spjeldnaes (1955) states that *Coelosphaeridium* in Norway, Great Britain and Esthonia are all Caradocian in age. A bed containing *Coelosphaeridium shianense* described below was correlated by Reed (1912) with the Trentonian of North America. Therefore the grenus *Coelosphaeridium* might be more or less restricted to the Caradocian, in the shallow water facies.

Coelosphaeridium shianense (Reed)

(Plate 2, figs. 2, 3, 4a, 4b and 5; Text-fig. 2)

Pasceolus? *shianensis* Reed, 1912, p. 119-120, Pl. XVI, figs. 17, 17a and 17b.

Description: Thallus spherical, 13.4mm in diameter in the largest specimen. The central stem is 5mm in diameter, situated in the centre of the thallus is represented by a hollow sphere with a number of irregularly scattered, small openings on its ceiling. These small openings must be interpreted as the bases of primary branches. Primary branches are radiating towards all direction from the central stem, and are gently tapering inward and downward. They are in elongated club-shape, 5mm long and 0.75mm wide in the thickest part. Outer parts of these branches are constricted and then expanded again to form a series of dermal layers. Exteriorly, the calcified body as a whole is seen to have honeycomb like structure in which hexagonal openings with thick margins are arranged. The diameter of these openings averages 1.2mm. These openings with round bases and with narrow holes at their bottom should represent supposedly bead-like heads of primary branches (bowl-shaped tips of Johnson, 1961a). The outermost, peripheral surface of these primary branches is not calcified (Text-fig. 2).

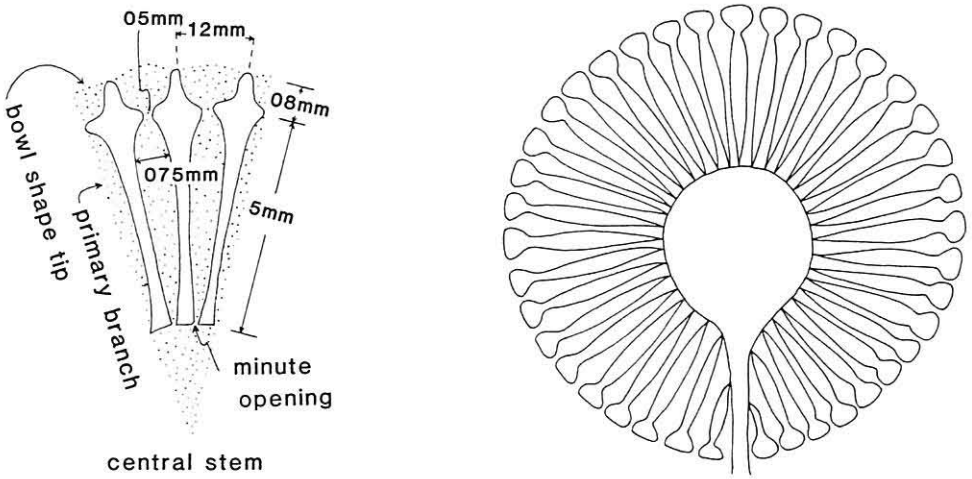
Remarks: Genus *Pasceolus* has been generally considered as synonymous with *Cyclocrinites* (*e.g.* Nitecki, 1970), but *Pasceolus* ? *shianensis* Reed has been classified

** After Pia (1927), Spjeldnaes (1955) and Johnson (1952, 1961a). And thus original articles for some species are not cited in *References*.

as a species of *Coelosphaeridium* by Pia (1927) and Johnson (1952, 1961a).

From other species of *Coelosphaeridium, C. shianense* differs but little. British forms of *Coelosphaeridium sphaericum*, illustrated by Spjeldnaes (1955) have thick primary branches, whereas *C. cyclocrinophilum*, illustrated by Johnson (1952, 1961a, 1961b), has a relatively small central stem for the size of thallus, as compared to the present Indian form.

Reed (1912) illustrated some specimens of *Pasceolus mellifluus* (Salter) from a number of localities in India. This form has much larger "honeycomb" structure, compared to *Coelosphaeridium shianense*; it was referred to *Cyclocrinus* by Pia (1927) and Johnson (1952, 1961a).



Text-fig. 2 *Coelosphaeridium shianense* (Reed)

A - A part of thallus showing relationship between algal body (dotted) and calcified tissue, and skeletal dimension. Much enlarged.

B - Schemetic reconstruction of a thallus in longitudinal section.

Genus *Apidium* Stolley, 1896

Apidium Stolley, 1896, S.234, 277.

Apidium, Pia, 1927, S.67.

Apidium, Johnson, 1952, p.44.

Apidium, Johnson, 1961a, p.36.

Generic diagnosis: Thallus small, globular or pyriform or club-shaped. Central stem probabley club-shaped. Primary branches straight or curved along the central stem. Secondary branches short. The external surface of minute, tertiary branches forms the thin cortical layer.

Type species: *Pasceolus krausei* Kiesow, 1893.
Included species:

Pasceolus Krausei (sic) Kiesow, 1893 (not seen, fide Stolley, 1896)
Apidium sororis Stolley, 1896
Apidium pygmaeum Stolley, 1896
Apidium indicum Reed, 1912
Apidium rotundum Høeg, 1932

Remarks: The genus has been known chiefly from its external shape and partly preserved cortical layer of thallus. Very fortunately we obtained many well preserved specimens of *Apidium indicum* in which branches are occasionally so well calcified as to reveal detail of the internal features of the thallus. At least in the present Indian specimens, the cortical layer of the thallus is made up of laterally fused tertiary branches. Primary branches may be long and curved as sausages along the external surface of swollen central stem. We are quite certain that our specimens are identical with *Apidium indicum* but are not quite certain that the features we found in our specimens hold true for all forms of *Apidium*, although that is quite likely. In any case, *Apidium indicum* should occupy a unique position among Ordovician algae. Our generic diagnosis is provisional, including new information from the Indian form. It resembles *Primicorallia* and *Palaeodasycladus* in having tertiary branches.

This Indian occurrence is the only record of the genus outside the Baltic region. *Apidium* and *Coelosphaeridium* often occur together (Stolley, 1896) as in the present Indian case. *Apidium krausei, sororis* and *pygmaeum* were all obtained from erratic boulder believed to have been derived from the *Coelosphaeridium* bearing "Jewe' schen Schichten" of the USSR (Stolley, 1896). *A. rotundum* was obtained from the Middle Ordovician Hovin Group of Norway (Høeg, 1932). The Indian beds containing *A. indicum* were correlated with the American Trentonian by Reed (1912). *Coelosphaeridium,* with which *Apidium* is often associated, is Middle Caradocian in Norway and Caradocian in Great Britain (Spjeldnaes, 1955). It is therefore reasonable to assume that the genus *Apidium* in general is also Caradocian in geological range.

The size and shape of the thallus are regarded as being important characters for differentiating species of *Apidium*. But in view of the range of variation found in the present Indian specimens caution is necessary.

Apidium indicum Reed

(Plate 2, figs. 1a, 1b and 5; plate 1, figs. 1-14; Text-fig. 3)

Apidium indicum Reed, 1912, p. 120-121, pl. XIV, figs. 18-20; Johnson, 1961a. pl. 14, figs. 1-5.

Description: The thallus is variable in shape. It is globular, pyriform or water-drop shape with stem somewhat pointed, like bottle neck. The widest portion of a relatively undeformed specimen measures 12.2mm; the longest is 15.4mm. No apical depression was observed. The surface of the thallus is either smooth or pitted. Minute pore like pits or a little larger holes may be seen scattered on the surface. These are interpreted as

cut edges of hollow tubes representing secondary and tertiary branches exposed according to the level of surface erosion of thalli. Bottle neck is narrow, 2mm in diameter. The inside of the thallus is often filled with sparry calcite or sometimes with amorphous silica, but, in some well preserved specimens showing strong calcification, internal features are revealed. The central stem is inferred to have been club-shaped. The primary branches are vertically elongated and are parallel to the growth direction of thallus in tangential section; they are curved along the surface of thallus. The size of the primary branches is as long as 27mm and as much as 0.25mm in diameter. From these primary branches rise short secondary branches, whose length is 0.5 ~ 0.7mm and the width is 0.1mm. Farther out there is a thin cortical layer made up by calcified parts around tertiary branches. Externally these tertiay branches are seen as minute pores or very small holes, unless covered by a thin calcareous layer terminating these holes or pores.

Text-figures 3 is a reconstruction of a thallus showing these branches of three orders. Difference of these three branches is best observed in a transverse section of thallus (Plate 2, figs. 1a, 1b).

Remarks: The degree of calcification is different from thallus to thallus, but in many cases the outermost cortical layer is well preserved.

For the size and shape of thallus, though a little variable, *Apidium indicum* compares well with *A. krausei* and *A. sororis*, but the Indian species differs from the latter two Baltic forms in having its cortical layer made up of calcified tertiary branches whose transverse section is round in outline. In the Baltic species, the form of the branches in the cortical layers are small hexagonal prisms in transverse section.

Branches in the thallus were first recognized by Høeg (1932) in a Norwegian form. But three orders of branching is first made known in *Apidium indicum*. This feature brings the genus *Apidium* somehow related to the Ordovician *Primicorallina* or the Jurassic *Palaeodasycladus*. It is clear that Dasycladaceae were already specialized to have higher orders of branching by Ordovician times.

Apidium indicum occurs in abundance (Plate 2, fig. 5) forming a band together with *Coelosphaeridium shianense* for which a Caradocian age is attributed.

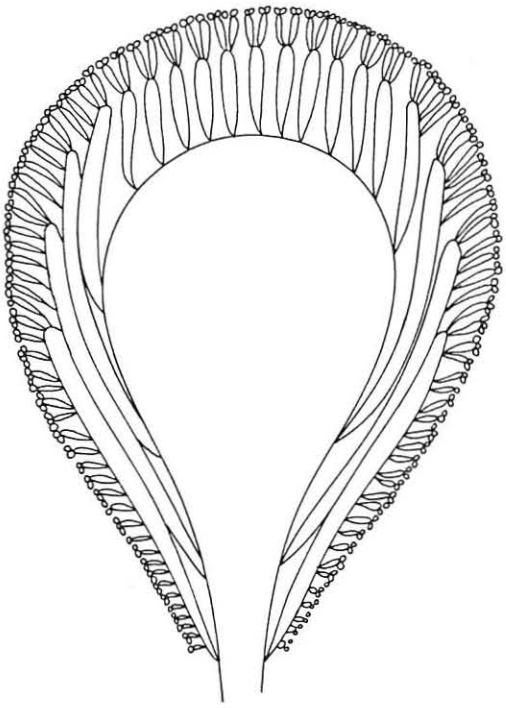
Acknowledgements

This little note is part of a larger collaborative programme of stratigraphic and palaeontologic investigations in Himalaya between Hokkaido University, Japan and University of Roorkee, India under the aegis of JSPS (Japan Society for Promotion of Science). One of the authors (Goel) gratefully records his indebtedness to the Government of Japan and JSPS administration for providing him the opportunity to visit Japan and work with earth scientists of Hokkaido University, Sapporo and for many fruitful discussions. We are indebted to Messrs. Santosh Kumar Tripathi and Ram Milan Verma, Research fellows in the department of Earth Sciences, University of Roorkee, for assistance in collecting of the samples that form the basis of this study.

For some algal literature Dr. N. Minoura kindly let us use his private collection of

papers.

The photographs are the work of Messrs. S. Kumano and Y. Ezaki. For the manuscript we thank Miss H. Sato and Miss M. Imamura.



Text-fig. 3 *Apidium indicum* Reed
Schematic reconstruction of thallus in longitudinal section, with central stem, primary, secondary and tertiary branches.

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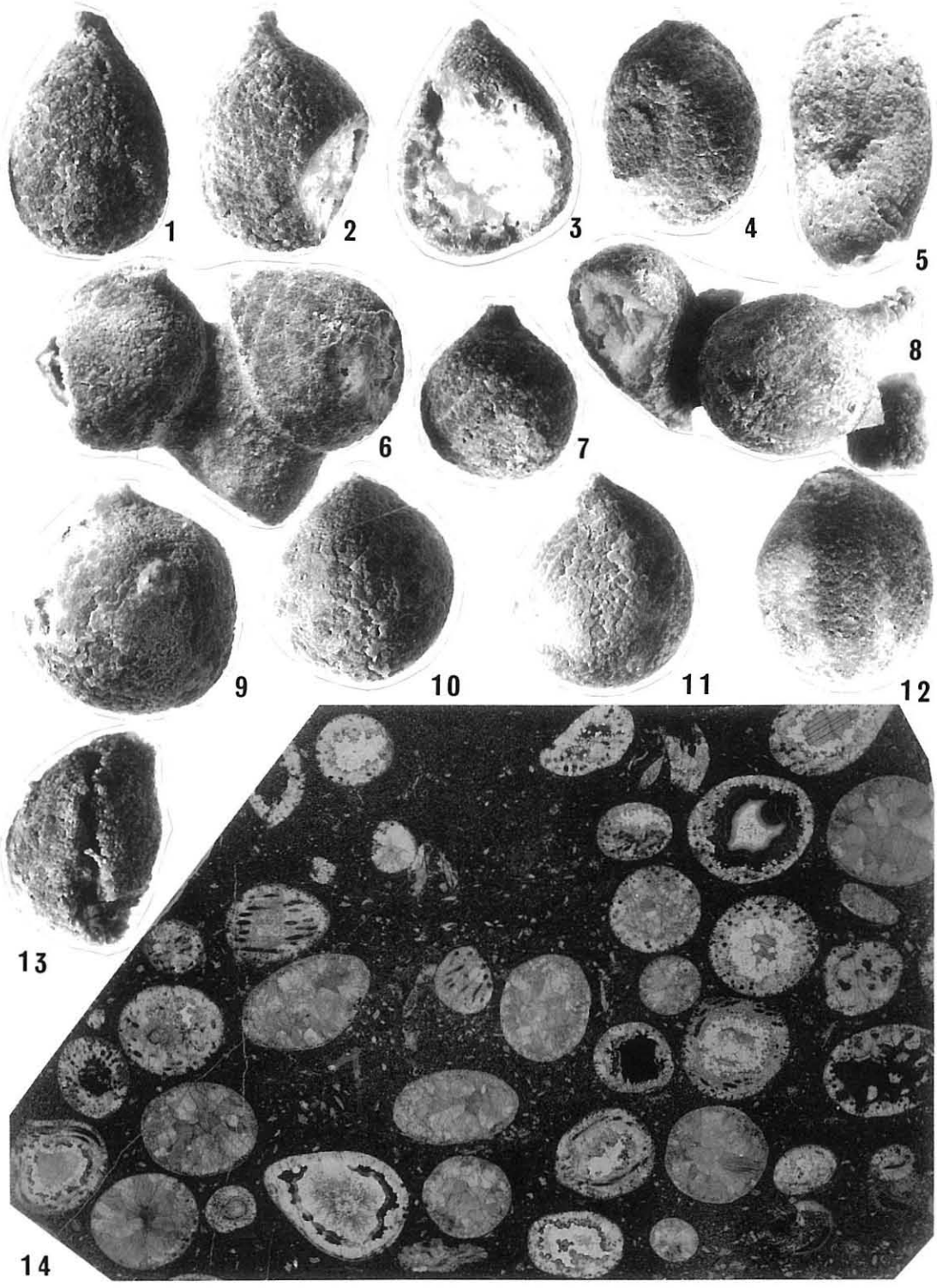
Explanation of Plate 1

Figs. 1-14 *Apidium indicum* Reed

Figs. 1-13 Weathered out and isolated thalli showing external shape and surface features. The interior of the thallus, as revealed on the broken surface, is filled with sparry calcite. Stem parts are placed upside. ×3

Fig. 14 Thin section showing internal characteristics of thalli. In many specimens sparry calcite fills the internal cavity of each thallus surrounded by a cortical layer. In other specimens calcification is so strong that branches of 3 different order are recognizable. Noteworthy are the elongated primary branches which are parallel in tangential section and are curved along the central stem. ×2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(Manuscript received on December 12, 1986; and accepted on February 6, 1987).

Explanation of Plate 2

Figs. 1a and 1b *Apidium indicum* Reed

Fig. 1a Transverse section of a thallus showing an open space of central stem and three orders of branches. Tertiary branches form a cortical layer. ×8

Fig. 1b Enlarged part of Fig. 1b. xca.12

Figs. 2, 3, 4a and 4b *Coelosphaeridium shianense* (Reed)

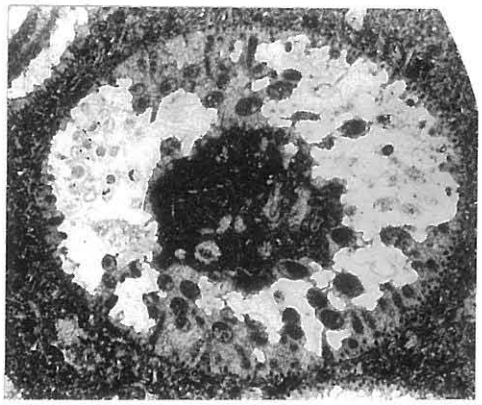
Fig. 2 Weathered transverse section of a thallus.
Note small holes on the ceiling of the spherical central stem. ×4

Fig. 3 Weathered surface of a thallus showing honeycomb structure. ×3

Fig. 4a Transverse section of a thallus showing elongated primary branches with "bowl-shaped tips". Note geopetal infilling in spherical open space of central stem. ×4

Fig. 4b Tangential section of a thallus showing that primary branches gradually expand their width outwards. ×4

Fig. 5 Weathered surface of a limestone slab containing *Apidium indicum* and *Coelosphaeridium shianense*. Natural size.



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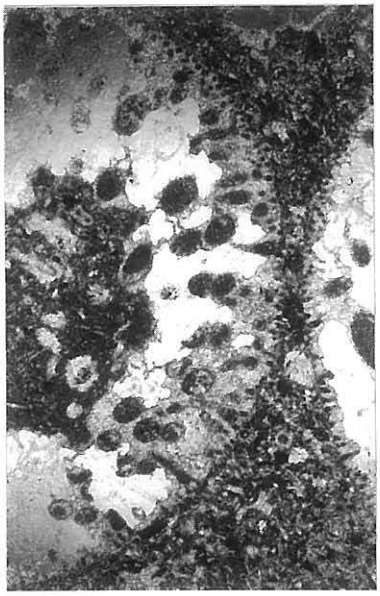

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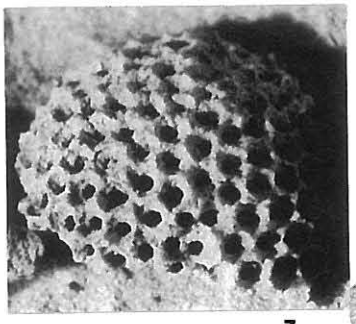

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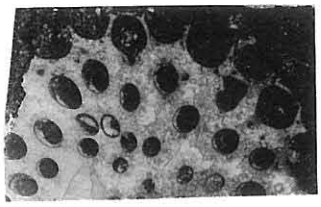

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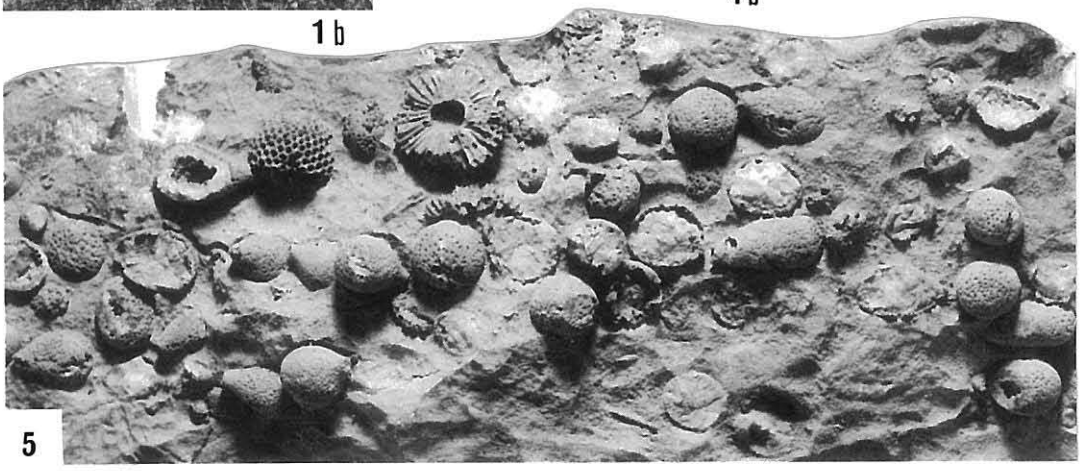

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